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" Impact of Industrial IoT, Automation and Artificial Intelligence on Supply Chain Performance : A case of Pharmaceutical Industry in Pakistan "

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ABSTRACT

This study aims to investigate how supply chain transformation affects overall performance in Pakistan's various Pharmaceutical industries. Therefore, the overall performance of the Pharmaceutical industry is being evaluated by assessing the impact of three key elements of Industry 4.0, that are Industrial Internet of Things (IIoT), Automation and Artificial Intelligence (AI). We will collect information directly from employees in various sectors of Pharmaceutical companies by using an online survey. Our goal is to study how three factors - IIoT, Automation, and Artificial Intelligence (AI) - affect the performance of the supply chain in Pakistan's Pharmaceutical industry. To analyze the data we collect, we will use SPSS software. This analysis will involve looking at the basic characteristics of the data and using linear regression to understand the relationships between the variables.

Through in our research, we anticipate finding a strong, significant and meaningful connection in a positive direction between IIoT, Automation, and AI, and the overall performance of the Pharmaceutical industry in Pakistan. This study holds practical significance as it focuses on the application of digital industrial transformation in the supply chain of Pakistan’s pharmaceutical industry. Implementation of digitization strategies will boost the supply chain performance.

Key words: Supply Chain Performance, Industrial IoT, Automation and Artificial Intelligence (AI)

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Chapter 1 : Introduction

1.1. Background of the Study

Industry 4.0, also known as the Fourth Industrial Revolution, refers to the integration of advanced technologies into various industrial sectors to create smart, automated, and connected systems. It includes the use of technologies such as the Industrial Internet of Things (IIoT), artificial intelligence (AI), big data analytics, robotics, and cloud computing to enable increased automation, data exchange, and real-time decision-making in manufacturing and production processes. Industry 4.0 focus is to rise the productivity, efficiency and flexibility in industrial operations. IIoT is integration of physical devices, machines and sensors with software and networks to allow for real-time monitoring and control of industrial processes. Automation involves using machines and software to perform tasks that were previously done by humans, while AI refers to the use of algorithms and machine learning to perform tasks that typically require human intelligence (Latif, Driss, Boulila, Huma, Jamal, Idrees, Ahmad, 2021).

The modern trend in Pharmaceutical processes is characterized by the transformation of Supply Chain 4.0. This transformation revolves around three key components: industrial Internet of Things (IIoT), automation, and artificial intelligence (AI). The primary objective of integrating IIoT, automation, and AI into the supply chain is to enhance productivity levels, minimize waste, automate processes, reduce manual labor, improve human factor engineering, and mitigate production defects within pharmaceutical companies (Chatterjee, Shukla, Wanganoo, Dubey, 2021).

AI plays a crucial role and has direct bearing on management of supply chain. Supply chain management of firms can be benefited from AI's capability to monitor freight forwarding on a enormous scale and forecast shipping requirements (Rahimi, Alemtabriz, 2022). Through effective use of AI, supply chain managers can get a updated real time picture of the complete logistic supply chain, leading him to make quick and smarter decisions and also keeping him more connected to his customer services (Li, 2020).

Digital transformation has activated the development of new models, principles, and paradigm in supply chain management. The IIoT and smart, connected products, facilitate the development of digital supply chains and smart operations (Panetto et al, 2019).

Previously also organizations have consistently remained involved in figuring out the models to increase profitability by embracing transformation processes, and progressing to computerized innovations. Presently also organizations performance management focus on smart strategic directions that are adoptive in ongoing business expansion. hese cutting-edge methodologies involve integrating advanced technologies and knowledge-based information, such as artificial intelligence, business analytics utilizing Big Data, automating contingency plans in the

pharmaceutical industry, data analytics, and implementing self-correction mechanisms (Rajnoha, Lorincova, 2015).

The impact of the digital supply chain goes beyond production and extends to various indirect departments, with engineering procedures being particularly influenced. This demonstrates that the influence of the digital supply chain reaches beyond specific domains, exerting its effects on multiple facets of organizational operations (Helo, Hao, 2022).

Industrial IoT, automation, and Artificial Intelligence integration in supply chain offer tremendous potential to optimize supply chain performance. By harnessing these technologies, organizations can achieve greater efficiency, visibility, and decision-making capabilities, leading to improved customer satisfaction and cost savings (Nguyen, Lamouri, Pellerin, Tamayo, Lekens, 2021).

Industrial IoT (Internet of Things), automation, and AI (Artificial Intelligence) are crucial in enhancing supply chain performance by enabling efficiency, visibility, and decision-making capabilities. Industrial IoT devices and sensors can be integrated throughout the supply chain to capture and transmit real-time data. This data enables automation and optimization of various processes such as inventory management, demand forecasting, and production scheduling. By automating routine tasks and streamlining workflows, organizations can achieve higher operational efficiency and reduce costs (Yerpude, Singhal, 2017).

Industrial IoT devices can track and monitor the logistics and assets. Real-time visibility allows organizations to gain insights into the location, condition, and status of their inventory. This visibility helps in identifying bottlenecks, optimizing routes, minimizing delays, and enhancing overall supply chain coordination. It also enables better customer service by providing accurate shipment tracking information. Artificial Intelligence integration with supply chain can analyze vast amounts of supply chain data to identify patterns, trends, and correlations. With predictive analytics, organizations can forecast demand more accurately, optimize inventory levels, and proactively address potential disruptions. AI algorithms can also help optimize production and distribution networks, enabling organizations to make data-driven decisions and respond quickly to changing market conditions. By leveraging AI-driven analytics, organizations can make better-informed decisions related to sourcing, procurement, pricing, and risk management. These technologies can also automate repetitive decision-making processes, freeing up human resources to focus on strategic tasks. Industrial IoT and Artificial Intelligence facilitates collaboration among supply chain stakeholders. By sharing real-time data and insights, organizations can enhance coordination, communication, and trust across the supply chain ecosystem. This collaboration leads to improved demand forecasting accuracy, reduced lead times, and increased responsiveness to customer needs (Saibania, Ghania, Akmara, Boon, Ravia, Nawawia, Asr, 2021).

Industrial IoT, Automation and Artificial Intelligence enable proactive risk management in the supply chain. Through real-time monitoring and analysis, organizations can identify potential

disruptions, such as equipment failures, quality issues, or delays, before they occur. By leveraging predictive analytics, organizations can develop contingency plans, optimize inventory buffers, and minimize the impact of unforeseen events on the supply chain (Liu, Chiu, Chu, Zheng, 2022).

1.2. Definition of Variables

1.2.1. Industrial Internet of Things (IIoT)

The IIoT is a interconnected network of industrial devices, machines, trackers and systems that collect and exchange data in the context of industrial operations and processes. IIoT involves integrating smart devices across the supply chain ecosystem to enable real-time data collection, communication, and analysis. This integration facilitates improved visibility, efficiency, and decision-making capabilities in the supply chain. It interconnected devices, sensors, and data analytics to improve visibility, efficiency, and decision-making. By harnessing this technology, organizations can achieve better control over their supply chain, optimize operations, and respond proactively to market demands and disruptions (Boyes, Hallaq, Cunningham, Watson, 2018).

1.2.2. Automation

Automation is to use of technology, machinery, and systems to perform tasks and processes with nominal or no human involvement. It involves the application of various tools, such as robotics, software, and control systems, to streamline and optimize operations throughout the supply chain. Automation is being utilized in industry in warehouse automation, inventory management and demand forecasting. By leveraging automation in the supply chain, organizations can achieve greater efficiency, accuracy, and responsiveness. Automation reduces costs, minimizes errors, enhances productivity, and enables organizations to adapt quickly to changing customer demands and market dynamics (Andiyappillai, 2021).

1.2.3. Artificial Intelligence

Artificial Intelligence (AI) is the ability of machines and computers to imitate human intelligence and perform tasks that typically needs human intellectual aptitude. In the context of the supply chain, AI technologies enable systems to analyze and interpret large volumes of data, make intelligent decisions, and automate complex processes. Through Integration of AI in supply chain, organizations can gain a competitive edge through improved efficiency, better decision-making, and enhanced customer experiences. AI systems can process and analyze vast amounts of data, optimize operations, and enable organizations to adapt quickly to dynamic market conditions (Awan, Kanwal, Alawi, Huiskonen, Dahanayake, 2021).

1.2.4. Supply Chain Performance

Performance in supply chain is the measurement and evaluation of the effectiveness and efficiency in term of (Cost, Sustainability, Flexibility, Responsiveness, Quality and Customer Services) in

various processes, activities, and metrics within the supply chain. It involves assessing how well the supply chain functions in achieving its objectives and meeting customer demands (Tahilani, Swami, Goyanar, Tiwari, 2022).

1.3. Research Gap

The adoption of IIoT, automation and AI in Pharmaceutical Industries is a crucial and decisive player in the current prevailing global industrial environment. Supply chain of Pharmaceutical Industries in Pakistan are continuously exploring to find how the Industry 4.0 digital transformation can be utilize to rise the supply chain performance (Arden, Fisher, Tyner, Lee, Kopcha, 2021).

Management of supply chain consist of monitoring and smoothing of the flows of resources and information between suppliers and customer through an organized network. The digital transformation in supply chain is considered as new gateway to progress supply chain operations (Taghipour, Lu, Derradji, Sow, 2022).

Digital Transformation has started rapid adapted in supply chain industries and is extensively used in organizations to monitor its logistic and other operations. The application of artificial intelligence (AI) has the potential to create substantial business value through up to date information gathered from the Industrial IoT devices, accumulated with the data from other processes. Which improves industry forecast of demands, inventory problems, improve resources and supplier relationships (Liu, Chiu, Chu, Zheng, 2022).

These pilers of industry 4.0 have completely modified the performance of the industries. Many industries have adapted digital model of supply chain without prior working on their exact requirement, which not only adversely impact that industries financially, but also did not showed any significance improvement in their performance (Abdalla, Nakagawa, 2021).

There is serious requirement to look in to the impact of adaptation of industry 4.0, three major factors (IIoT, Automation and Artificial Intelligence) on supply chain performance of Pharmaceutical Industries in Pakistan.

1.4. Problem Statement

COVID-19 pandemic has taught the world that a digital supply chain system is significant for the smooth operations and sustainability of industries. During this period mostly those organizations remained sustainable and performed well, who were already prepared for adaptation of digital businesses and digital smart supply chain system.

The combination of globalization and technological advancements in the Industry has brought a significant paradigm shift in the working environment and cultural landscape of industries. In order to thrive in the modern business culture, industries are progressively embracing digitization

and technological advancements within their logistics functions. Conversely, companies that fail to make any efforts in this regard are at risk of fading away from the industry, unable to keep pace with the evolving business landscape. (Wojcicki, Nska, Paliwoda and Gorna, 2022).

The rapid advancement of technology has brought about significant changes in the supply chain sector, thereby increasing its vulnerability. However, the integration of technology has also introduced various improvement techniques, enhancing the supply chain's agility, resilience, and efficiency. As a result, technology integration has a decisive role in making lean supply chain model, that is more robust, and highly efficient (Olah et al, 2018).

Pakistan is still relying on old supply chain techniques and present multifarious issues of political turmoil, inflation and unrest has further increased hurdle in performance of supply chain. Only adaptation of suitable technology in IIoT, automation and AI can help in increasing sustainable performance in supply chain. Keeping this fact in mind, the focus of research is to high light obstacles which are causing hindrance in the adoption of digital transformation. The study seeks to explore the interplay between these factors and their impact on the industrial landscape in the country. (Waris, Asim, Manzoor, 2020).

The pharmaceutical industry in Pakistan is facing increasing pressure to improve supply chain efficiency, reduce costs, and enhance quality control. Industrial IoT, automation, and artificial intelligence are the futuristic solutions to resolve these challenges. However, there is limited research on impact of these Industry 4.0 technologies on the supply chain performance of the Pakistan's pharmaceutical industry. Therefore, the focus of this research study is to study the effect Industrial IoT, automation, and artificial intelligence on the supply chain performance of the pharmaceutical industry in Pakistan. Specifically, it aims to analyze their effects on efficiency, cost savings, quality control, and overall profitability. This study seeks to provide valuable insights into the potential advantages and challenges associated with the adoption of these technologies in the pharmaceutical industry in Pakistan (Nguyen, Lamouri, Pellerin, Tamayo, Lekens, 2021).

1.5. Research Objectives

The main objective of this research is to measure bearing of Industry Supply chain 4.0 (IIoT, Automation and AI) on the performance of Pharmaceutical industry in Pakistan. Following are the research paper objectives:

RO1. To study the impact of Industrial IOT on Supply Chain Performance of Pharmaceutical industries of Pakistan.

RO2. To study the impact of Automation on Supply Chain Performance of Pharmaceutical industries of Pakistan.

RO3. To study the impact of Artificial Intelligence on Supply Chain Performance of Pharmaceutical industries of Pakistan.

1.6. Research Questions

RQ1. What is the impact of Industrial IOT on Supply Chain Performance of Pharmaceutical industry of Pakistan?

RQ2. What is the impact of Automation on Supply Chain Performance of Pharmaceutical industry of Pakistan?

RQ3. What is the impact of Artificial Intelligence on Supply Chain Performance of Pharmaceutical industry of Pakistan?

1.7. Scope of Study

The primary aim of this research is to analyze the influence of Industrial Internet of Things (IIoT), AI and Automation on the Industry 4.0 transformation of the supply chain. Furthermore, study seeks to gain a deeper understanding of the environmental factors exclusive to pharmaceutical industry of Pakistan, given their significant impression on supply chain performance of the pharmaceutical industry. To achieve these objectives, the study focuses on conducting questionnaire-based research to analyse the role of the digital supply chain including IIoT, automation, and AI, in increasing the supply chain dynamics to enhancing the supply chain performance of pharmaceutical companies in Pakistan. Adaptation and these 3x factors of industry 4.0 (IIoT, Automation and Artificial Intelligence) into supply chain processes, pharmaceutical companies can improve efficiency, enhance visibility, and reduce costs, ultimately leading to improved performance and profitability.

1.8. Significance of the Study

The study highlights the impact of Industrial IoT, automation, and artificial intelligence on supply chain performance. It fills a research gap by specifically focusing on the pharmaceutical industry in Pakistan, providing insights into the use of these technologies in a specific context.

It addresses a relevant and practical issue faced in pharmaceutical industry by enhancing supply chain performance, by examining the influence of Industrial IoT, automation, and artificial intelligence. The research provides valuable insights that can guide decision-makers in the industry in adopting and implementing these technologies to improve supply chain efficiency.

Contextual understanding focus on the pharmaceutical industry in Pakistan offers valuable insights into a specific context which has been given inadequate attention in the literature. Understanding the challenges and opportunities of implementing emerging technologies in this particular industry and country setting can contribute to the development of localized strategies and solutions.

The research has practical implications for managers and practitioners in the pharmaceutical industry in Pakistan. The findings can inform decision-making processes related to technology adoption, resource allocation, and supply chain optimization. The study's recommendations can

assist managers in leveraging Industrial IoT, automation, and artificial intelligence for enhancing their supply chain performance.

Examination of study complements the theoretical framework for managing supply chain and the adoption of technological innovations. It highlights a new path for future research in the field, encouraging further exploration of the relationships between Industry4.0 and supply chain performance.

The significance of this work is to make advances understanding supply chain management field and sheds light on the implications of Industrial IoT, automation, and artificial intelligence for the pharmaceutical industry in Pakistan, thereby enriching both academic and practical domains.

Chapter 2 : Literature Review

In last few decades, managing supply chain has faced a paradigm shift and rapid advancement, Supply chain has adopted the digitization by data science and AI. All techniques in the SCM are continuously improving and changing, from forecasting to product delivery to the end consumer, each stage of the process has been seamlessly interconnected, ensuring real-time information updates for the end use (Saibania, Ghania, Akmara, Boon, Ravia, Nawawia ,Asr, 2021).

In Pakistan, numerous industries are actively engaged in implementing digital supply chain strategies. However, in pharmaceutical Industry the employment of digital supply chain poses exceptional intricacies. Currently, there is limited research available on the specific implementation of digital supply chain in Pakistan's pharmaceutical sector (Dossou, 2018).

2.1. Theoretical Underpinning

A resource-based view is a management approach for identifying major strategic resources that organizations can use to gain long-term competitive advantage (Barney, 1991; Gupta & George 2016). RBV specifies that “tangible resources” are those that are easily available to all organizations and can be traded whereas 'intangible' resources are those that have no clear and obvious boundaries (Barbosa et al. 2017; Kamble and Gunasekaran, 2020). Tan et al., (2015) stated in their study that BDA is an important technological and organizational resource that gives relevant knowledge and information that leads to the development of appropriate competencies. According to Gunasekaran et al.(2017), BDA assimilation impacts the overall SC performance and is facilitated by the firm’s resources backed by the organizational top management.

We have focused on study of implementation of following factors:-

1. Industrial IoT (IIoT)
2. Automation

3. Artificial Intelligence
4. Supply Chain Performance

2.1.1. Industrial Internet of Things (IIoT)

Industrial IoT is a networked system comprised of devices, applications, and software that collaboratively gather, monitor, and analyze information derived from industrial operations. By analyzing this information, visibility is enhanced, and troubleshooting and maintenance capabilities are improved. Furthermore, Industrial IoT has the potential to enhance efficiencies, minimize costs, and elevate safety and security measures (Sailaja, 2022).

Industrial IoT establishes connections between machinery and devices in various industry sectors, including manufacturing, logistics and Power. In contrast, commercial, enterprise, or consumer IoT may have different applications and focus areas (Ugwuanyi, Irvine, 2021).

Industrial IoT enables industry to get a access of actionable data directly from their operations. When properly gathered and analyzed the data assist them in exercising better control operations, with the potential to:

- Improve forecasting and scheduling
- Enhance operational efficiencies
- Rise production and prior information of maintenance of machinery
- Increases flexibility in response times
- Increase access to monitor product quality
- Improve industry - customer relation (Information sharing)
- Improve worker safety

(Rajarajan, Renukadevi, Basim, 2021)

The affordability and ease of use of Industrial IoT have contributed to its growing popularity. Industrial IoT integrates various networks and programing applications that flawlessly operate together using a standard protocol. This integration is facilitated by leveraging applications such as Industrial IoT, automation and AI (Khan, Javaid, 2021).

The architecture of Industrial IoT consists of multiple layers, each serving a specific purpose. At the ground level, sensors like GPS and temperature controller are utilized for identification, sensing, organization, and control. The next layer encompasses the network infrastructure responsible for communication and logistics, which can include connections such as Wi-Fi, WiMAX, switches, and the internet. This layer facilitates and provide media for the transmission of real-time data to the management level for monitoring and decision-making. In managing layer, where all the received data from the lower layers is analyzed, and final decisions regarding information processing are made. This layer incorporates technologies such as artificial

intelligence, business intelligence, data centers, and information security. Currently, cloud-based software and IoT are commonly used for these tasks, either through purchasing or subscribing to relevant services. The application layer, is dedicated to it responds accordingly based on the interpretation. Examples of Industrial IoT applications include smart logistics operations, smart grids system, smart energy saving streetlights, and remote site monitoring (Sethi, Bhushan, Sharma, Kumar, 2020)

The adoption of IIoT technologies is rapidly increasing, and projections for the next decade estimate that more than 125 billion IoT devices will be interconnected (Techradar, 2019). Furthermore, investments in IIoT technologies are expected to exceed, with a 7.3% compound annual growth rate (Forbes, 2018). The current market landscape of IIoT technologies is depicted in the figure below, highlighting a predominant focus on smart cities and industrial IoT applications.

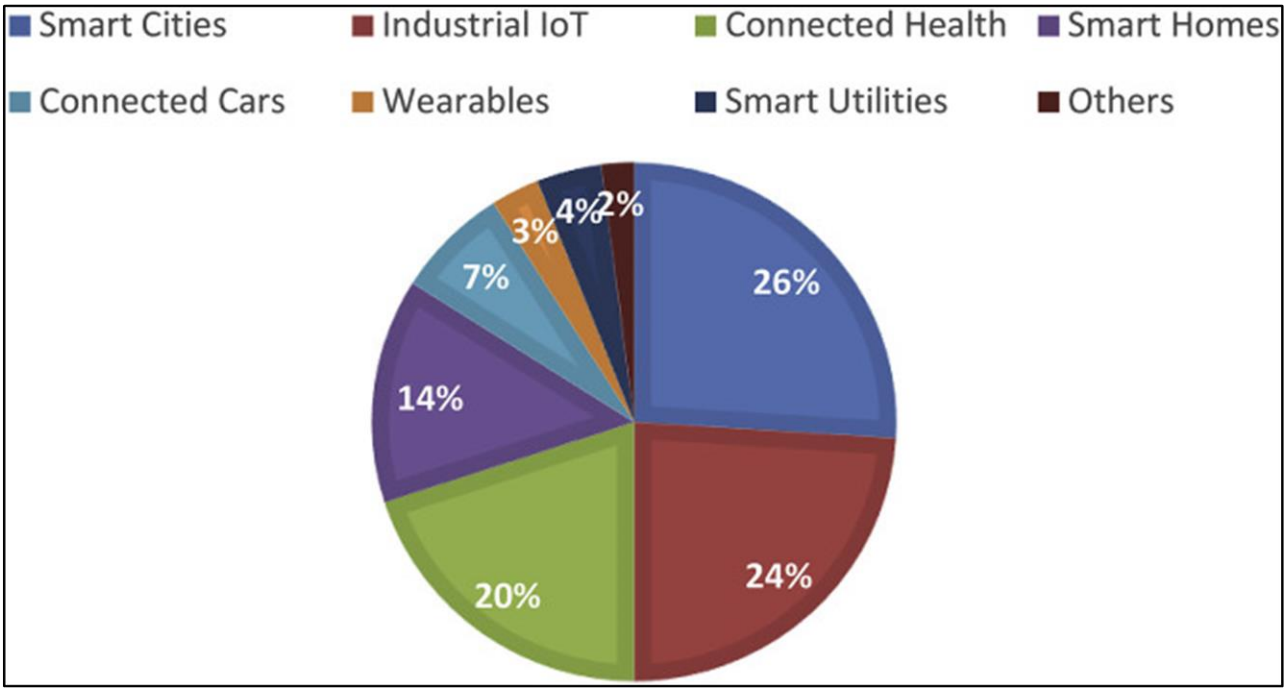

Figure No. 1 (Nizetic, Solic, Patrono, 2020)

Industrial IoT offers several key benefits, including enhanced information availability, improved tracking capabilities, and significant time and cost savings. However, it is not without its drawbacks, such as increased cyber risks, bandwidth limitations, and the complexity of implementation (Bhayani et al., 2016).

In the pharmaceutical industry, warehouse management has vital part in ensuring customer satisfaction. The cost of warehousing is a critical factor in achieving maximum profitability while maintaining cost-effective operations. Efficient warehouse management provides a competitive edge by reducing lead times and facilitating prompt product delivery to customers. This knowledge is essential for optimizing operations and gaining a competitive advantage in the industry (Arana, Flores, Ramos, Mesia, 2020).

The implementation of Industrial IoT in warehouse management brings significant improvements in meeting customer demand swiftly and accurately, maintaining optimal service levels, and reducing or eliminating non-value-added activities. Introducing Industrial IoT in pharmaceutical industry warehouses yields fruitful impacts, as it enables real-time monitoring of warehouse processes and operations through system integration. Industrial IoT assist in integration of inventory and demand (Jarasuniene, Ciziuniene, Cereska, 2023).

Industrial IoT (IIoT) enhances business efficiency by minimizing human labor and maximizing automation through its implementation. By leveraging IIoT technologies, Pharmaceutical industries can achieve cost savings and increase overall profitability (Arnold, Kiel, Voigt, 2016).

Pharmaceutical industries are expected to face significant operational changes in their supply chain due to the digitization of processes. Considering the current scenario, relying solely on the government sector is insufficient, and these industries must proactively embrace technological advancements. It is crucial to acknowledge that certain pharmaceutical companies still lack basic digital capabilities, emphasizing the need to develop a comprehensive design that integrates Industrial IoT and digital supply chain practices. Cloud technology implementation necessitates internet connectivity and a compatible platform to support the operations (Radanliev, Roure, Nurse, Burnap, et al., 2019).

Supply chain is facing challenges in sustaining their operations and control within the complex economy. Many companies encounter financial difficulties, and some even face closure due to ineffective supply chain management practices. Therefore, companies must adopt smarter approaches by leveraging technologies to ensure their sustainability in the economy. One of the primary reasons for supply chain failures can be attributed to the inadequate integration of Industrial IoT into their operations (Majeed, Rupasinghe, 2017).

2.1.2. Automation

The supply chain automation has capability to completely revolutionized supply chain operations, through integration of various processes. The main objective is adoption of advance automation technologies in the pharmaceutical industry to decrease operational costs (Radanliev, Roure, et al., 2019).

Automation in supply chain involves minimizing manual labor within the complete supply chain system. It facilitates the flow of electronic information, reduces paperwork, improves tracking capabilities, automates inventory and warehouse management, and employs robotics to streamline the production process (Dallasega et al, 2019).

Furthermore, Automation in supply chain helps in tackling the rapidly changes in demands in uncertain situations. Adopting automation in Pharmaceutical Industry, we can reduce energy consumption and manual workload, and can enhanced system efficiency. It contributes to

environmental protection by minimizing carbon footprints and wastage, thereby creating a safer environment and reducing the risk of accidents. Moreover, education and proper training to employees before implementing automation in the Pharmaceutical industry is very important. The biggest hurdle in adopting automation in the Pharmaceutical industry in Pakistan are financial constraints, inadequate infrastructure, potential disruptions to employment, organizational structural changes, and inappropriate processes (Hussaina, Mirb, Musharaf, Sajid, 2023).
Pharmaceutical industry enhance quality, conserve energy, increase productivity, and decrease production and operation costs through automation (Singh, 2018).

2.1.3. Artificial Intelligence (AI)

AI, typically comprises three components: Sensing, Processing, and Learning. Conventional resource planning software systems used by traditional firms are often limited to transactional management. The systems incorporating Artificial Intelligence, such as Big Data Analytics, offer the capability to transcend transactional management(Toorajipour, Sohrabpour, Nazarpour, Oghazi, Fischl, 2021).

AI enables the optimization and coordination of supply chain efficiency in ways that transactional systems alone cannot achieve. The incorporation of AI in supply chain management allows more effective utilization of optimization tools in various business operations. This includes improved configuration of supply chains by defining key stakeholders, geographic distribution, primary transportation systems, and more. Additionally, AI facilitates enhanced demand forecasting and risk analysis within supply chain management (Helo, Hao, 2022).

AI in supply chain management offers optimization and enhanced agility in tracing transport routes, both inbound and outbound. It also assists in enabling improved quality management of operations, as well as more efficient inventory management. This can be achieved by leveraging new methods such as object detection and recognition of visual patterns (Kaptanoglu, 2020).

The continuous utilization of AI enables more accurate demand management, leading to enhanced monitoring and visibility of supply chain operations. This, in turn, facilitates dynamic decision-making and optimization processes. AI also enhances scheduling and control capabilities, enabling more comprehensive and optimized management of operations. Additionally, it improves predictive asset management by maximizing their utilization and mitigating interruptions in supply chains caused by machinery and equipment shutdowns (Dash, Murtrey, Rebman, Ka, 2019).

The implementation of AI with its broad range of capabilities, scalability, and analytical features, can effectively optimize operations. These processes benefit from the advanced capabilities of AI, enabling improved efficiency and execution (Boute, Udenio, 2021).

2.1.4. Supply Chain Performance

Indusrty 4.0 transformation can extends performance of supply chain in various aspects such as demand, forecasting, inventory management and its distribution. Objective of implementing a digital transformation is to enhance efficiency and performance of the industry conventional supply chain by controlling cost and increasing flexibility of the supply chain (Yan , Shi, Kang, 2022) .

In the developing industries of Pakistan, the digital supply chain, which incorporates factors such as Industrial IoT, automation, and AI has proven to be a cost effective solution. The adoption of digital technologies has not only reduced material and resource waste but has also resulted in enhanced production operations, quality control, decrease lead time, improve resource utilization, ecofriendly production and cost management (Saleem, 2020).

Effective information sharing is a crucial component in the flexible supply chain performance. It improves information sharing flow. Industries are investing to establish effective and robust communication channels through digital transformation. (Govindan et al., 2017).

The digital supply chain is recognized as a major factor in achieving flexible and efficient supply chain performance, as it facilitates connectivity of stakeholders and processes. Integration of supply chain crucial for enabling real time information flow among stakeholders and to establishing end to end business processes. Integration can lead to improvements in various aspects of performance, including operations costs, improved flexibility, product quality, production capacity and waste reduction (Swift et al., 2019).

Implementation of supply chain transformation increases the perceptibility and traceability of pharmaceutical products across the entire supply chain. This improvement allows for better tracking of inventory, mitigates the risk of counterfeit drugs, and ultimately enhances overall product safety(Chakravarthy, Anurag, 2019).

Digital supply chain technologies, such as real-time monitoring systems, can optimize inventory management processes. By providing accurate and timely data on stock levels, expiration dates, and demand patterns, pharmaceutical companies can reduce stockouts, minimize wastage, and ensure efficient utilization of resources (Zwaida, Pham, Beauregard, 2021).

Digitalization can streamline logistics and distribution operations by automating processes such as order management, route optimization, and delivery tracking. This leads to faster and more accurate deliveries, reduced transportation costs, and improved customer satisfaction (Taghipour, Lu, Derradji, Sow, 2022).

The pharmaceutical industry is subject to strict regulatory requirements. Digital supply chain solutions can help ensure compliance by providing comprehensive documentation, tracking the movement of pharmaceutical products, and facilitating transparency in the supply chain. The utilization of digital tools increases coordination among stakeholders within the supply chain of

pharmaceutical industry. This improved coordination facilitates better information sharing and communication, resulting in faster decision-making, reduced lead times, and improved overall operational efficiency (Kapoor, 2018).

The successful implementation of digital supply chain initiatives requires investment in technology infrastructure, data security measures, and training of personnel. Additionally, it is essential to establish regulatory frameworks and industry standards that guarantee the secure and ethical implementation of digital technologies in the pharmaceutical sector.

2.2. Theoretical Framework

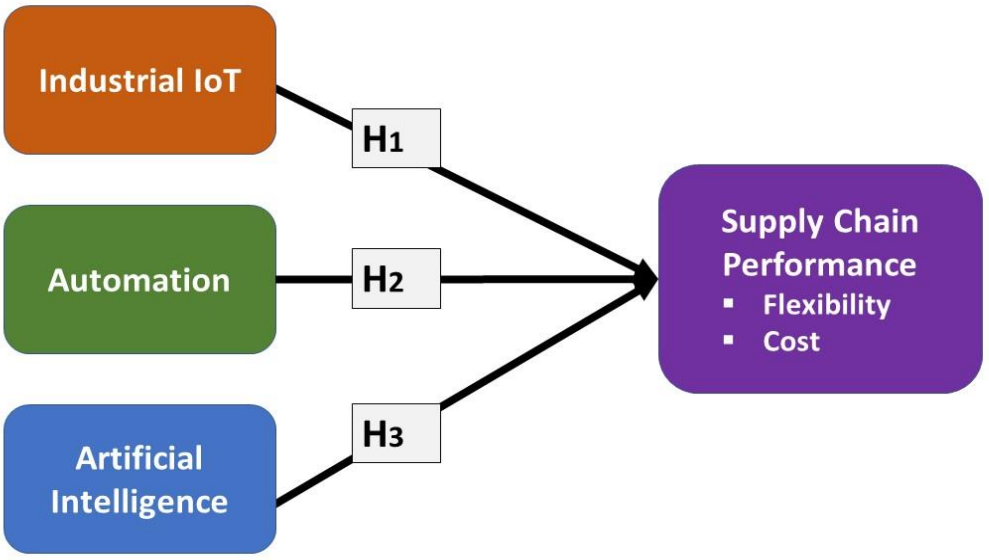

Figure - 1 Theoretical Framework

2.3. Hypothesis Development

The IIoT incorporates the integration of network connected devices, trackers and data analytics within industrial processes. This technology can impact supply chain performance by providing updated analysis from multiple points across supply chain, Industrial IoT facilitates enhanced visibility. This improved visibility, in turn, enables more effective inventory tracking, monitoring of equipment health, and identification of bottlenecks or inefficiencies. Timely and accurate information, supply chain managers can make decisions basing on the data available, improve processes and enhance overall performance (Pundir, Jagannath, Ganapathy, 2019).

Industrial IoT devices can monitor the condition of machinery and equipment, detecting anomalies and potential failures. This enables proactive maintenance, reducing downtime and improving the reliability of operations. By minimizing unplanned equipment failures, supply chain performance is enhanced, ensuring smooth and uninterrupted operations. It enables the optimization of supply chain processes through automation and data-driven insights. For example, sensors can track the movement and condition of goods, providing valuable information on shipment status, temperature control, and delivery times. This enables proactive problem-solving, efficient inventory management, and optimized logistics, leading to improved supply chain performance (Zhou, Chua, Chan, Lim, 2021).

As a result, hypotheses is suggested to clarify the association between Industrial IoT and supply chain performance

H_1: Industrial IoT has a significant impact on Supply chain performance.

Supply chain automation involves the use of industry 4.0 such as robotics, automatic vehicles, and automated systems to streamline operations. Automated processes are generally faster and more efficient than manual ones. Automation can reduce human errors, improve throughput rates, and minimize lead times, leading to faster and more reliable order fulfillment and delivery (Andiyappillai, 2021).

Automation can help reduce costs in the supply chain by optimizing labor utilization, minimizing the need for manual intervention, and improving resource allocation. With fewer errors and delays, costs associated with rework, inventory holding, and expedited shipping can be reduced (Sharakhin, Levchenko, Kaminskiy, 2022).

Automation reduces the likelihood of human errors in tasks such as order processing, picking, and packing. This improves accuracy, reduces product defects, and enhances overall quality control in the supply chain (Viswanadham, 2000).

Automation enables greater scalability and adaptability in supply chain operations. Automated systems can handle higher volumes of orders and accommodate changing demand patterns more easily. This agility allows for faster response times to market fluctuations and customer demands (Atieh, Kaylani, Abdallat, Qaderi, 2016).

As a result, hypotheses is suggested to explain the relationship between Automation and supply chain performance

H_2: Automation has a significant impact on Supply chain performance.

Artificial Intelligence (AI) involves emulate human intelligence, utilizing techniques such as machine learning, language processing and predictive analytics. AI powered algorithms can analyze large volumes of historical data and market trends to generate accurate demand forecasts. This helps in optimizing inventory levels, production planning, and ensuring adequate stock availability, leading to improved supply chain performance (Wang, Pan, 2022).

AI enables data-driven decision-making by providing insights and recommendations by analyzing all the massive amounts of supply chain data. This helps supply chain managers make more informed decisions related to sourcing, pricing, inventory management, and logistics optimization (Alomar, 2022).

AI can identify potential risks and disruptions in the supply chain, such as weather events, geopolitical factors, or supplier reliability issues. By proactively identifying and mitigating risks,

AI improves supply chain resilience and minimizes the impact of disruptions (Atwani, Hlyal, Alami, 2022).

Various aspects of supply chain can be enhanced through AI algorithms, such as route planning, inventory and warehouse layout. By finding the most efficient configurations and workflows, AI improves overall supply chain performance and resource utilization (Ghouati, Amri, Oulfarsi, 2022).

As a result, hypotheses is suggested to explain the relationship between Artificial Intelligence and supply chain performance.

H_3: Artificial Intelligence has a significant impact on Supply chain performance.

Hypothesis

H_1 : Industrial IoT has a significant impact on Supply chain performance

H_2 : Automation has a significant impact on Supply chain performance

H_3 : Artificial Intelligence has significant impact on Supply chain performance

Chapter 3 : Research Methodology

3.1. Introduction

Research methodology is a methodical and technical way of finding the facts and exploring new dimensions. (Sahithi, 2021). The pursuit of valuable and novel information pertaining to a chosen topic is the essence of research. The research methodology aims to validate previously stated facts. Information can be gathered from various sources, including social media, journals, books, research articles, personal experiences, surveys, and questionnaires. Research is conducted through methods such as studying, observing, experimenting, comparing, reasoning, and analyzing, among others. The study was conducted to examine the impact of Industrial IoT, Automation, and AI on the supply chain performance of the Pharmaceutical Industry in Pakistan.

3.2. Research Philosophy

In this research work, the relevant study philosophy is epistemology. Epistemology focuses on the study of knowledge, exploring its nature, scope, sources and validity. It delves into the acceptable knowledge within the research field and establishes the credibility of information through rigorous testing (Isaacs, 2014).

3.2.1. Philosophical Stance

The philosophical stance adopted in this study is positivism, wherein the research questions are initially formulated, followed by the utilization of relevant data to conduct further research. Positivism generates the hypothesis that can be tested and it allows the measurements that are against the accepted knowledge. This philosophy creates research that allows other to replicate and generate the same results. It puts emphasis on the quantifiable results. Positivism is applicable in this research, because hypothesis generated in the study can be tested and can be explain.

3.3. Research Approach

The purpose of research approach is to determine whether the research is based on a quantitative or qualitative approach. We have used deductive approach as it focus is to address the research question at hand. In order to prove the existing theory, deductive method is the most common approach. First the problem statement is analyzed, after that the answers to the identified questions are given in the form of theory. This study started from the research questions that were set out to study the significance of Industrial IoT, Automation and Artificial Intelligence on supply chain performance in Pakistan's Pharmaceutical Industry. The research process advanced by data and information gathering and analysis, and finally leading to the discovery of findings that provide an answer to the research problem.

3.4. Research Method

The research method adopted in this research work is the mono method and the study is quantitative in nature because it is consistent and provides accurate results. This study will use the statistical data analysis techniques to quantify the results. The questionnaire will be utilized to analyze and quantify the results. The data analysed in this research is collected from both primary as well as secondary sources.

3.5. Methods of Data Collection

To find the bearing of industrial IoT, Automation and Artificial Industry on supply chain performance of Pakistan's Pharmaceutical Industry, we have used primary data gathering techniques. The first-hand source data is collected through structured questionnaire.

In questionnaires respondents of research were instructed to rate each item as Strongly disagree, Disagree, Neutral, Agree and Strongly agree.

The questionnaire we used was adapted from prior research studies. The questionnaire target respondents to investigate influence of Industrial IoT, Automation, and AI on the supply chain performance of the Pharmaceutical Industries in Pakistan. Additionally, secondary data was gathered from previous reports, journals, research articles, and experiments to provide support to the existing literature.

3.5.1. Industrial IoT Relationship

Five questions were adapted form previous research develop by Anwar, Zainal, Abdullah, Iqbal (2020) designed to obtain the response from audience on Industrial IoT. The questionnaire asked participants to score their opinion from "strongly disagree" to "strongly agree".

3.5.2. Automation Relationship

These questions are adapted from previous researches (Mettler, Pinto, Raber, 2012). In questionnaires respondents were given options to select their opinion from Strongly disagree, Disagree, Neutral, Agree and Strongly agree.

3.5.3. Artificial Intelligence Relationship

In questionnaires was designed to obtain response from the audience to which extent they examine the importance of Automation. These questions are adapted from questionnaire developed by Daneshvar, Hajiagha, Tupenaite, Khoshkheslat (2020). The questionnaire asked participants to score their opinion from "strongly disagree" to "strongly agree".

3.5.4. Supply Chain Performance Relationship

To find the relationship between Industrial IoT, Automation and Artificial Intelligence on Performance of supply chain the current study adapts a questionnaire developed by Fantazy, Mukerji, Kumar (2012). This questionnaire uses 5-items to analyze the procurement performance

of an organization. The questionnaire asked participants to score their opinion from “strongly disagree” to “strongly agree”.

3.6. Unit of Analysis

Unit of analysis is basically the 'who' or what' that the researcher is interested in analyzing. We have used employees of Pharmaceutical Industries of Rawalpindi and Islamabad twin cities of Pakistan.

3.7. Population

The population includes all the elements from set of data. Population can be the complete community of a particular country or part of community. To narrow down our research we have considered the Pharmaceutical Industries in twin cities of Pakistan (Rawalpindi, Islamabad). Pharmaceutical industries are targeted specifically for the data collection. Amongst 338 registered pharmaceutical firms in Pakistan, the data was collected from first 10 pharmaceutical firms registered in Rawalpindi and Islamabad (SECP, 2019). The Pharmaceutical firms selected for study are:-

- Scotmann Pvt. Ltd
- Scotmann Pvt. Ltd Islamabad,
- Ambrosia Pvt. Ltd Rawalpindi
- Amson Vaccines &Pharma Pvt. Ltd
- BioGen Pharma Pvt. Ltd
- Caraway Pvt. Ltd
- CIRIN Pvt. Ltd
- Danas Pvt. Ltd
- Shaigan Pvt. Ltd and
- Relliance Pharma Pvt. Ltd

3.8. Sample Size

The selection of an appropriate sample size and observations is of utmost importance in research. Data obtained without a proper sample size may lack reliability, and the resulting findings may not be generalizable. In the current study, the sample consisted of 346 respondents who were literate employees working in pharmaceutical firms located in the twin cities of Pakistan.

Out of approximately 3000 employees in the pharmaceutical firms, a subset of 600 literate employees was selected for the study. By applying the appropriate formula, the calculated sample size was determined to be 346. The confidence level for the study was set at 95%, corresponding to a significance level or proportion of sampling error of 0.05.

3.9. Sampling Techniques

Accurate sample size and a proper reference scale are essential for conducting reliable and authentic research work, making the sampling technique a crucial aspect of the research process. We have employed a non-probability sampling technique, which is considered a reliable method. However, it's important to note that findings obtained through non-probability sampling may not be generalized to all industries, and the responses collected from a single individual may not represent the views of the entire company.

3.9.1. Convenience Sampling

In this study, we have chosen to utilize a convenient sampling technique. Convenience sampling is selected from a group who are easily accessible or convenient to reach out to. This technique relies on gathering data from respondents who are available and willing to contribute in the study. It implies that the respondents are obtained wherever and whenever they happen to be available (Stratton, 2021).

3.10. Time horizon

This study is a cross sectional and will analyze the data gathered through organizations using surveys at a single point in time.

3.11. Data Collection and Data Analysis

3.11.1. Data Collection Procedure

The adapted questionnaires were further simplified to and circulated to the respondents to obtain accurate and reliable responses. The aim was to eliminate any vagueness in the questionnaire (Flick, 2015). The data collection process involved the researcher distributing structured questionnaires among employees working in manufacturing firms located in the twin cities of Pakistan. The questionnaires were distributed using online platforms such as "Google Docs," and the data was gathered on an individual basis. To ensure meaningful findings and draw sound conclusions from the study, the data gathered from the questionnaires was properly synchronized. A total of 346 questionnaires were received. All the questionnaires received had complete results and none of the responses were excluded. 346 valid responses were recorded and analyzed in IBM SPSS statistics 25.

3.11.2. Data Analysis

To analyse the data, a different types of tests and analyses were performed as part of the data analysis procedure. (Silman, Macfarlane, 2019). or statistical analysis, the study employed tools such as regression and correlation analysis using the SPSS software. These tools were utilized to determine the extent of relationship between Industrial IoT, Automation, and Artificial

Intelligence which are independent variables and supply chain performance that is dependent variable. Regression and correlation analysis are widely recognized statistical methods used globally for data analysis, known for their reliability and validity in deriving meaningful insights.

3.12. Measurement/Scale Used

This particular study has three independent variables, which are, Industrial IoT, Automation and Artificial Intelligence and one dependent variable supply chain performance. This research work utilized a 5-point Likert scale, enabling the researcher to analyze the data effectively by making comparisons and reporting the degree of positive or negative inclination of respondents towards the elements in the questionnaire. (Dalmoro, Vieira, 2014).

Each variable of the study was measured using 5-option point scale. Range is from 1 to 5. Where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly Agree. (Sounders, Lewis, & Thornhill, 2016).

Chapter 4 : Data Analysis and Finding

4.1 Demographic Profile

The online survey forms received a total of 346 respondents. The demographic characteristics of the respondents were categorized into four groups: industry by types, industry by size, number of plant sites in the industry, and years of establishment of the industry

4.2 General Discussion about Demographic characteristics of the respondents and Discussion

4.2.1 Frequency Distribution and Descriptive Statistics with Respect to Gender

Table 1: Gender of Respondents

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	239	69.1	69.1	68.8
	Female	107	30.9	30.9	100.0
	Total	346	100.0	100.0	

The following table presents the gender distribution of the respondents in this study. Out of the total 346 respondents, 239 were male, accounting for 69.1% of the total, while 107 were female, representing 30.9% of the total. These results indicate a notably higher proportion of male respondents compared to female respondents.

4.2.2. Frequency Distribution and Descriptive Statistics with Respect to Age

Table 2: Age of the respondents

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 30 Years	270	78.2	78.2	78.2
	30 to 45 years	58	16.5	16.5	94.7
	More than 45 years	18	5.3	5.3	100.0
	Total	346	100.0	100.0	

The table presented below contains information regarding the age of the respondents. Out of 346 respondents, 270 respondents were below 30 years of age and represented 78.2% of the total respondents. 58 out of 346 respondents lie between age bracket of 30 to 45 years and accounted for 16.5% of the total respondents. 18 out of total respondents were above 45 years of age and which represented 5.3% of total respondents.

4.2.3. Frequency Distribution and Descriptive Statistics with Respect to Designation

Table 3: Designation of the respondents

Designation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Senior Manager	26	7.6	7.6	7.6
	Middle Level Manager	136	39.4	39.4	47.1
	Support Staff	11	2.9	2.9	50.0
	Other	173	50.0	50.0	100.0
	Total	346	100.0	100.0	

Based on designation, 26 out of 346 respondents are serving as senior level managers. Middle level managers accounted for 39.4% of the total respondents that equals to 136 out of 346

respondents. 11 out of 346 respondents were support staff and accounted for 2.9% of the total respondents.173 respondents lied on “Other” category and represented 50% of total respondents.

4.2.4. Frequency Distribution and Descriptive Statistics with Respect to Experience

Table 4: Experience of the respondents

Experience					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5 Years	248	71.8	71.8	71.8
	5 to 10 Years	61	17.6	17.6	89.4
	Greater than 10 Years	37	10.6	10.6	100.0
	Total	346	100.0	100.0	

In this table out of 346 respondents, 248 had an experience of less than 5 years and represented 71.8% of the total respondents. 61 out of 346 respondents had an 5 – 10 years of experience and 37 respondents had experience greater than 10 years.

4.3. Reliability Analysis

The table displays the Cronbach's Alpha values of variables utilized in this study, namely industrial IoT, automation, AI and performance. The minimum Cronbach's Alpha value observed is 0.66, which exceeds the accepted threshold of 0.6. This indicates that variables have passed the reliability test.

Table 5: Reliability Analysis

Variables	Cronbach Alpha	Items
Industrial IOT	0.665	5
Automation	0.709	5
Artificial Intelligence	0.660	5
Performance	0.730	5

4.5. Normality Analysis

The normality test is a statistical procedure that is conducted to control whether a sample or a group of data fits the normal distribution. It determines how well the set of data is modelled by normal distribution. Kurtosis and Skewness tests are applied to determine the normality of the study. Kurtosis is defined as a measure of normality that is used to indicate the peaks and tails of the distribution.

Table 6: Skewness and Kurtosis

	Skewness		Kurtosis	
	Statistic	Std Error	Statistic	Std Error
IIoT	.183	.133	-.241	.265
Automation	-.099	.133	-.234	.265
Artificial Intelligence	-.060	.133	.094	.265
Performance	-.241	.133	-.113	.265
Valid N (listwise)				

The value 3 in Kurtosis indicates a normal distribution and the range of Kurtosis lies between +3 and -3. The outcome of all 3 variables lie in range of +3 and -3 which indicates that data is normally distributed. Skewness defines the extent to which the data is non-symmetrical. The range of skewness is -1 to +1. The values below zero are negatively skewed while the values above zero are positively skewed. According to the table, all the values lie in range of skewness i.e., between -1 and +1, which shows normally distribution of vatiables.

4.7. Correlation Analysis

Correlation is the measures of relationship between dependent and independent variables, which represents level of their association. It can be positive or negative relationship. A positive correlation suggests that both variables move in the same direction, meaning an increase in one variable corresponds to an increase in the other. The correlation coefficient ranges from -1 to +1, where a positive sign signifies a direct relationship (positive correlation), while a negative sign indicates an inverse relationship (negative correlation). The most commonly used correlation coefficient is Pearson's r. The correlation is shown in table below.

Table 7: Correlation

Correlations					
		Industrial IoT	**Automation**	**AI**	**Performance**
Industrial IoT	Pearson Correlation	1	.492**	0551	.419**
	Sig. (2-tailed)	.001	.000	.001	.000
	N	346	346	346	346
Automation	Pearson Correlation	.492**	1	.434	.254**
	Sig. (2-tailed)	.000	.001	.001	.001
	N	346	346	346	346
Artificial Intelligence	Pearson Correlation	.551	.434	1	.514
	Sig. (2-tailed)	.001	.000	.000	.001
	N	346	346	346	346
Performance	Pearson Correlation	.419**	.254**	.514	1
	Sig. (2-tailed)	.000	.001	.001	.000
	N	346	346	346	346

* *. Correlation is significant at the 0.01 level (2- tailed).

4.7.1. Correlation Interpretation

- Industrial IoT and supply chain performance, relation is significant (0.01). The Pearson correlation coefficient of .419 which is a positive relationship. Which shows that there is a direct and positive connection between Industrial IoT, automation, AI and supply chain performance.

- The Automation and supply chain performance correlation is at significance level of 0.01. And Pearson correlation coefficient of .254, which shows a positive relationship between Automation and supply chain performance. And a direct and positive association between Automation and supply chain performance, suggesting that improvements in Automation can contribute to enhanced performance in the supply chain.

- AI and supply chain performance Correlation is also significant at level of 0.01. With a Pearson correlation coefficient of .514, that tell a positive relationship between Artificial

Intelligence and supply chain performance. This suggests that there is a strong and positive association between Artificial Intelligence and supply chain performance, indicating that improvements in Artificial Intelligence can contribute to enhanced performance in the supply chain.

4.4. Regression Analysis

The existence of relationship is determined by correlation analysis while the nature of relationship can only be investigated through regression analysis. The table given below is generally used for providing an overview of the regression model.

4.4.1 Model Summary Results

Table 8: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.655[b]	.429	.424	.52888
b. Predictors: (Constant), Industrial IoT, Artificial Intelligence, Automation				

In this case, coefficient of determination (R-squared) is 0.429, indicating that approximately 42.9% of the variation in industry performance. Moreover, the adjusted R-squared value is 0.424, indicating that approximately 42.4% of the variation in industry performance is accounted for by the independent variables, after adjusting for the number of predictors in the model. Both values demonstrate that independent variables and supply chain performance have significant relationship.

4.4.2. Regression Interpretation

The model summary explains about different factors of regression analysis. The R is 0.429, which shows that supply chain performance has positive relationship with Industrial IoT, Automation and Artificial Intelligence. Value of coefficient of determination R squared is 0.429. Multiplying 0.429 with 100 gives us the percentage of 42.9%. It means that 42.9% variance in supply chain performance is explained by Industrial IoT, Automation and Artificial Intelligence. Approximately 57.1% of the variance in supply chain performance may be attributed to external variables not considered in the study, which have the potential to positively or negatively influence the performance. These external variables encompass factors beyond the scope of the independent variables examined in the study, such as Industrial IoT, Automation, and Artificial Intelligence.

4.4.2 ANOVA test Results

The ANOVA examination reveals that model is statistically significant, indicated by a p-value less than 0.05. However, it is worth noting that the model exhibits a relatively low correlation and adjusted R value. In order for the regression model to be considered significant, the F-value should exceed 4 ($F > 4$) and the p-value should be below 0.05 ($p < 0.05$). In this case, the F-value is 83.493, surpassing the threshold of 4, and the p-value is below 0.05, indicating that the overall regression model is indeed significant.

Table 9: ANOVA Test Results

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	70.063	3	23.354	83.493	.000[c]
	Residual	93.145	343	.2871		
	Total	163.208	346			
a. Dependent Variable: Performance						
b. Predictors: (Constant), Industrial IoT, Artificial Intelligence, Automation,						

4.4.3 Coefficient Test Results

Based on the findings from Table 9, it can be inferred that the three independent variables, namely Industrial IoT, Automation, and Artificial Intelligence, have a direct and significant bearing on the dependent variable. The p-values of independent variables are below 0.05, representing their significance. Additionally, the VIF (Variance Inflation Factor) values are below 10, further supporting the significance of all independent variables. The drived equation derived from the above collected information is presented in Table 9.

All the t-values exceed 2 ($t > 2$) and the p-values are below 0.05 ($p < 0.05$), indicating a significant relationship between the dependent and independent variables. The Beta values, specifically 0.212 for Industrial IoT, 0.278 for Artificial Intelligence, and 0.301 for Automation, demonstrate positive and statistically significant associations with procurement performance. This means that a one-unit increase in Industrial IoT will result in a 0.212-unit increase in supply chain performance. Similarly, a one-unit change in Artificial Intelligence will lead to a 0.278-unit change in supply chain performance, and a one-unit change in Automation will result in a 0.301-unit change in procurement performance (Tauni et al. 2017).

Supply chain Performance = 0.784 + 0.212 (IOT) + 0.278 (AI) + 0.301 (Automation)

Table 10 - Coefficient test results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.784	.189		4.138	.000
	Industrial IoT	.212	.071	.191	2.983	.003
	Artificial Intelligence	.278	.069	.265	4.027	.000
	Automation	.301	.062	.282	4.837	.000
a. Dependent Variable: Performance						

4.5 Discussion

This research investigated the impact of three key components of Industry 4.0, which are Industrial IoT (IIoT), automation and AI on the supply chain performance of the Pakistan's pharmaceutical industries.

The findings of this research study show that Industrial IoT, Artificial Intelligence, and Automation have a substantial bearing on the supply chain performance of the pharmaceutical industry. Specifically, Industrial IoT shows a positive and significant effect on industry performance.(Witkowski et al., 2017).

The outcomes of study specify that Artificial Intelligence and Automation have a positive and significant impact on the supply chain performance of the Pharmaceutical Industry of Pakistan. The t-values for Artificial Intelligence and Automation are 4.027 and 4.837, respectively, with corresponding B-values of 0.278 and 0.301. These findings are consistent with previous studies conducted in this field (Bauer et al., 2018).

Therefore, the study suggests that above mentioned components of the Industry 4.0 exert a significant influence on performance of the Pharmaceutical industry in Pakistan.

4.6 Hypothesis assessment summary

Table 11, displays the outcomes of hypothesis testing. This table indicates whether the hypotheses of the study were accepted or rejected.

Table 11 Hypotheses assessments summary

	Hypotheses	**t- Value**	**P-Value**	**Empirical Conclusion**
H_1	IIoT have a significant relationship with supply chain performance	2.983	0.003	H_1 Accepted
H_2	Automation has a significant relationship with supply chain performance	4.837	0.000	H_2 Accepted
H_3	Artificial Intelligence have significant relationship with supply chain performance	4.027	0.000	H_3 Accepted

Chapter 5 : Conclusion and Recommendations

5.1 Conclusion

Research study aim to identify the impact of Industrial IoT, Automation and Artificial Intelligence on supply chain performance of Pharmaceutical industry in Pakistan. Data collection for this study primarily through the questionnaires directed to supply chain professionals in the pharmaceutical industry of Pakistan. The performance of the industry was assessed using three dimensions: Industrial Internet of Things, Automation, and Artificial Intelligence. Based on our research findings significant bearing of Industrial IoT, Automation, and AI on supply chain performance of the pharmaceutical industry in Pakistan was concluded. Therefore, it can be inferred from the results of the study that implementation of Industrial IoT, Automation, and Artificial Intelligence in the supply chain positively affects the supply chain performance of Pakistan's pharmaceutical industry.

5.2 Limitations and Future Implementations

Research included the Pharmaceutical industries of twin cities (Islamabad and Rawalpindi) in Pakistan due to time limitation for MBA (2 Year) student, so the research cannot be widespread to all the Pharmaceutical Industry of Pakistan; In future research to include all Pharmaceutical Industries in Pakistan.

Data is collected utilizing quantitative data collection methodology, which is later statistical analysis to obtain desire objectives. Cross sectional data collection was adopted, data was collected from limited respondent sample size. Targeted audience were accessed and questionnaire were been forwarded by online e-forms.; Future research can focus on Longitudinal and Qualitative research study.

Research is limited to Pharmaceutical Industry (manufacturing industry) only, in future other Services industry be included in the research.

In future researcher can verify the impact of other independent variables from Industry 4.0 (Block Chain, Robotics, Cyber Physical System, Cloud Computing, Smart Manufacturing System Integration and Big Data Analysis) on the supply chain performance of Pharmaceutical Industry.

5.3 Practical Implications

The data of this research study give us an insight influence of Industrial IoT, Automation, and Artificial Intelligence on the supply chain performance of the pharmaceutical industry in Pakistan. The objective to enhance the supply chain efficiency, production and operation management within the industry, ultimately improving its overall profitability. Additionally, the study encourages other business sectors to adopt Industrial IoT, Automation, and Artificial Intelligence tools to enhance their own performance and productivity.

The study emphasizes the perception of digital transformation in emerging economies, shedding light on its significance. It provides valuable insights for institutions, associations, governments, and other sectors when developing future policies to enhance IT infrastructure in the supply chain. Additionally, the study's findings can benefit industry management by serving as secondary data, enabling them to respond effectively to the digital transformation in Pakistan's supply chain

Chapter 6 : References

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Appendices

A-Questionnaire

Impact of Industrial IoT, Automation and Artificial Intelligence on supply chain performance. A case of pharmaceutical Industry in Pakistan

Research Questionnaire

This questionnaire has been designed for the sole purpose of collecting data regarding 'The impact of Industrial IoT, Automation and Artificial Intelligence on Supply chain Performance of pharmaceutical Industry of Pakistan. The data collected will be treated with high degree confidentiality and it is meant for academic purpose only. You are kindly asked to fill out this questionnaire by circling appropriate answers.

Regards,

Ammar Asghar

Section A : General Information

Name: __

Gender:

- Male
- Female

Age:

- Less than 30 years
- 30 to 45 years
- More than 45 years

Designation:

- Senior Manager
- Middle Level Manager
- Support Staff
- Others

Section B : Industrial IoT, Automation and Artificial Intelligence

Industrial IoT	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Reference
Does Industrial IoT tools help to decrease network security risks and identifies vulnerabilities.	1	2	3	4	5	Anwar, Zainal, Abdullah, Iqbal, 2020
Does Industrial IoT tools help in effective integration and synchronization of data and manufacturing.	1	2	3	4	5	
Do you think Industrial IoT applications, tools and technological products still not mature.	1	2	3	4	5	
Does obtaining the needed supporting staff with right skills and knowledge is challenging.	1	2	3	4	5	
Do you think significant financial investments is required to design and deploy Industrial IoT technologies.	1	2	3	4	5	
Automation						
Does automation improve supply chain flexibility (react to product changes, volume, and mix).	1	2	3	4	5	Mettler, Pinto, Raber, 2012
Does automation enhance ability to respond to and accommodate demand variation.	1	2	3	4	5	
Does automation increases ability to respond to and accommodate the periods of poor delivery performance	1	2	3	4	5	

Does automation reduces total cost of manufacturing, including labor, maintenance and re-work cost	1	2	3	4	5	
Does automation improve supply chain delivery reliability	1	2	3	4	5	
Artificial Intelligence (AI)						
Does AI improve perfect order fulfilment and inventory management (deliveries with no errors).	1	2	3	4	5	Daneshvar, Hajiagha, Tupėnaitė, Khoshkheslat, 2020
Does AI improve manufacturing and lead time	1	2	3	4	5	
Does AI improve monitoring and maintaining the product quality control.	1	2	3	4	5	
Does AI improve workers safety performing hazardous task and	1	2	3	4	5	
Does AI contribute in continuous improvement in supply chain design.	1	2	3	4	5	

Section C : Supply Chain Performance

Supply Chain Performance	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Reference
Does your organization consider supply chain flexibility important for increasing supply chain performance.	1	2	3	4	5	Fantazy, Mukerji, Kumar, 2012
Do you organization gives importance to cost efficiency to increase supply chain performance.	1	2	3	4	5	
Do you think, in a company without efficient and flexible supply chain, it would be difficult to come up with efficient supply chain performance	1	2	3	4	5	
Does Flexible supply chain process increase customers satisfaction.	1	2	3	4	5	
Do you think importance of Cost efficient and flexible supply chain process can not be deny for effective supply chain performance	1	2	3	4	5	

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B-Output Files

B-I) Frequency Tables

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	239	69.1	69.1	68.8
	Female	107	30.9	30.9	100.0
	Total	346	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 30 Years	270	78.2	78.2	78.2
	30 to 45 years	58	16.5	16.5	94.7
	More than 45 years	18	5.3	5.3	100.0
	Total	346	100.0	100.0	

Designation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Senior Manager	26	7.6	7.6	7.6
	Middle Level Manager	136	39.4	39.4	47.1
	Support Staff	11	2.9	2.9	50.0
	Other	173	50.0	50.0	100.0
	Total	346	100.0	100.0	

Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5 Years	248	71.8	71.8	71.8
	5 to 10 Years	61	17.6	17.6	89.4
	More than 10 Years	37	10.6	10.6	100.0
	Total	346	100.0	100.0	

Q.1. Does Industrial IoT tools help to decrease network security risks and identifies vulnerabilities.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	15	4.1	4.1	4.1
	Agree	276	80.0	80.0	84.1
	Strongly Agree	55	15.9	15.9	100.0
	Total	346	100.0	100.0	

Q.2. Does Industrial IoT tools help in effective integration and synchronization of data and manufacturing.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	6	1.8	1.8	1.8
	Neutral	33	9.4	9.4	11.2
	Agree	185	53.5	53.5	64.7
	Strongly Agree	122	35.3	35.3	100.0
	Total	346	100.0	100.0	

Q.3. Do you think Industrial IoT applications, tools and technological products still not mature.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	6	1.8	1.8	1.8
	Neutral	25	7.1	7.1	8.8
	Agree	199	57.6	57.6	66.5
	Strongly Agree	116	33.5	33.5	100.0
	Total	346	100.0	100.0	

Q.4. Does obtaining the needed supporting staff with right skills and knowledge is challenging.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	4	1.2	1.2	1.2
	Neutral	26	7.6	7.6	8.8
	Agree	198	57.1	57.1	65.9
	Strongly Agree	118	34.1	34.1	100.0
	Total	346	100.0	100.0	

Q.5. Do you think, significant financial investments is required to design and deploy Industrial IoT technologies.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	12	3.5	3.5	3.5
	Agree	157	45.3	45.3	48.8
	Strongly Agree	177	51.2	51.2	100.0
	Total	346	100.0	100.0	

Q.6. Does automation improve supply chain flexibility (react to product changes, volume, and mix).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	8	2.4	2.4	2.4
	Agree	234	67.6	67.6	70.0
	Strongly Agree	104	30.0	30.0	100.0
	Total	346	100.0	100.0	

Q.7. Does automation enhance ability to respond to and accommodate demand variation.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	4	1.2	1.2	1.2
	Neutral	4	1.2	1.2	2.4
	Agree	210	60.6	60.6	62.9
	Strongly Agree	128	37.1	37.1	100.0
	Total	346	100.0	100.0	

Q.8. Does automation increases ability to respond to and accommodate the periods of poor delivery performance.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	2	.6	.6	.6
	Agree	248	71.8	71.8	72.4
	Strongly Agree	96	27.6	27.6	100.0
	Total	346	100.0	100.0	

Q.9. Does automation reduces total cost of manufacturing, including labor, maintenance and re-work cost.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	26	7.6	7.6	7.6
	Agree	173	50.0	50.0	57.6
	Strongly Agree	147	42.4	42.4	100.0
	Total	346	100.0	100.0	

Q.10. Does automation improve supply chain delivery reliability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	28	8.2	8.2	8.2
	Disagree	181	52.4	52.4	60.6
	Neutral	19	5.3	5.3	65.9
	Agree	59	17.1	17.1	82.9
	Strongly Agree	59	17.1	17.1	100.0
	Total	346	100.0	100.0	

Q.11. Does AI improve perfect order fulfilment and inventory management (deliveries with no errors).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	33	9.4	9.4	9.4
	Agree	254	73.5	73.5	82.9
	Strongly Agree	59	17.1	17.1	100.0
	Total	346	100.0	100.0	

Q.12. Does AI improve manufacturing and lead time.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	20	5.9	5.9	5.9
	Neutral	14	4.1	4.1	10.0
	Agree	240	69.4	69.4	79.4
	Strongly Agree	72	20.6	20.6	100.0
	Total	346	100.0	100.0	

Q.13. Does AI improve monitoring and maintaining the product quality control.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	18	5.3	5.3	5.3
	Agree	240	69.4	69.4	74.7
	Strongly Agree	88	25.3	25.3	100.0
	Total	346	100.0	100.0	

Q.14. Does AI improve workers safety performing hazardous task and Ergonomics.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	14	4.1	4.1	4.1
	Neutral	16	4.7	4.7	8.8
	Agree	251	72.4	72.4	81.2
	Strongly Agree	65	18.8	18.8	100.0
	Total	346	100.0	100.0	

Q.15. Does AI contribute in continuously improves supply chain design.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	59	17.1	17.1	17.1
	Agree	185	53.5	53.5	70.6
	Strongly Agree	102	29.4	29.4	100.0
	Total	346	100.0	100.0	

Q.16. Does your organization considers supply chain flexibility important for increasing supply chain performance.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	17	4.7	4.7	4.7
	Agree	256	74.1	74.1	78.8
	Strongly Agree	73	21.2	21.2	100.0
	Total	346	100.0	100.0	

Q.17. Do you organization gives importance to cost efficiency to increase supply chain performance.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	14	4.1	4.1	4.1
	Neutral	51	14.7	14.7	18.8
	Agree	208	60.0	60.0	78.8
	Strongly Agree	73	21.2	21.2	100.0
	Total	346	100.0	100.0	

Q.18. Do you think, in a company without efficient and flexible supply chain, it would be difficult to come up with efficient supply chain performance.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	51	14.7	14.7	14.7
	Agree	183	52.9	52.9	67.6
	Strongly Agree	112	32.4	32.4	100.0
	Total	346	100.0	100.0	

Q.19. Does Flexible supply chain process increase customers satisfaction.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	51	14.7	14.7	14.7
	Agree	183	52.9	52.9	67.6
	Strongly Agree	112	32.4	32.4	100.0
	Total	346	100.0	100.0	

Q.20. Do you think importance of Cost efficient and flexible supply chain process can not be deny for effective supply chain performance.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	51	14.7	14.7	14.7
	Agree	183	52.9	52.9	67.6
	Strongly Agree	112	32.4	32.4	100.0
	Total	346	100.0	100.0	

B-II) Reliability Analysis

Industrial IoT

Reliability Statistics

Cronbach's Alpha	N of Items
.665	5

Automation

Reliability Statistics

Cronbach's Alpha	N of Items
.709	5

Artificial Intelligence

Reliability Statistics

Cronbach's Alpha	N of Items
.660	5

Supply Chain Performance

Reliability Statistics

Cronbach's Alpha	N of Items
.730	5

B-III) Normality Analysis

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Gender	346	1	2	1.31	.465	.820	.133
Age	346	1	3	1.27	.552	1.947	.133
Designation	346	1	4	2.95	1.098	-.259	.133
Experience	346	1	3	1.39	.672	1.480	.133
Industrial IoT	346	2.50	5.00	4.1985	.40876	-.183	.133
Automation	346	3.75	5.00	4.3397	.27676	.099	.133
Artificial Intelligence	346	3.56	5.00	4.2833	.43443	-.060	.133
Performance	346	3.00	4.80	4.0000	.39148	.268	.133
Valid N (listwise)	346						

	Kurtosis	
	Statistic	Std. Error
Gender	-1.344	.256
Age	2.820	.256
Designation	-1.591	.256
Experience	.802	.256
Industrial IoT	-.241	.256
Automation	-.234	.256
Artificial Intelligence	.094	
Performance	-.113	.256
Valid N (listwise)		

B-IV) Correlation

Correlations

		Industrial IoT	Automation	AI	Performance
Industrial IoT	Pearson Correlation	1	.492**	0551	.419**
	Sig. (2-tailed)	.001	.000	.001	.000
	N	346	346	346	346
Automation	Pearson Correlation	.492**	1	.434	.254**
	Sig. (2-tailed)	.000	.001	.001	.001
	N	346	346	346	346
Artificial Intelligence	Pearson Correlation	.551	.434	1	.514
	Sig. (2-tailed)	.001	.000	.000	.001
	N	346	346	346	346
Performance	Pearson Correlation	.419**	.254**	.514	1
	Sig. (2-tailed)	.000	.001	.001	.000
	N	346	346	346	346

B-V) Regression

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	Industrial IoT, Automation, Artificial Intelligence	.	Enter

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	Industrial IoT, Automation, Artificial Intelligence	.	Enter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.655b	.439	.424	.52888

a. Predictors: (Constant), Industrial IoT, Automation, Artificial Intelligence

B-VI) ANOVA Table

ANOVAa

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	70.063	2	23.354	83.493	.000[c]
	Residual	93.145	343	.271		
	Total	163.208	346			

a. Dependent Variable: Supply chain Performance

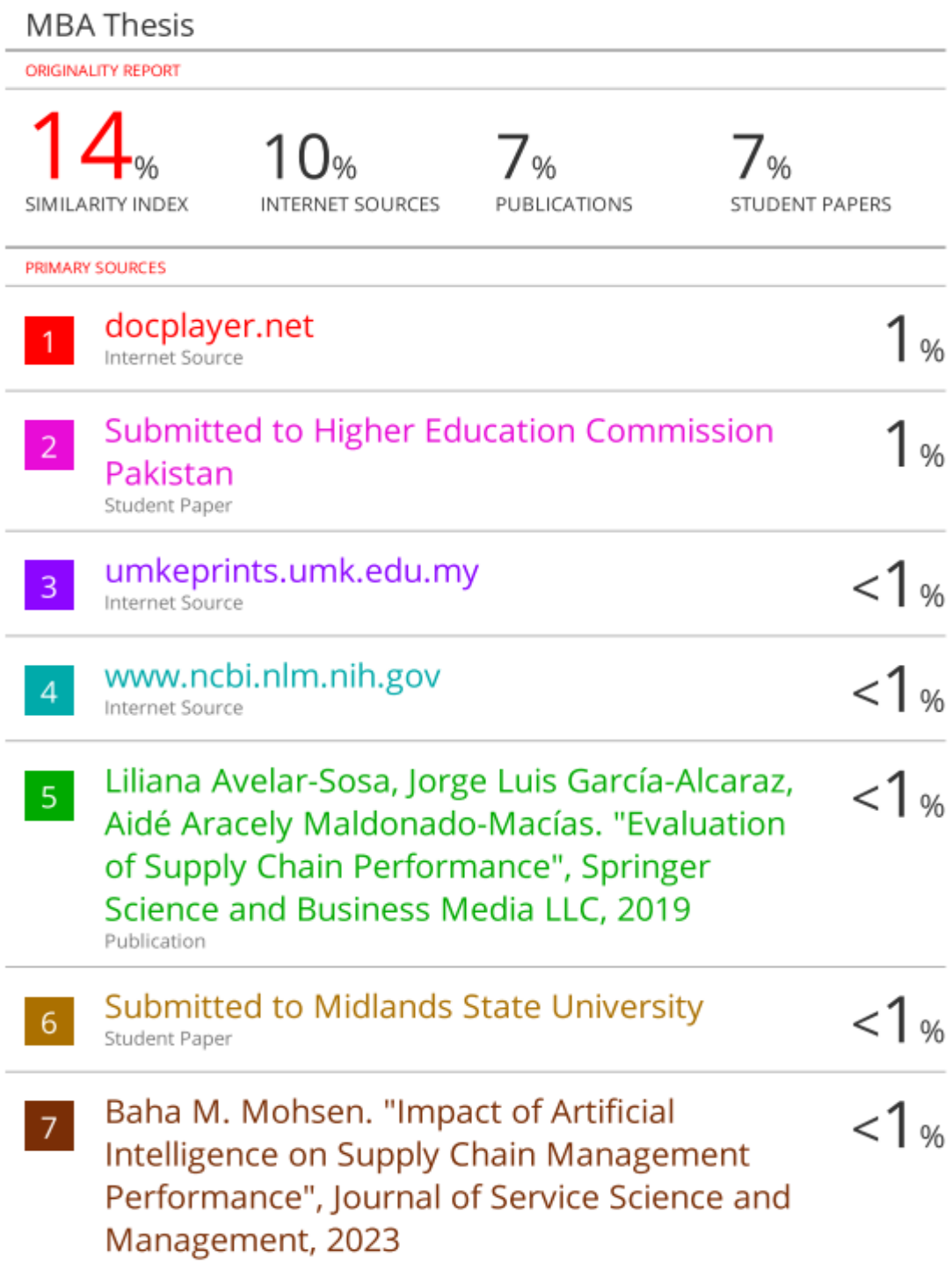
b. Predictors: (Constant), Industrial IoT, Automation, Artificial Intelligence

B-VII) Co-efficient

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.784	.189	.023	4.138	.000
	Industrial IoT	.212	.071	.191	2.983	.003
	Automation	.278	.069	.265	4.027	.000
	Artificial Intelligence	.301	.062	.282	4.837	.000

C-Plagiarism Report



MBA Thesis

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D- 1st Half Report

Bahria University
Islamabad Campus

MBA/BBA

1st Half Semester Progress Report

Enrollment No.	01-322212-002
Thesis/Project Title	Impact of Industrial IoT, Automation and Artificial Intelligence on Supply Chain Performance: A Case of Pharmaceutical Industry in Pakistan

Supervisor Student Meeting Record

No.	Date	Place of Meeting	Topic Discussed	Signature of Student
1	11/3/2023	Bahria University	Selection of Topic	
2	15/3/2023	Bahria University	Conceptual Framework	
3	02/4/2023	Zoom Meeting	Literature review	
4	19/4/2023	Bahria University	Methodology	

Progress Satisfactory ☑ Progress Unsatisfactory ☐

Remarks: _____

_____

_____

Signature of Supervisor: _____ Date: 14-6-2023

E- 2nd Half Report

Bahria University
Islamabad Campus

MBA/BBA

2nd Half Semester Progress Report & Thesis Approval Statement

Enrollment No.	01-322212-002
Thesis/Project Title	Impact of Industrial IoT, Automation and Artificial Intelligence on Supply Chain Performance: A Case of Pharmaceutical Industry in Pakistan

Supervisor Student Meeting Record

No.	Date	Place of Meeting	Topic Discussed	Signature of Student
5	29/4/2023	Zoom Meeting	SPSS	
6	03/5/2023	Bahria University	Data Analysis	
7	17/5/2023	Zoom Meeting	Final review of thesis	

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 testof this thesis using HEC prescribed software and found similarity index at 14% that is within the permissible limit set by the HEC for thesis/ project MBA/BBA. I have also found thethesis/project in a format recognized by the department of Business Studies.

Signature of Supervisor:_____ Date: 14-6-2023