

YEDITEPE UNIVERSITY
INSTITUTE OF SOCIAL SCIENCES

**THE IMPACT OF IOT ON SUPPLY CHAIN INTEGRATIONS & AGILITY ON
SUPPLY CHAIN PERFORMANCE IN THE RETAIL SECTOR IN TÜRKİYE**

Anas Abdelhadi

Istanbul - 2024

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CHAIN PERFORMANCE IN THE RETAIL SECTOR IN TÜRKİYE

By

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DECLARATION OF ORIGINALITY

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ABSTRACT

In the highly competitive retail sector, supply chain efficiency is paramount for ensuring timely delivery, cost-effectiveness, and customer satisfaction. Efficient supply chains can significantly enhance a company's ability to respond to market demands and maintain a competitive edge. However, the supply chain systems in Türkiye's retail industry face significant challenges, including inefficiencies, lack of real-time data visibility, and difficulties in adapting to market changes. These issues hinder the overall performance and sustainability of the supply chains, leading to increased operational costs and reduced customer satisfaction. **Specifically, there is a pressing need for a more efficient design of the logistic network, necessitating the study of specific variables to enhance logistics operations. The aim of this study** is to identify the interrelationship between the Internet of Things (IoT), Supply Chain Agility (SCA), and Supply Chain Integration (SCI) and their overall effect on Supply Chain Performance (SCP) within the retail sector's supply chain. The IoT possesses significant potential to transform supply chain operations by augmenting decision-making capabilities, promoting enhanced transparency, and enabling better coordination among the various stakeholders within the supply chain. This transformative capability arises from its provision of real-time connectivity and data. The efficacy of supply chain management is dependent upon its ability to promptly adapt to changes in the market landscape. Moreover, the integration of the supply chain encompasses a wide range of activities and the collaborative relationships among partners. To fulfill the purpose of the study, **a quantitative analysis using structural equation modelling (SEM) was conducted using Amous software.** Basic Condition Modeling (SEM) constitutes a vigorous measurable strategy that encourages the concurrent examination of complex interrelationships among different factors. This technique gives a comprehensive system for assessing the impact of the appropriation of Web of Things (IoT) advances on Supply Chain Integration (SCI) and dexterity, whereas explaining how these components in this way affect generally supply chain execution. **The results obtained from the analysis significantly prove the positive impact of IoT, SCA, and SCI on SCP.** The findings elucidate that the implementation of Internet of Things (IoT) technology enhances connectivity and facilitates instantaneous data

accessibility, which subsequently promotes advanced integration and agility within the supply chain. Such advancements render the supply chain more resilient and cohesive, thereby enabling it to respond promptly to fluctuations in the market, ultimately resulting in improved efficiency. By integrating IoT, Supply Chain Analytics (SCA), Supply Chain Integration (SCI), and Supply Chain Planning (SCP), this research contributes to the existing body of knowledge and provides insightful information regarding the pivotal role of IoT in developing responsive, effective, and sustainable supply chains within Turkey's retail sector. **The contribution of this study** to the existing body of literature is substantial, this research addresses a significant deficiency in the existing literature, as, despite numerous investigations into supply chain management and the Internet of Things across various contexts, there is a lack of comprehensive studies examining the impact of IoT on supply chain performance specifically within Turkey. By explaining this difference, the investigate offers basic viewpoints for both professionals and policymakers inside the retail division. Partners have the opportunity to expand supply chain deftness and integration by recognizing the imperative commitment of IoT advances in improving by and large supply chain adequacy. The investigate emphasizes the significance of grasping modern advances such as the Web of Things to address existing wasteful aspects and challenges predominant within the supply chain. It highlights the basic of a comprehensive supply chain administration technique that leverages IoT to cultivate made strides integration, straightforwardness, and responsiveness. Subsequently, retail undertakings may accomplish predominant supply chain viability, which comes full circle in increased client fulfillment, diminished operational consumptions, and a more invaluable position inside the commercial center.

Keywords: Company Performance, IoT, Supply Chain Integration, Supply Chain Agility, Structural Equation Modeling

ÖZET

Son derece rekabetçi perakende sektöründe, tedarik zinciri verimliliği zamanında teslimat, maliyet etkinliği ve müşteri memnuniyeti için büyük önem taşımaktadır. Verimli tedarik zincirleri, bir şirketin piyasa taleplerine yanıt verme ve rekabet avantajını sürdürme yeteneğini önemli ölçüde artırabilir. Ancak, Türkiye'nin perakende endüstrisindeki tedarik zinciri sistemleri, çeşitli verimsizlikler, gerçek zamanlı veri görünürlüğünün eksikliği ve piyasa değişikliklerine uyum sağlama zorlukları gibi önemli sorunlarla karşı karşıyadır. Bu sorunlar, tedarik zincirlerinin genel performansını ve sürdürülebilirliğini olumsuz etkileyerek operasyonel maliyetlerin artmasına ve müşteri memnuniyetinin azalmasına yol açmaktadır.

Özellikle, lojistik ağının daha verimli bir şekilde tasarlanması için acil bir ihtiyaç bulunmaktadır, bu da lojistik operasyonlarını geliştirmek için belirli değişkenlerin incelenmesini gerektirmektedir. Çalışma, bu zorlukları ele almayı amaçlamakta ve Nesnelerin İnterneti (IoT), Tedarik Zinciri Çevikliği (SCA) ve Tedarik Zinciri Entegrasyonu (SCI) arasındaki karşılıklı ilişkiyi ve bunların perakende sektörünün tedarik zincirindeki Tedarik Zinciri Performansı (SCP) üzerindeki genel etkisini araştırmayı hedeflemektedir. Gerçek zamanlı veri ve bağlantı sağlama yeteneği ile IoT, görünürlüğü artırarak, karar vermeyi iyileştirerek ve farklı tedarik zinciri birimleri arasında daha iyi koordinasyon sağlayarak tedarik zinciri operasyonlarını dönüştürme potansiyeline sahiptir. Tedarik Zinciri Çevikliği, tedarik zincirinin piyasa ortamındaki değişikliklere hızla yanıt verme yeteneğini ifade ederken, Tedarik Zinciri Entegrasyonu, çeşitli tedarik zinciri süreçlerinin ve ortaklarının sorunsuz koordinasyonunu ve iş birliğini içerir. **Araştırma hedefine ulaşmak için, Amous yazılımı kullanılarak yapısal eşitlik modellemesi (SEM) ile nicel bir analiz yapılmıştır.** SEM, aynı anda birden fazla değişken arasındaki karmaşık ilişkilerin incelenmesine olanak tanıyan güçlü bir istatistiksel tekniktir. Bu metodoloji, IoT uygulamasının SCI ve çeviklik üzerindeki etkisini ve dolayısıyla bu faktörlerin genel tedarik zinciri performansını nasıl etkilediğini kapsamlı bir şekilde analiz etmeyi sağlar. **Analizden elde edilen sonuçlar, IoT, SCA ve SCI'nin SCP üzerindeki olumlu etkisini önemli ölçüde kanıtlamaktadır.** Özellikle bulgular, IoT uygulamasının gerçek zamanlı veri görünürlüğünü ve bağlantıyı artırdığını, bunun da tedarik zinciri entegrasyonunu ve çevikliğini iyileştirdiğini

göstermektedir. Artan entegrasyon ve çeviklik, tedarik zincirinin piyasa değişikliklerine daha duyarlı ve uyumlu olmasını sağlayarak genel performansı iyileştirir. Çalışma, IoT, SCA, SCI ve SCP'yi birleştirerek literatüre katkıda bulunmakta ve Türkiye'nin perakende sektöründe sürdürülebilir, verimli ve duyarlı tedarik zincirleri oluşturmanın stratejik önemi hakkında değerli içgörüler sağlamaktadır. **Bu çalışmanın mevcut literatüre katkısı önemli olup,** önemli bir araştırma boşluğunu doldurmaktadır. Tedarik zinciri yönetimi ve IoT konularında çeşitli bağlamlarda birçok çalışma yapılmış olsa da, Türkiye'nin perakende sektöründe IoT'nin tedarik zinciri performansı üzerindeki etkisine odaklanan kapsamlı çalışmalar eksiktir. Bu çalışma, bu boşluğu doldurmakla kalmayıp, aynı zamanda perakende endüstrisindeki uygulayıcılar ve politika yapıcılar için pratik sonuçlar da sunmaktadır. IoT'nin tedarik zinciri performansını artırmadaki kritik rolünü anlayarak, paydaşlar IoT teknolojilerine ve stratejilerine yatırım yapma konusunda bilinçli kararlar alabilirler. Genel olarak, bu araştırma, tedarik zincirindeki mevcut verimsizlikleri ve zorlukları aşmak için IoT gibi ileri teknolojilerin benimsenmesinin önemini vurgulamaktadır. IoT'yi kullanarak daha fazla görünürlük, çeviklik ve entegrasyon sağlamak için stratejik bir tedarik zinciri yönetimi yaklaşımının gerekliliğini vurgulamaktadır. Sonuç olarak, perakende şirketleri tedarik zinciri performansını iyileştirerek daha yüksek müşteri memnuniyeti, azaltılmış operasyonel maliyetler ve piyasada daha güçlü bir rekabetçi konum elde edebilirler.

****Anahtar Kelimeler: Şirket Performansı, IoT, Tedarik Zinciri Entegrasyonu, Tedarik Zinciri Çevikliği, Yapısal Eşitlik Modellemesi**

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List of Abbreviations

- (IoT) Internet of Things
- (SCI) Supply Chain Integration
- (SCA) Supply Chain Agility
- (ICT) Information and Communication Technologies
- (SCs) Supply Chains
- (CFA) Confirmatory factor analysis
- (CFI) comparative fit index
- (GFI) The goodness of the fit index
- (RMSEA) Root mean square error of approximation

The Impact of IoT on Supply Chain Integrations & Agility on Supply Chain Performance in the Retail Sector in Türkiye

Introduction

This section delineates the structure of the thesis by articulating essential research inquiries and establishing the study's objectives. The paper investigates the benefits of combining supply chain efficiency (SCA) and supply chain integration (SCI) within the Turkish retail industry, leveraging the capabilities of the Internet of Things (IoT), a technology that is evolving swiftly. It is shown how crucial SCI and SCA are to raising supply chain effectiveness. Moreover, despite the extensive literature produced by Data and Communication Innovations (ICT) in the realm of SCI, this chapter underscores the deficiency of empirical research regarding the precise impact of the IoT as a contemporary enabler for Supply Chain Innovation and SCA.

This section details the methodology employed to assess the impact of the IoT on SCI and SCA, aiming to enhance overall supply chain performance from the perspective of retailers who prioritize agility. It contends that this study holds significance and relevance due to the existing gap in the literature concerning this specific area.

1.1. Definition of the Problem

The rapid growth of the IoT has brought about a significant change in the supply chain management sector. Despite its potential, the true impact of IoT on supply chain integrity and flexibility is unknown. Existing literature provides a fragmented view, with many studies focusing on specific aspects of IoT or using conceptual models that lack empirical validation. Moreover, there is a lack of industry-specific insights and detailed case studies demonstrating successful IoT implementations. This creates a research gap in understanding the holistic effects of IoT on supply chain management and identifying best practices for its adoption and integration across different sectors.

1.2. Definitions of Variables

1.2.1. IoT

The IoT encompasses a system of interconnected devices that engage in communication and data exchange with one another as well as with cloud-based platforms. These devices, which include a variety of sensors, software, and advanced technologies, can be mechanical or digital in nature, extending to commonplace items found in daily life (Yasar & Gillis, 2024).

The need to make machines more effective, efficient and smart through the so-called IoT which based on a new era and is the age of Industry 4.0, or the fourth Industrial Revolution.

Industry 4.0 is a paradigm-shifting idea that aims to combine information technology and production in a way that maximizes performance through automation and information technology integration. It is defined by the application of key ideas like big data analytics, cloud computing, artificial intelligence (AI), cyber-physical systems, the IoT, and additive manufacturing are increasingly being adopted across various industries. (Bilgin, 2021; Jayashree & Reza, 2021; Kunkel, Matthess, & Xue, 2022).

The IoT signifies a transformative phase marked by the incorporation of advanced ICT devices within a digital framework, facilitating the smooth orchestration of logistics and supply chain activities (De Vass, Shee, Miah, 2018). In contrast to conventional ICT systems, the IoT encompasses an extensive array of interconnected network nodes.

1.2.2. SCA

Supply chain nimbleness is conceptualized as the capacity of a supply chain to quickly and successfully react to variances in supply, request, and showcase conditions. This concept includes the versatility and reactivity of the supply chain in adjusting its operations, forms, and assets to fulfill client prerequisites and alter to advertise variances (Khan & Wisner, 2019). Prater et al. (2001) emphasizes the basic noteworthiness of dexterity inside the modern

commerce scene, wherein factors such as advancing client inclinations, showcase unsettling influences, and worldwide marvels can significantly impact supply chain viability.

1.2.3. SCI

Supply chain integration includes managing tactical, strategic, and operational processes cooperatively between and within companies. Its goal is to guarantee smooth and effective flows of goods, data, and money, eventually providing the end user with the most value at the lowest possible cost and fastest possible pace. Numerous studies concur with this definition. (Alfalla-Luque et al., 2013; Huo, 2012; De Vass, Shee, & Miah, 2018).

1.2.4. SCP

The performance of the supply chain pertains to the capability of the comprehensive supply chain to fulfill the demands of end customers. This encompasses ensuring the availability of products, adhering to delivery schedules, and sustaining the necessary inventory and capacity to swiftly attain these objectives(Hausman, 2004).

This study aims to define the traits of the supply chain within the Turkish retail sector, which is completely influenced by the Internet and the IoT. By using statistical modeling based on secondary data, information gathered from a survey of 315 experts, including managers and employees, was examined to evaluate how IoT affects supply chain operations from two main perspectives SCI and structure. The findings reveal that IoT has both positive and negative effects on SCP, enhancing SCI and flexibility.

The results highlight the importance of IoT in creating a state-of-the-art supply chain system that includes powerful predictive analytics, real-time data access and process automation. These capabilities are expected to promote flexible and responsive supply chains, reduce inefficiencies and improve resource efficiency. The research highlights how crucial IoT is in developing supply chains that are not just effective and strong but also in harmony with environmental care and social ethical values, backing the necessity for further

studies to more accurately grasp the intricate impacts of IoT on the sustainability of supply chain operations.

1.3.The Gaps and Motivation

1.3.1. The Gaps

- Industry-Specific Insights

Gap: There is a lack of research focusing on the unique challenges and opportunities of IoT implementation in specific industries such as retail, manufacturing, and healthcare.

- IoT

Gap: While there is some research on IoT's impact on supply chain performance, the synergistic effects of implementing IoT in SCI and SCA are underexplored.

- Empirical Validation of Conceptual Models

Gap: Many existing studies propose conceptual models for IoT in supply chains without empirical testing.

1.3.2. Motivation

The motivation for this study was the emerging need and the sudden demand for IoT technologies, especially after the Covid-19 pandemic and how the early adopters became the leaders in their field, on the other hand, those who failed to keep up because they couldn't or didn't adopt early, they suffered the most, particularly in the retail sector and in the Supply Chain Business. Self-observations and negotiations among retailers also motivated the author of this thesis.

1.3.3. Contributions

This research enhances our comprehension of the utilization of IoT technologies, the interconnectivity of supply chains, the rapidity of corporate adaptability, and the performance metrics of enterprises operating within the Turkish retail industry, substantiated by robust evidence. This research contributes to the current understanding of IoT implementation,

supply chain integration, flexibility, and organizational success in Turkey's retail industry by presenting substantial empirical evidence that supports the theoretical connections between IoT adoption, supply chain dynamics, and organizational outcomes. It fills a gap in existing knowledge by providing a more comprehensive insight into how IoT technology impacts supply chain efficiency in retail. While some studies have previously examined the relationships between certain variables, this study uniquely measures all these factors together, significantly enhancing our understanding of this topic.

1.4. Research Questions and Hypotheses

- **This study is driven by the following research questions:**

1. How does IoT implementation affect Supply Chain Integration (SCI) in Turkey's retail sector?
2. What is the impact of IoT on Supply Chain Agility (SCA)?
3. How do SCI and SCA collectively influence overall Supply Chain Performance (SCP)?

- **Hypotheses:**

- **H0a:** IoT implementation has no significant effect on Supply Chain Agility in the retail sector of Turkey.
- **H1a:** IoT implementation positively affects Supply Chain Agility, in the retail sector of Turkey.
- **H0b:** IoT implementation has no significant effect on Supply Chain Integration in the retail sector of Turkey.
- **H1b:** IoT implementation positively affects Supply Chain Integration in the retail sector of Turkey
- **H0c:** IoT implementation has no significant effect on Supply Chain Performance in the retail sector of Turkey.

- **H1c:** IoT implementation positively affects Supply Chain Performance in the retail sector of Turkey
- **H0d:** IoT implementation in Supply Chain Integration and Agility has no significant effect on improving Supply Chain Performance in the retail sector of Turkey.
- **H1d:** IoT implementation positively affects Supply Chain Integration, leading to improved Supply Chain Performance in the retail sector of Turkey
- **H0e:** IoT implementation in Supply Chain Agility has no significant effect on improving Supply Chain Performance in the retail sector of Turkey.
- **H1e:** IoT implementation positively affects Supply Chain Agility, leading to improved Supply Chain Performance in the retail sector of Turkey.

1.5. Research Objectives

The primary objectives of this research are:

1. To analyze the current state of IoT implementation in Turkey's retail supply chains.
2. To gain insight into how IoT, supply chain agility, and integration relate to one another.
3. To evaluate the impact of IoT-driven SCI and SCA on overall Supply Chain Performance.
4. To provide strategic insights for enhancing supply chain efficiency and sustainability through IoT.

1.6. Research Steps

- **Literature Review:** Conduct a comprehensive review of existing literature on IoT, SCI, SCA, and SCP.
- **Data Collection:** Gather quantitative data from professionals in Turkey's retail sector through surveys and interviews.

- **Data Analysis:** Use Structural Equation Modeling (SEM) to analyze the relationships between IoT, SCI, SCA, and SCP.
- **Results Interpretation:** Interpret the results to understand the impact of IoT on SCI and SCA and their collective effect on SCP.
- **Recommendations:** Develop strategic recommendations for retail businesses in Turkey to leverage IoT for improved supply chain performance.
- **Conclusion:** Summarize the findings, discuss their implications, and suggest areas for future research.

This study aims to expand our understanding of how IoT can improve supply chain efficiency and effectiveness by addressing these issues. It will also provide insightful information about the strategic importance of IoT in building resilient, effective, and responsive supply chains for Turkey's retail industry.

1.7. Surveys Information

To validate the research findings, detailed surveys were conducted, including survey design, distribution process, sample size, and specific questions and scales used to gather data.

- **Survey Design**

The study was fastidiously made to accumulate experimental information with respect to the seen impact of the Web of Things (IoT) on the execution, integration, and nimbleness of supply chain operations. The questions were categorized into sections based on key constructs such as operational efficiency, customer satisfaction, and real-time data utilization.

- **Distribution Process**

The survey was distributed to 500 randomly selected managers and employees within the retail sector in Turkey. It was conducted through both online platforms and physical distribution to ensure a comprehensive response rate.

- **Sample Size**

To establish a random sample representative of the retail industry, a total of 315 responses were collected from an initial target of 500. This sample size was chosen based on the total population and anticipated response rate to ensure statistical significance.

- **Questions and Scales**

The survey included 42 Likert-scale questions (ranging from 1 to 5) to measure respondents' agreement with statements related to IoT impact. Examples of survey questions include:

- "IoT improves real-time visibility of supply chain operations."
- "The use of IoT has reduced our operational costs."
- "IoT has enhanced our ability to respond to market changes swiftly."
- "IoT improves real-time visibility of supply chain operations."

Literature Review

1.8. Internet of Things (IoT) in Supply Chain

The Internet of Things (IoT) has a major impact on supply chain management (SCM) due to its many disruptions. For physical objects to communicate and exchange information with other systems in the organization, the Internet of Things requires their integration with sensors, computers, and other technologies. This network increases the possibility of perception, verification, and computerization in real time in real-time, which adapts to execution, dexterity, and integration. This written survey is included in the multifaceted part of SCM by analyzing the advantages, problems, applications, and future titles of the title.

1.8.1. IoT and SCP

A-Benefits of IoT in Supply Chains

IoT enhances supply chain operations by offering real-time data and insights that save expenses, boost productivity, and facilitate improved decision-making. DeVas et al. (2018)

contend that it is simpler to connect various supply chain components because IoT offers real-time visibility and communication capabilities. This integration allows for more efficient inventory management, precise demand forecasting, and overall coordination across the supply chain. Shafique et al. (2018) further emphasize that IoT adoption can significantly reduce operational costs and improve supply chain reliability and responsiveness by enabling automated tracking and monitoring of goods.

A significant advantage of the IoT in SCM lies in its ability to enhance visibility throughout the supply chain. By enabling the tracking of products from the point of production to the final delivery, IoT fosters greater transparency, which in turn allows organizations to address problems more swiftly. This functionality is crucial for sustaining elevated service standards and fulfilling customer expectations. Sensors integrated with IoT technology can monitor environmental parameters such as temperature and humidity, which are critical for the proper storage and transportation of sensitive goods like medicines and perishable foods (Sabre, 2005). Furthermore, IoT facilitates predictive maintenance strategies, enhancing asset utilization and reducing downtime. By continuously assessing the condition of machines and vehicles, organizations can foresee potential issues and perform maintenance before breakdowns happen. This proactive approach minimizes disruptions and extends the operational lifespan of assets, leading to significant financial savings.

Additionally, IoT facilitates better resource allocation by providing insights into the utilization rates of machinery and labour, optimizing production schedules, and reducing waste. The incorporation of IoT technology into supply chain management (SCM) markedly enhances both the precision and effectiveness of inventory management practices. Automated systems facilitate real-time monitoring of inventory levels, thereby reducing the likelihood of stockouts and excess inventory. This level of accuracy allows organizations to sustain leaner inventory levels, which in turn lowers carrying costs and permits the reallocation of financial resources to alternative investments. Besides, the capacity to follow items all through the supply chain altogether makes strides in traceability and responsibility, a figure that's especially crucial in segments such as nourishment and pharmaceuticals, where adherence to administrative measures and security contemplations is basic (Kunrath, 2023).

B- Challenges of IoT Implementation

Despite its numerous benefits, According to Lee et al. (2022), implementing IoT in supply chains presents several challenges. In light of the considerable vulnerability posed by the vast quantities of data generated by IoT devices to cyber threats, the two most critical factors are cybersecurity and data protection. The safeguarding of data transmission and storage necessitates robust access control measures and encryption protocols. Additionally, companies must comply with various data protection regulations, which can vary significantly across regions. The complexity of managing these requirements could prevent businesses from utilizing IoT to its fullest extent. Integrating IoT technologies into existing systems poses considerable financial and logistical challenges. Many current systems are not compatible with modern IoT solutions, necessitating costly upgrades or replacements. Furthermore, the initial implementation of IoT devices involves substantial expenses related to sensors, connectivity infrastructure, and data management systems. This financial burden can be particularly overwhelming for small and medium-sized businesses (SMBs), potentially restricting their ability to adopt IoT innovations. This financial barrier underscores the need for scalable and affordable IoT solutions tailored to the needs of smaller businesses.(Barco & Khatib, 2021)

The absence of established protocols and compatibility between IoT devices made by various manufacturers presents another difficulty. This disarray may make it more difficult for suppliers to communicate and share data efficiently. Developing industry-wide standards and promoting collaboration among stakeholders are essential to overcoming this barrier. Without such standards, companies may face difficulties in integrating IoT technologies into their operations, leading to inefficiencies and increased costs.(Albouq et al., 2022; Wernerfelt, 1984) Moreover, The vast amount of data generated by Internet of Things devices presents significant difficulties for data analysis and management. Businesses need advanced analytics and big data expertise to extract valuable insights from this data.

This requirement necessitates investments in sophisticated data processing tools and the hiring of skilled data scientists, adding to the overall cost of IoT implementation. Furthermore, the swift evolution of technology compels organizations to consistently refresh

their systems to maintain a competitive edge, thereby intensifying the financial strain they face.

1.8.2. IoT and SCI

A- Enhancing Supply Chain Integration

A critical factor in improving supply chain integration is the ability of various stakeholders to coordinate and communicate effectively, a capability greatly facilitated by the IoT. According to de Vass et. al (2018) and (Muafi & Sulistio, 2022), The IoT facilitates the consolidation of organizational resources onto a single platform, allowing for the efficient monitoring of processes and activities while enabling real-time information sharing. This functionality is especially beneficial for the integration of retailers, manufacturers, logistics providers, and suppliers, which in turn improves supply chain operations. To ensure a smooth flow of goods, data, and profits, effective SCI requires the strategic, tactical, and operational management of business processes. IoT facilitates this integration by providing real-time data on inventory levels, production status, and shipment locations. Supply chain participants are better able to coordinate their efforts, work together more successfully, and react swiftly to shifts in supply or demand. IoT's increased visibility improves coordination and lowers the possibility of stockouts or surplus inventories.

Furthermore, IoT enhances the ability to manage complex supply chain networks by offering tools for tracking and analyzing data across multiple tiers of suppliers and partners. This multi-tier visibility is essential for identifying potential risks and disruptions, enabling proactive mitigation strategies. For instance, if a supplier experiences delays, IoT can alert downstream partners to adjust their schedules accordingly. This level of integration fosters a more resilient and responsive supply chain (Abdel-Basset et al., 2018). The Web of Things encourages the improvement of advanced twins, which serve as virtual representations of substantial resources, forms, and frameworks. Through the creation of advanced twins for differing components of the supply chain, organizations have the opportunity to mimic different scenarios, pinpoint potential bottlenecks, and optimize operational effectiveness. This advanced modelling capability greatly improves decision-making and strategic

planning, allowing businesses to adapt more effectively to changing market conditions (Manavalan & Jayakrishna, 2019).

B- Impact on Internal and External Integration

There exist two distinct categories of supply chain integration: internal and external integration. The orchestration of commercial operations is referred to as internal integration, while collaboration with external partners, including suppliers and customers, is identified as external integration. Yu (2013) and Zhao et al. (2011) argue that internal integration is essential for breaking down cross-functional barriers and achieving superior performance through real-time information sharing and strategic collaboration.

Internal integration focuses on creating a seamless flow of information and materials across different departments within an organization. IoT enables real-time data sharing among departments such as procurement, production, and sales, facilitating better coordination and decision-making. For example, production schedules can be adjusted based on real-time demand signals from the sales department, reducing lead times and minimizing inventory costs. (Tavana et al., 2020), Further enhances internal collaboration by providing a unified platform for data management and analysis.

On the other hand, external integration promotes collaboration with clients and vendors, team planning, and the sharing of strategic data. IoT technologies enable real-time tracking and monitoring of shipments, allowing companies to share accurate delivery information with their customers. This transparency improves trust and collaboration, leading to better demand forecasting and inventory management. Huo (2012) emphasizes that external integration is crucial for managing synchronized processes and achieving maximum value for the end customer.

By integrating IoT with Customer Relationship Management (CRM) systems, companies can gain deeper insights into customer behaviour and preferences, enabling more personalized and responsive service. For example, IoT data can inform dynamic pricing strategies and tailored promotions, enhancing customer satisfaction and loyalty. Additionally, the integration of IoT with supplier management systems facilitates better collaboration and

performance monitoring, ensuring that suppliers meet quality and delivery standards. (Abu Ghazaleh & Zabadi, 2020),

The integration of IoT in SCM also bolsters the improvement of Collaborative Arranging, Determining, and Recharging (CPFR) activities. One of these ventures includes working in conjunction with supply chain accomplices to make strides in fulfilment, stock control, and request estimating forms. IoT increases the effectiveness of CPFR programs and reduces the risk of supply chain disruptions by providing real-time data required for quick and accurate decision-making.

1.8.3. IoT and SCA

A- Supply Chain Agility

Supply chain versatility is characterized by the supply chain's ability to respond quickly and productively to changes in sales conditions, availability of supplies, and customer demand. The concept incorporates flexibility and responsiveness in changing supply chain operations, configurations, and resources to meet customer needs and adapt to market changes (Khan & Wisner, 2019). Prater et al. (2001) emphasize the essential importance of agility in today's business landscape, where shifting customer preferences, market disturbances, and international occurrences can significantly impact supply chain functions.

Processes and resources may be swiftly set up to adapt to unforeseen developments. This capability is essential for maintaining competitiveness in markets characterized by high variability and uncertainty. Supply chain agility involves several dimensions, including responsiveness, flexibility, and innovation. While responsiveness refers to the supply chain's ability to swiftly identify and respond to changes, flexibility is the capacity to alter operations to meet changing demands. Innovation is related to workflow enhancement through the use of new technologies and methods and ongoing improvement.

B- Role of IoT in Enhancing Agility

The appropriation of IoT innovation can essentially move forward supply chain deftness by giving real-time permeability, experiences, and mechanization capabilities. Real-time information permeability permits organizations to track the status and area of items all through the supply chain, permitting them to reply rapidly to disturbances or variances in requests (James, J. A. 2023). Predictive analytics and process automation further enhance agility by enabling proactive decision-making and reducing the time required to adjust to new conditions (Jiga, 2023).

IoT-enabled sensors, for instance, are capable of monitoring variations in environmental factors that could affect product quality, including temperature changes during transit. The provision of real-time alerts allows organizations to implement corrective measures, such as altering shipment routes or modifying storage environments, thus averting spoilage or damage. This real-time responsiveness is crucial for maintaining high service levels and customer satisfaction (Sehrawat & Gill, 2019).

Predictive analytics helps businesses predict changes in demand and improve inventory levels by using data from the Internet of Things. Businesses may enhance their production and logistics plans and gain a better understanding of demand by examining historical sales data, market trends, and external variables. This proactive approach increases supply chain effectiveness while reducing excess and inventory.

Moreover, the IoT supports the implementation of Just-In-Time (JIT) inventory systems by delivering real-time data on inventory levels and usage rates. This capability allows organizations to align their production schedules with actual market demand, reducing the need for large inventory reserves and lowering holding costs. The flexibility provided by IoT-integrated JIT systems is particularly beneficial in industries with substantial demand fluctuations or short product life cycles (Qu et al., 2015).

IoT also supports the development of adaptive supply chain strategies. These strategies involve the continuous monitoring of market conditions and the dynamic adjustment of supply chain operations to meet changing requirements. Businesses may utilize IoT data, for

instance, to spot emerging trends and modify their distribution, manufacturing, and sales plans. This adaptive approach enhances the overall agility of the supply chain, enabling companies to capitalize on new opportunities and mitigate risks. (Ashton, 2009)

1.8.4. Empirical Evidence on IoT in Supply Chain Management

A- Case Studies and Empirical Research

Numerous studies have looked empirically at how the IoT affects the agility, integration, and performance of supply chains.

The research conducted by de Vass et al. (2018) examined the influence of the IoT on the integration and performance of supply chains, focusing on organizational capabilities. The findings revealed that the implementation of IoT significantly bolsters organizational capabilities, subsequently leading to enhanced integration and performance outcomes. The authors emphasized the necessity for organizations to develop the essential capabilities required to leverage IoT technologies effectively. This development entails investing in workforce training, modernizing IT infrastructure, and promoting an innovative organizational culture.

Lee et al. (2022) conducted an observational ponder on the effect of IoT appropriation on supply chain execution in Malaysia. Adoption of IoT enhances supply chain responsiveness, efficiency, and visibility, according to the report. However, the researchers also pointed out that problems like data security, complicated integration, and the high cost of IoT devices must be resolved for IoT to be used successfully. The study highlighted the need for a strategic approach to IoT adoption, involving careful planning, stakeholder engagement, and continuous monitoring.

B-. Mediating Role of Integration and Agility

It is commonly understood that combining and being flexible in supply chains helps connect the IoT and SCP. For example, de Vass and others. In 2018, it was found that strong connections in the supply chain help improve how the IoT affects how well the supply chain works. The authors emphasized how important it is to have good integration skills to take

full advantage of the benefits of the IoT. This means creating a strong IT system, setting up clear ways to communicate, and encouraging teamwork among everyone involved in the supply chain.

In a similar vein, Wamba (2022) emphasized that the agility of supply chains serves as a mediator in the connection between the adoption of IoT technologies and organizational performance. This suggests that organizations possessing agile supply chains are more adept at leveraging the advantages offered by IoT. The study points out that real-time data and predictive analytics, enabled by IoT, significantly improve supply chain agility, thereby enabling firms to react more swiftly and efficiently to fluctuations in the business landscape. These results underscore the essential importance of agility as a strategic asset in the context of the digital age.

In another study, Lee and others. In 2022, a study looked at how bringing together different parts of the supply chain affects the connection between IoT technologies and how well the supply chain performs. The results showed that using IoT solutions in supply chain operations helps improve how well companies see what's happening, work together, and respond to changes. This leads to better overall performance. The authors suggested that companies should work closely with their suppliers and customers, spend money on better tools for analyzing data, and keep improving how they work together.

These empirical studies offer insightful information on how IoT impacts supply chain efficiency. They highlight the importance of developing complementary capabilities, such as integration and agility, to fully leverage the potential of IoT. Moreover, these studies underscore the need for a strategic approach to IoT adoption, involving careful planning, continuous monitoring, and a focus on building strong relationships with supply chain partners.

1.8.5. Future Directions and Research Opportunities

A- Emerging Trends and Technologies

The application of artificial intelligence (AI), blockchain, and advanced data analysis to supply chain management is promising for the Internet of IoT. By enabling automation, providing sophisticated predictions, and assisting in decision-making, AI can augment the capabilities of IoT. This increases supply chain management's usage of IoT. AI systems, for instance, can identify patterns in data from networked devices and predict future events. This facilitates improved supply chain activity management. (Wamba, 2022).

Blockchain technology provides a secure and shared method to keep track of transactions and monitor assets throughout the supply chain. Blockchain helps supply chain partners trust each other more, easily track products, and be more open by creating a permanent record of transactions that can't be changed. Blockchain helps keep data safe and real when used with the IoT. This lowers the chance of cheating and makes the supply chain more secure. The combination of IoT and blockchain can provide end-to-end visibility and accountability, from raw materials to finished products (Min, 2019).

Advanced analytics, fueled by Internet of Things data, allow businesses to learn more about their supply chain processes. Optimizing inventory levels, enhancing decision-making, and improving demand forecasts are all possible with the use of predictive and prescriptive analytics. Future research should explore the integration of these technologies with IoT to further enhance supply chain performance and resilience. The potential of combining IoT with machine learning and big data analytics presents new opportunities for innovation and efficiency gains(Fathy, 2018).

Furthermore, the possibilities of IoT in SCM may be improved by the advancement of edge computing technologies. By processing data closer to the point of generation, edge computing lowers latency and enhances real-time decision-making. By integrating edge computing with IoT, companies can enhance their ability to respond to dynamic changes in the supply chain, improve operational efficiency, and reduce the burden on centralized data centres.

B- Addressing Implementation Challenges

Addressing the challenges of IoT implementation, such as data security, interoperability, and cost, is crucial for broader adoption. Creating standardized frameworks and protocols for the safe and smooth integration of IoT devices into current supply chain systems should be the main goal of research. Cooperation between industrial participants, technology suppliers included, standard-setting organizations, and regulatory bodies, is essential to develop and implement these standards. Establishing best practices and guidelines can help organizations navigate the complexities of IoT adoption. (Abdelhadi & Akkartal, 2019)

Cost-effective solutions and best practices for IoT adoption in SMEs should be explored to democratize the benefits of IoT across different business sizes. Government incentives and support programs can play a crucial role in facilitating IoT adoption among SMEs. Additionally, case studies and pilot projects can demonstrate the value of IoT and provide practical insights into overcoming implementation challenges. Developing scalable IoT solutions that can be customized to the needs of smaller businesses is essential for widespread adoption. (Hajibashi, 2018)

Training and education are key to using IoT effectively. Companies need to invest in training programs to help employees learn how to use IoT technology properly. Educational institutions can play a role by incorporating IoT and related technologies into their curricula, preparing the future workforce for the digital economy. Collaboration between academia and industry can foster innovation and ensure that training programs are aligned with the needs of the market (Madni et al., 2022).

Another area for future research is the development of sustainable IoT solutions. The proliferation of IoT devices raises concerns about energy consumption and electronic waste. Research should focus on developing energy-efficient IoT technologies and sustainable practices for managing the lifecycle of IoT devices. This includes designing devices with longer lifespans, promoting recycling and reuse, and developing eco-friendly materials (Gray, 2018).

1.8.6. IoT Applications in Supply Chain Management

- **Real-time Tracking and Monitoring:** IoT enables the instantaneous monitoring of products and assets throughout the supply chain. This functionality improves transparency, mitigates the likelihood of theft or loss, and guarantees prompt delivery (Kamble et al., 2020).
- **- Predictive Maintenance:** IoT sensors can forecast when machines might fail and when they need fixing, which helps reduce downtime and makes operations run better (Srinivasan & Swink, 2018).
- **Inventory Management:** IoT enhances inventory management by providing accurate, real-time data on stock levels, reducing overstocking and stockouts (Khan & Turowski, 2016).

1.8.7. Summary

Studies on supply chain management emphasize how IoT can improve productivity, connectivity, and flexibility in a variety of ways. The Internet of Things (IoT) offers a lot of advantages, but to really take off, issues with data security, interoperability, and cost need to be resolved.

Future research should focus on emerging technologies, standardized frameworks, and cost-effective solutions to drive broader adoption and innovation in IoT-enabled supply chains. The continued evolution of IoT and its integration with other advanced technologies will likely lead to new opportunities and challenges, shaping the future of supply chain management.

1.9. Supply Chain Integration (SCI)

SCI is now important for making supply chains work better and for getting ahead of competitors. Manufacturers, distributors, suppliers, and customers are some of the many people and businesses that need to work together smoothly for SCI to happen. The purpose of this review is to look closely at supply chain integration, studying its benefits, drawbacks, and the factors that help make it successful. It synthesizes findings from recent research, with

a particular focus on the role of contemporary technologies, such as the IoT, in facilitating effective supply chain integration(Alfalla-Luque et al., 2013)

Supply chain integration involves the coordination and synchronization of operations, processes, and information exchange among all the entities involved in the supply chain. According to Flynn, Huo, and Zhao (2010), SCI is characterized by the extent to which a company can strategically interact with its supply chain partners and jointly manage intra- and inter-organizational processes. The purpose of this coordination is to facilitate efficient and effective flows of products, services, information, financial resources, and decision-making processes.

1.9.1. Dimensions of Supply Chain Integration

A- Internal Integration

Internal integration involves the alignment and coordination of activities within a firm. According to Zhao et al. (2011), internal integration focuses on breaking down silos and fostering cross-functional collaboration to ensure that all departments within an organization are working towards common goals. This includes the integration of processes such as procurement, production, and logistics.

Internal integration ensures that various functions within a firm, such as sales, operations, and logistics, work in harmony. This is essential for improving efficiency and responsiveness. According to Frohlich and Westbrook (2001), internal integration enhances visibility within the organization, allowing for better decision-making and quicker responses to market changes.

For example, the integration of ERP systems can streamline internal processes by providing a unified platform for managing inventory, orders, and production schedules. This visibility helps in identifying potential bottlenecks and enables more efficient resource allocation. Moreover, internal integration supports better alignment between demand forecasting and production planning, reducing the risk of overproduction or stockouts.

B- External Integration

On the other hand, external integration means working together and coordinating with other people, like customers and suppliers. According to Flynn and others. In 2010, being responsive and efficient in the supply chain requires working together with others outside the company. Supplier and customer integration are two more types of external integration.

- Supplier Integration

Strategic cooperation with suppliers is required for supplier integration to enhance the information and material flow. According to Vachon and Klassen (2006), supplier integration enhances the ability to manage supply chain risks and improve product quality by fostering closer relationships and information sharing with suppliers. Supply chains must be informed of demand projections, manufacturing plans, and inventory levels in order for supplier integration to be effective. Through this partnership, suppliers are better able to comprehend the demands of the business and modify their operations appropriately, improving dependability and cutting lead times.

For instance, JIT manufacturing relies heavily on supplier integration. According to Audino, (2024), By maintaining close communication with suppliers and coordinating deliveries based on production schedules, companies can reduce inventory holding costs and improve production efficiency. Additionally, collaborative planning and forecasting with suppliers can lead to better demand alignment and reduced stockouts(Audino, 2024).

- Customer Integration

Customer integration focuses on aligning the supply chain operations with customer needs and preferences. This involves close collaboration with customers to understand their requirements and ensure timely delivery of products and services. According to Frohlich and Westbrook (2001), customer integration is essential for enhancing customer satisfaction and loyalty. Customer integration includes activities such as Collaborative Planning, Forecasting, and Replenishment (CPFR). By working closely with customers, companies can better predict demand, reduce stockouts, and improve service levels, ultimately leading to increased customer satisfaction.

For example, in the retail sector, customer integration allows companies to tailor their product offerings and inventory levels based on real-time sales data and customer feedback. This responsiveness to customer needs enhances the shopping experience and fosters loyalty. Furthermore, customer integration enables companies to develop personalized marketing strategies, such as targeted promotions and loyalty programs, based on customer preferences and purchasing behaviour (Javaid 2024).

1.9.2. Enablers of Supply Chain Integration

A- Information Technology

IoT plays a vital role in the integration of supply chains. By enabling real-time data exchange and communication among various supply chain stakeholders, IoT systems significantly improve coordination and decision-making processes. According to Rai, Patnayakuni, and Seth (2006), the integration of information technology, particularly IoT, enhances the visibility of supply chain activities and facilitates the uninterrupted flow of information.

Advanced IoT solutions like ERP systems, SCM software, and cloud computing help companies connect their different processes both within the company and with others outside. As per Inc. In 2024, these technologies give real-time data and insights that help make better decisions and improve how the supply chain works.

For example, cloud-based SCM platforms allow companies to share data and collaborate with suppliers and customers in real time, improving transparency and coordination. According to Schwarz (2023), these platforms also support advanced analytics capabilities, enabling companies to analyze historical data and predict future trends, thereby enhancing supply chain planning and optimization.

B- Internet of Things (IoT)

The integration of IoT technologies is essential for enhancing supply chain operations by providing real-time information on the location, status, and transit of products. IoT-enabled devices and sensors offer exceptional visibility into supply chain activities, allowing for

proactive management of inventory levels, transportation logistics, and manufacturing processes. According to Ben-Daya, Hassini, and Bahrour (2019), the implementation of IoT facilitates immediate data sharing, thereby improving decision-making and operational effectiveness.

IoT applications in supply chains encompass real-time tracking of shipments, monitoring environmental conditions during transportation, and predictive maintenance of equipment. These capabilities allow supply chains to react more swiftly to disruptions and optimize operations for enhanced efficiency and effectiveness.

IoT sensors can monitor the temperature and humidity of perishable goods during transport to ensure they are stored at the right temperature. The sensors can send alerts if they notice something unusual, helping businesses troubleshoot issues and prevent spoilage. Similarly, IoT-based predictive maintenance can detect potential hardware issues before they occur, preventing long periods of inactivity and resulting in smoother operations.

C- Organizational Culture

An organizational culture that promotes integration is characterized by a focus on collaboration, transparency, and continuous improvement. Companies with integrated cultures encourage cross-functional teams, open communication, and a willingness to embrace change. According to Huo (2012), a culture of integration supports the implementation of integrated practices and the adoption of new technologies. Organizations with a culture of integration prioritize collaboration and information sharing across departments and with external partners. This culture fosters trust and transparency, which are essential for successful integration. Additionally, companies that embrace continuous improvement are more likely to adopt innovative technologies and practices that enhance integration.

For example, companies can encourage inclusion by forming teams with people from different departments to work on supply chain projects. These teams get workers from different departments to work together, helping them solve problems better. Also, companies

can set up training sessions and workshops to teach workers about the advantages of combining systems and how to use new technologies to make the supply chain work better (Oliveira et al., 2016),

D- Strategic Partnerships

Strategic partnerships and alliances with supply chain partners are essential for achieving integration. According to Lambert and Cooper (2000), strategic partnerships involve long-term relationships based on trust, mutual benefits, and shared goals. These partnerships facilitate better coordination, information sharing, and joint problem-solving.

Strategic partnerships involve close collaboration with key suppliers and customers to achieve common objectives. These partnerships are built on trust and mutual understanding, allowing for greater flexibility and responsiveness. By working together, companies and their partners can develop more efficient and resilient supply chains (Lönngren et al., 2010). For example, by collaborating with key suppliers, companies can work together on new products and ideas. These collaborations may result in the development of novel goods and technological advancements that improve supply chain efficiency. Additionally, companies can collaborate with customers to co-create solutions that address their specific needs and preferences, leading to improved customer satisfaction and loyalty.

1.9.3. Benefits of Supply Chain Integration

A- Improved Operational Efficiency

Supply chain integration improves operational efficiency by enhancing coordination and reducing redundancies. Integrated supply chains can streamline processes, reduce lead times, and minimize inventory costs. According to Flynn et al. (2010), internal and external integration collectively contribute to improved overall supply chain performance. Operational efficiency is achieved through the elimination of waste and the optimization of resources. Integrated supply chains can better align production schedules with demand forecasts, reducing excess inventory and minimizing stockouts. This efficiency leads to cost savings and improved profitability.

For example, integrated supply chains can optimize production schedules based on real-time demand data, reducing the need for safety stock and lowering inventory holding costs. Additionally, integrated supply chains can streamline transportation and logistics operations by coordinating shipments and deliveries, reducing transportation costs and improving delivery times (Management, 2022).

B- Enhanced Responsiveness

Integrated supply chains are more responsive to changes in demand and supply conditions. According to Frohlich and Westbrook (2001), integration enables supply chains to quickly adapt to market fluctuations, customer preferences, and unforeseen disruptions, ensuring continuity and reliability. Enhanced responsiveness is achieved through real-time visibility and collaboration. Integrated supply chains can quickly identify and address issues, such as production delays or changes in customer demand. This responsiveness improves service levels and customer satisfaction.

Integrated supply chains can leverage real-time information obtained from IoT sensors and various other sources to monitor the progress of shipments and production activities. In the event of a delay or disruption, organizations can swiftly enact remedial actions, such as altering shipment routes or modifying production timelines, to lessen the adverse effects on customers.

C- Better Risk Management

SCI enhances the ability to manage risks by improving visibility and collaboration among supply chain partners. According to Vachon and Klassen (2006), integrated supply chains can better anticipate and mitigate risks, reducing the impact of disruptions and ensuring a smoother flow of goods and information.

Risk management is enhanced through the sharing of information and the development of joint contingency plans. Integrated supply chains can more effectively identify potential risks and implement strategies to mitigate them. This proactive approach reduces the

likelihood and impact of disruptions. For example, integrated supply chains can develop joint risk management strategies with suppliers and customers, such as creating contingency plans for potential disruptions and conducting regular risk assessments. Additionally, integrated supply chains can leverage predictive analytics to identify potential risks and take preventive measures to mitigate them (Kauppi et al., 2016).

D- Increased Customer Satisfaction

Customer integration leads to higher levels of customer satisfaction by ensuring that supply chain operations are aligned with customer needs and preferences. According to Zhao et al. (2011), integrated supply chains can deliver products and services more reliably and efficiently, enhancing customer loyalty and competitive advantage.

Increased customer satisfaction is achieved through improved service levels and reliability. Integrated supply chains can better meet delivery commitments and respond to customer inquiries and issues more effectively. This reliability and responsiveness lead to higher customer satisfaction and loyalty.

For example, Real-time data and analytics may be used by integrated supply chains to forecast consumer demand and modify production and inventory levels appropriately. By doing this, items are guaranteed to be accessible when and where customers need them, reducing stockouts and backorders. Moreover, integrated supply chains improve visibility into order statuses and delivery timelines, which fosters better communication and transparency with customers.

1.9.4. Challenges to Achieving Supply Chain Integration

A- Data Security and Privacy

Data security and privacy are problems that come up because so much information is shared among people in a connected supply chain. Keeping important data safe and building trust with partners relies a lot on securing how data is sent and stored. Ben-Daya, Hassini, and Bahroun (2019) say that businesses need to have strong security steps to keep data safe.

To prevent unwanted access and breaches, data security measures include the use of encryption, access restrictions, and secure communication protocols. To protect people's personal information, businesses need to follow rules about data protection, like the General Data Protection Regulation (GDPR).

For example, Businesses may use encryption technology to safeguard data both in transit and storage. Companies can also set up access controls to limit authorized personnel's access to data. Frequent supply chain vulnerability evaluations and audits can also aid in locating and addressing such weaknesses.

B- Integration Complexity

Integrating diverse systems and processes across multiple organizations can be complex and costly. According to Lambert and Cooper (2000), the lack of standardization and interoperability among systems can hinder seamless integration. Companies must invest in compatible technologies and develop standardized protocols to facilitate integration.

Integration complexity involves addressing technical challenges, such as data synchronization and system compatibility. Companies must develop integration strategies that ensure seamless communication and data exchange between different systems. This may involve implementing middleware solutions or developing custom interfaces to facilitate integration.

For example, companies can invest in middleware solutions that enable data exchange between different systems and platforms. These solutions can help bridge the gap between legacy systems and modern technologies, ensuring seamless integration. Additionally, companies can develop standardized protocols and interfaces to facilitate communication and data exchange with external partners.

C- Organizational Resistance

Resistance to organizational change can significantly impede the implementation of integrated practices. According to Huo (2012), People who fear losing control or who are unaware of the advantages of unity frequently oppose change. The organization needs to

work on creating a culture that values cooperation and continuous development to lessen this resistance. The introduction of an effective change management strategy is essential for fighting tissue resistance and succeeding in integrating practice. This includes communicating the benefits of integration, providing training and support, and involving employees in the integration process. By addressing concerns and building buy-in, companies can overcome resistance and successfully implement integrated practices.

For example, companies can make plans to help manage change by holding workshops, training sessions, and outreach programs. These will teach employees about the benefits of integrating new systems and how it will improve their work. Additionally, companies can involve employees in the planning and implementation of integration initiatives, giving them a sense of ownership and involvement.

D- Cost and ROI

The adoption of integrated technologies and practices requires substantial initial investments, prompting organizations to carefully evaluate the return on investment (ROI) to justify these costs. According to Rai, Patnayakuni, and Seth (2006), financial considerations include the initial expenditure on IT infrastructure, ongoing maintenance and support costs, and the potential benefits from improved efficiency and cost savings.

Cost considerations include the initial investment in technology and infrastructure, as well as ongoing maintenance and support costs. Companies must conduct cost-benefit analyses to assess the financial viability of integration projects and develop strategies to maximize ROI.

For example, companies can develop detailed cost-benefit analyses that consider the potential savings from improved operational efficiency, reduced inventory holding costs, and enhanced customer satisfaction. These analyses can help companies justify their investment in integration technologies and practices. Additionally, companies can explore funding options, such as government grants and incentives, to offset the costs of integration initiatives.

1.9.5. Future Directions and Research Opportunities

A- Emerging Technologies

The use of emerging technologies such as blockchain, AI, and sophisticated data analysis is becoming more and more important in the process of connecting supply chains. Blockchain provides a clear and safe means for data to be shared throughout the supply chain, while artificial AI helps with automation and enhances prediction skills. According to Wamba (2022), the integration of these technologies with the IoT can significantly enhance the overall performance and interoperability of supply chains.

Because they provide new capabilities and solutions, emerging technologies have the potential to significantly improve supply chain integration. For example, Blockchain may increase supply chain transparency and traceability, while AI-powered chatbots can improve customer experience by responding to queries in real time. To find new ways to enhance supply chain integration, future research should examine how these technologies integrate with IoT.

For example, AI may be used to create predictive analytics models that optimize inventory levels and estimate demand, lowering the possibility of overproduction and stockouts. Supply chain participants' confidence and responsibility may be increased by using blockchain technology to construct transparent and safe ledgers that trace the flow of products and transactions.

B- Standardization and Interoperability

Developing standardized protocols and ensuring interoperability among systems from different manufacturers is essential for seamless integration. Industry-wide standards will facilitate communication and data exchange, enhancing the overall effectiveness of supply chain integration. According to Ben-Daya, Hassini, and Bahroun (2019), standardization will reduce integration complexity and promote the widespread adoption of integrated practices. Standardization involves developing common protocols and interfaces that ensure compatibility between different systems. This standardization will reduce integration

complexity and promote the widespread adoption of integrated practices. Additionally, industry-wide collaboration is needed to develop best practices and guidelines for IoT implementation.

For example, for IoT devices and systems, industry and standards organizations can work together to create common standards and protocols that can ensure interoperability and simplify data integration and exchange. Companies can also participate in working groups and industry forums to comply with new standards and best practices.

C- Sustainable Supply Chain Practices

Future research should investigate how supply chain integration can advance sustainable practices. Integrated supply chains have the potential to enhance resource utilization, minimize waste, and improve energy efficiency. Shafique et al. (2018) suggest that IoT can support sustainability efforts by offering real-time data on resource consumption and environmental impact.

Reducing the environmental impact of supply chain operations and enhancing social responsibility are two aspects of a sustainable supply chain strategy. IoT devices may help with sustainability programs by giving statistics on waste, pollution, and resource usage in real time. Using this information, methods for lessening environmental effects and enhancing sustainability may be created.

For example, companies can use IoT sensors to monitor energy consumption and identify opportunities for reducing energy usage. Additionally, companies can implement recycling and waste reduction programs, leveraging real-time data to track progress and measure impact. Future research should explore the potential of IoT and other emerging technologies to support sustainable supply chain practices and reduce environmental impact.

1.9.6. Summary

Integrated supply chains are essential for businesses looking to improve productivity, agility, and competitiveness. Supply chain integration is greatly improved by the integration of contemporary technology, especially the IoT, which offers automation, real-time visibility,

and predictive analytics. Although there are certain difficulties in integrating, such as organizational opposition, data security, and complexity of integration, the advantages of doing so much exceed these difficulties. Future research should focus on leveraging emerging technologies and developing standardized frameworks to further enhance supply chain integration and sustainability.

Future developments in supply chain management will probably come from the integration of supply chain integration with other cutting-edge technologies, which will continue to grow and present new opportunities as well as obstacles.

1.10. Supply Chain Agility (SCA)

Supply chain agility has become a vital skill for businesses functioning in the fast-paced, fiercely competitive business world of today. The capacity to react swiftly and efficiently to shifting market conditions, client needs, and unanticipated interruptions is referred to as supply chain agility. This study of the literature explores the idea of SCA, looking at its advantages, facilitators, and aspects. It also explores how current technologies, such as the Internet of Things, might improve agility. The review integrates insights from existing research, with a specific focus on the retail sector, to provide a comprehensive understanding of how agility can be achieved and sustained in supply chains.

Supply chain flexibility refers to its ability to adapt quickly to market changes, consumer preferences, and fluctuations in demand. Agility encompasses the promptness and adaptability with which a supply chain can modify its operations and processes to meet diverse and changing needs. This capability is essential for maintaining competitiveness in markets characterized by high variability and uncertainty.

Prater, Biehl, and Smith (2001) emphasized that agility involves not only responsiveness but also the ability to anticipate changes and proactively manage risks. This proactive approach includes developing strategies to mitigate the impact of disruptions and leveraging opportunities presented by changing market conditions. Agility in supply chains is thus a multifaceted concept that integrates responsiveness, flexibility, and innovation.

1.10.1. Dimensions of Supply Chain Agility

A- Responsiveness

Responsiveness refers to the speed with which a supply chain can detect and respond to changes in demand, supply, or market conditions. Christopher (2000) highlighted that responsiveness is crucial for minimizing lead times and meeting customer expectations. A key element of responsiveness is the ability to quickly react to emerging information, such as changes in customer orders or disruptions within the supply chain. A flexible supply chain can swiftly adjust its resources and processes to address unforeseen circumstances. For instance, if there is a disruption in the availability of raw materials, the supply chain may need to identify and engage alternative suppliers. The ability to implement these changes promptly mitigates the negative impacts of disruptions and ensures the uninterrupted delivery of goods and services to customers.

B- Flexibility

Flexibility in the supply chain involves the capacity to adapt operations and processes to meet diverse requirements. This includes the ability to switch suppliers, alter production schedules, and modify product designs in response to changing market conditions. Swafford, Ghosh, and Murthy (2008) identified flexibility as a critical component of agility, enabling supply chains to accommodate variability without significant disruptions.

Flexibility can be achieved through various strategies, such as maintaining buffer stock, using multi-skilled labour, and implementing modular production systems. These strategies allow supply chains to adjust quickly to changes in demand and supply conditions, ensuring continuity and efficiency. Additionally, flexible supply chains are better equipped to handle product customization and variations, which are increasingly important in meeting specific customer needs (Stevenson & Spring, 2009).

C- Innovation

Innovation is the process of continuously enhancing supply chain performance via the adoption of new technology and techniques. Cutting-edge supply chains use IoT and AI

among other cutting-edge technologies to increase visibility, forecasting, and decision-making. According to Gosling, Will, and Naim (2012), innovation drives agility by enabling supply chains to respond to changes more effectively and efficiently.

According to Hopkins, (2021), these technologies enable rapid prototyping and production, reducing lead times and allowing for quick adjustments to production schedules. Moreover, innovation fosters a culture of continuous improvement, encouraging supply chains to explore new methods and technologies to stay competitive.

1.10.2. Enablers of SCA

A- Information Technology

Information technology systems provide instantaneous data and analytical insights that enhance decision-making processes and increase transparency throughout the supply chain (Abdallah & Ayoub, 2020). The integration of IT systems, such as ERP and warehouse management systems (WMS), facilitates the seamless flow of information, enabling faster and more accurate responses to changes.

Being able to handle and study a lot of data quickly, using modern technology like cloud computing and big data analysis, is important for spotting trends, making predictions, and reaching good decisions. It helps supply chain partners work together by offering a way to share information and communicate (Dehgani & Jafari Navimipour, 2019).

B- IoT

IoT technology, which offers real-time data on the location, condition, and movement of commodities, significantly contributes to improving supply chain agility. Sensors and gadgets enabled by the Internet of Things provide unparalleled insight into supply chain activities, allowing for proactive management of inventory, transportation, and production processes. According to Patil & Suresh, (2019), IoT's impact on supply chain performance is mediated by its ability to improve integration and agility.

IoT applications in supply chains include real-time tracking of shipments, monitoring of environmental conditions during transportation, and predictive maintenance of equipment. The aforementioned capabilities allow supply chains to react more swiftly to disruptions while enhancing operational efficiency and effectiveness. For instance, IoT sensors can provide real-time monitoring of temperature and humidity, thereby guaranteeing that perishable items are stored and transported in ideal conditions (Aeknarajindawat, 2019).

C- Organizational Culture

An organizational culture that promotes agility is characterized by a focus on collaboration, innovation, and continuous improvement. Companies with agile cultures encourage cross-functional teams, open communication, and a willingness to embrace change. According to Dubey, Gunasekaran, and Childe (2018), A flexible culture helps teams use agile methods and adopt new technologies. Organizations that prioritize agility foster a collaborative environment where employees are empowered to make decisions and take initiative. This empowerment leads to faster problem-solving and more effective responses to changes. Additionally, an agile culture encourages experimentation and learning, allowing organizations to adapt and innovate continuously.

D- Supply Chain Integration

The smooth coordination and cooperation of various supply chain participants, such as suppliers, manufacturers, logistics companies, and customers, is known as supply chain integration. Integration enhances agility by ensuring that information flows freely across the supply chain, enabling synchronized responses to changes. According to Lee et al., (2022), supply chain integration significantly enhances the positive impact of IoT on supply chain performance.

While external integration entails working with outside partners, internal integration concentrates on streamlining organizational procedures. To achieve supply chain agility, both forms of integration are necessary. Integrated supply chains shorten lead times and raise service standards by reacting faster to shifts in supply and demand (Turkulainen et al., 2017).

Integration can be achieved through various mechanisms, such as joint planning and forecasting, shared technology platforms, and collaborative decision-making processes. These techniques improve overall performance by helping supply chain partners align their goals and tactics. Moreover, integration fosters trust and transparency, which are crucial for effective collaboration and coordination.

1.10.3. Benefits of Supply Chain Agility

A- Enhanced Customer Satisfaction

Agile Supply Chains can better meet customer expectations by delivering products more quickly and reliably. This responsiveness to customer needs enhances customer satisfaction and loyalty. According to Fulfilment (2023), companies with agile supply chains can provide superior service levels, leading to higher customer retention rates.

Customer satisfaction is a key driver of business success, and agile supply chains contribute to this by ensuring timely and accurate delivery of products. Additionally, agility allows supply chains to offer personalized and customized products, meeting specific customer preferences and increasing satisfaction. By maintaining high service levels, agile supply chains can build strong customer relationships and enhance brand reputation.

B- Improved Operational Efficiency

Supply Chain Agility improves operational efficiency by enabling faster decision-making and reducing lead times. Agile supply chains can quickly adjust production schedules, optimize inventory levels, and streamline transportation processes. This efficiency reduces costs and enhances overall supply chain performance.

Operational efficiency is achieved through the elimination of waste and the optimization of resources. Agile supply chains minimize excess inventory, reduce idle time, and enhance the utilization of assets and labour. This effectiveness boosts the supply chain's overall competitiveness in addition to lowering costs.

C- Risk Mitigation

A supply chain's capacity to handle risks and interruptions is improved by agility. By acting swiftly in the face of unanticipated circumstances, including supply shortages or natural disasters, agile supply chains can minimize the impact of disruptions and maintain continuity. According to Jiga (2023), the predictive analytics capabilities provided by IoT help companies anticipate and mitigate risks more effectively. Risk mitigation encompasses the identification of potential hazards, the evaluation of their consequences, and the formulation of strategies to address them. Agile supply chains possess a superior capacity to manage risks, owing to their established contingency plans and flexible processes. This forward-thinking methodology diminishes the probability of disruptions and facilitates rapid recovery in the event of interruptions.

D- Competitive Advantage

Organizations that possess agility gain a competitive edge by being able to react swiftly to emerging market opportunities and potential hazards. Agile supply chains can quickly introduce new goods, break into untapped markets, and adjust to the demands of their customers. This adaptability aids businesses in gaining market share and staying one step ahead of competitors. A key competitive advantage in a corporate environment that is changing quickly is the capacity to react swiftly to consumer requests and market trends. Agile supply chains can innovate and introduce new products faster than competitors, meeting customer needs and capitalizing on new opportunities. This agility fosters a culture of continuous improvement, driving long-term success and growth.

1.10.4. The Role of IoT in Enhancing Supply Chain Agility

A- Real-Time Visibility

Using IoT technology, companies can continuously monitor the location, condition, and status of goods, providing real-time visibility into supply chain operations. Transparency allows issues like delays and damage to be identified and resolved more quickly, improving overall responsiveness.

Real-time visibility enhances decision-making by providing accurate and timely information on the status of shipments, inventory levels, and production processes. Supply chain managers may use this information to make well-informed choices and take remedial action as necessary. Additionally, real-time visibility improves communication and coordination among supply chain partners, enhancing overall performance.

B- Predictive Analytics

Predictive analytics models that estimate demand, optimize inventory levels and foresee interruptions may be developed using Internet of Things data. Businesses may oversee supply chain operations more proactively and make better decisions by using both historical and current data.

Supply chains may use predictive analytics to foresee shifts in demand and modify their operations accordingly. For example, companies can use predictive models to forecast seasonal demand fluctuations and adjust their inventory levels to meet expected demand. By taking a proactive stance, the likelihood of stockouts and overstock scenarios is decreased, improving overall effectiveness and responsiveness.

C- Automation and Process Optimization

IoT-enabled automation enhances supply chain agility by streamlining processes and reducing manual interventions. Automated systems can manage tasks such as inventory replenishment, order processing, and transportation scheduling, improving efficiency and reducing lead times.

Automation helps make fewer mistakes and speeds up the supply chain process while making it more accurate. For example, automated inventory systems can keep track of stock levels right away and automatically order more products when the amount gets too low. This change can help you manage your stock better and reduce the risk of having too much.

D- Case Studies and Empirical Evidence

Several studies have demonstrated the positive impact of IoT on supply chain agility. For instance, Lee et al. (2022) showed that IoT adoption leads to better visibility, efficiency, and responsiveness in supply chains.

The examination of case studies involving companies that have effectively adopted IoT technologies reveals significant advantages in terms of enhanced agility. These enterprises have shown marked improvements in their capacity to swiftly adjust to changes, optimize their operations, and react more adeptly to market fluctuations and disruptions. For instance, a well-known shop improved customer happiness and decreased stockouts by using IoT sensors to track inventory levels in real time. Another company implemented IoT-enabled predictive maintenance for its manufacturing equipment, reducing downtime and increasing operational efficiency.

1.10.5. Challenges to Achieving Supply Chain Agility

A- Data Security and Privacy

Data security and privacy are concerns raised by the large amount of information created by IoT devices. Ensuring the security of data transmission and storage is critical to protecting sensitive information and maintaining trust among supply chain partners(Elvy, 2022).

To ensure data security, you need to use powerful code to clog information and set the rules that can reach it. This helps prevent unauthorized people from entering data leaks and stopping them. These steps help protect sensitive information and maintain data accuracy and confidentiality along the supply chain. To ensure they handle data responsibly, companies must comply with data protection regulations such as the General Data Protection Regulation (GDPR). In addition, companies need to create clear data security rules, regularly check the gaps, and solve the problems they find.

B- Integration Complexity

The incorporation of IoT technologies into pre-existing systems presents significant challenges and financial burdens. Many legacy systems may not be compatible with contemporary IoT solutions, which often require considerable expenditures for either enhancements or total overhauls to ensure effective integration.

The complexity of integration refers to solving technical problems, such as the collaborative work of various systems and updating data. Companies need to guarantee data exchange for IoT devices and create plans to connect to existing systems. This may involve using software that helps different systems work together or creating special connections to link them.

C- Cost and Return on Investment (ROI)

The deployment of IoT devices involves substantial upfront costs for sensors, connectivity infrastructure, and data management platforms. Companies must carefully evaluate the ROI to justify these expenditures.

When thinking about costs, you need to consider how much money you spend on IoT equipment and software at the start, the regular costs for maintenance and support, and the possible benefits of working better and saving money. Companies should conduct cost-benefit analyses to assess the financial viability of IoT projects and develop strategies to maximize ROI.

1.10.6. Future Directions and Research Opportunities

A- Emerging Technologies

The use of new technologies such as advanced data analytics, blockchain and artificial intelligence will be essential to making supply chains more resilient in the future. While blockchain provides safe and transparent data exchange throughout the supply chain, AI may improve automation and predictive analytics.

Emerging technologies have the potential to further enhance supply chain agility by providing new capabilities and solutions. For instance, real-time query replies from chatbots driven by AI may improve customer service, while supply chain transparency and traceability can be increased using blockchain technology. Future research should explore the integration of these technologies with IoT to identify new opportunities for improving supply chain agility.

B- Standardization and Interoperability

From different manufacturers is essential for seamless integration. Industry-wide standards will facilitate communication and data exchange, enhancing the overall effectiveness of IoT in supply chains.

Making rules and guidelines that help different IoT systems and devices work together is called a standardization process. Making things standard helps simplify how different systems work together and encourages more people to use IoT technologies. Additionally, industry-wide collaboration is needed to develop best practices and guidelines for IoT implementation (Pal et al., 2018).

C- Sustainable Supply Chain Practices

Future studies ought to examine how IoT might support sustainable supply chain strategies. Through resource optimization, waste reduction, and increased energy efficiency, IoT may assist businesses in monitoring and mitigating their environmental effect.

Reducing the environmental impact of supply chain operations and fostering social responsibility are two aspects of sustainable supply chain strategies. IoT devices may help sustainability efforts by giving real-time data on waste, pollution, and resource use. This data can be used to develop strategies for reducing environmental impact and improving sustainability.

1.10.7. Summary

SCA represents an essential competency for organizations seeking to succeed in the contemporary volatile and rapid business landscape. The incorporation of advanced

technologies, especially the IoT, markedly improves supply chain agility by offering real-time insights, predictive analytics, and automation functionalities. Even if there are difficulties with data protection and integration, the advantages of reaching agility must exceed these difficulties. Subsequent investigations need to concentrate on using nascent technology and formulating uniform structures to augment supply chain flexibility and durability. The continued evolution of IoT and its integration with other advanced technologies will likely lead to new opportunities and challenges, shaping the future of supply chain management.

1.11. Supply Chain Performance (SCP)

With the introduction of contemporary technologies like the IoT, which have transformed supply chain management by combining disparate operations and enhancing agility and efficiency, SCP has become an increasingly important field of study. This literature review explores the vast array of studies concerning supply chain performance, highlighting the significance of the IoT, SCI, and SCA.

1.11.1. Theoretical Foundations of SCP

SCP evaluates how well a supply chain satisfies both operational objectives and consumer needs. Standard criteria for measuring the success of a supply chain encompass cost, quality, speed, and adaptability. However, with the integration of IoT, these metrics have evolved to include real-time data analytics, predictive maintenance, and enhanced decision-making capabilities (De Vass, Shee, & Miah, 2018).

A- Impact of IoT on Supply Chain Performance

The IoT has greatly improved how supply chains work by allowing real-time tracking, better visibility, and smarter decision-making. IoT technologies like RFID tags, sensors, and GPS trackers give constant information about where products are and how they are doing. This helps businesses predict demand better and manage their inventory more effectively (Whitmore et al., 2014).

B- Real-Time Tracking and Visibility

One of the most significant contributions of IoT to supply chains is real-time tracking and visibility. This capability allows for the monitoring of goods throughout the supply chain, reducing delays and inefficiencies. Real-time data from IoT devices help in identifying bottlenecks and optimizing routes for transportation, thus improving delivery times and reducing costs (Shafique et al., 2018).

C- Predictive Maintenance

Predictive maintenance provided by IoT technology helps to save maintenance costs and downtime by foreseeing equipment faults before they happen. Machine sensors can track performance and forecast when repairs are needed, resulting in more productive operations with fewer interruptions (Mishra et al., 2016).

D- Enhanced Decision-Making

A plethora of data from IoT may be evaluated to help with decision-making. This data contains projections for demand, transportation routes, and inventory levels. Advanced analytics and machine learning algorithms can process this data to provide actionable insights, improving overall supply chain performance (Xu, He, & Li, 2014).

1.11.2. Empirical Studies on IoT and SCP

Numerous empirical investigations have demonstrated the beneficial effects of the IoT on SCP. For instance, the research conducted by De Vass, Shee, and Miah (2018) revealed that IoT substantially improves SCP, leading to enhanced operational efficiency and increased customer satisfaction. Similarly, Xu, He, and Li (2014) highlighted the importance of IoT in enhancing SCA through the enablement of real-time data analysis and informed decision-making.

1.11.3. Challenges and Future Directions

Even while IoT has a lot to offer in terms of improving SCP, putting it into practice comes with certain difficulties. These difficulties include worries about data security, the high

cost of installation, and the requirement for qualified staff to oversee IoT devices (Mishra et al., 2016).

Future research should work on solving these problems and finding new ways to use IoT to make supply chains work better. Also, we need more detailed studies to better understand how the IoT affects supply chains over a long time.

A- Supply Chain Performance Metrics

Metrics for measuring supply chain performance are crucial for assessing how well and efficiently supply chain activities are running. Conventional measures include delivery, quality, cost, and adaptability. However, with the advent of IoT, new metrics have emerged, including real-time data accuracy, predictive maintenance efficiency, and response time to market changes (Huo et al., 2012).

B- Cost Reduction

IoT contributes to cost reduction by improving inventory management, reducing waste, and optimizing transportation routes. Real-time data from IoT devices enable companies to track inventory levels accurately and reduce excess stock, thereby lowering holding costs. Additionally, IoT helps in identifying and eliminating inefficiencies in transportation, leading to reduced fuel consumption and logistics costs (Huo et al., 2012).

C- Quality Improvement

Another important area where IoT has contributed significantly is quality enhancement. IoT sensors may keep an eye on product quality throughout the supply chain, ensuring that the final product meets all the specifications. For instance, temperature and humidity sensors can monitor and control the storage and transportation conditions of perishable goods, reducing spoilage and maintaining product quality. (Zhao et al., 2011).

D- Delivery Performance

One important indicator in supply chain management is delivery performance. IoT improves delivery efficiency by allowing proactive control of any delays and real-time shipment status awareness. Companies can use IoT data to optimize delivery routes and schedules, ensuring timely delivery of goods to customers (Yu, 2015).

E- Flexibility and Responsiveness

The ability to be flexible and responsive is essential for organizations to effectively navigate shifts in demand and market dynamics. IoT significantly improves these qualities within supply chains by delivering real-time information and predictive analytics. This functionality allows businesses to rapidly modify production timelines and inventory quantities in reaction to variations in demand, thus reducing the likelihood of stock shortages or surplus inventory (GEP, 2023).

1.11.4. Integration of IoT in Various Supply Chain Functions

The integration of IoT spans various functions within the supply chain, enhancing overall performance and efficiency.

A- Inventory Management

IoT is important for managing inventory because it allows businesses to see inventory levels in real time. This helps reduce the chances of running out of stock or having too much inventory by letting businesses handle their stock better. IoT-enabled inventory management systems can automatically order more stock when the amount gets too low, making sure there are always enough goods available (De Vass et al., 2018).

B- Transportation and Logistics

IoT improves logistics and transportation by streamlining routes and enhancing insight into the flow of products. With the use of GPS trackers and sensors, businesses can better monitor and control their transportation operations by getting real-time data on the position

and state of shipments. This leads to improved delivery performance and reduced transportation costs (Shafique et al., 2018).

C- Production Planning and Scheduling

IoT gives immediate updates on how machines are working and their condition, which helps in organizing and planning. As a result, companies can use their resources better and improve their production plans. IoT can help predict when machines might break down or need fixing. This can lead to less downtime and make production work better (Xu et al., 2014).

D- Supplier and Customer Integration

The integration of suppliers and customers is crucial for an effective supply chain. The IoT enhances communication and collaboration between these parties by providing real-time data and analytical insights. This advancement improves the alignment of supply with demand, leading to more streamlined operations and greater customer satisfaction (Alfalla-Luque et al., 2013).

1.11.5. Case Studies on IoT Implementation in Supply Chains

Several companies have successfully implemented IoT in their supply chains, demonstrating its significant impact on performance.

A- Case Study: Walmart and Procter & Gamble

Walmart and Procter & Gamble implemented an RFID-based inventory management system to enhance visibility and accuracy. This system allowed both organizations to track inventory levels in real time, thereby minimizing stockouts and improving inventory precision. The incorporation of IoT technology into their supply chain resulted in significant cost reductions and heightened customer satisfaction (K. Lim, 2013).

B- Case Study: Amazon

Amazon's use of IoT in its warehouses has revolutionized its order fulfilment process. The company uses robots and automated systems to manage inventory and fulfil orders

quickly and accurately. IoT has enabled Amazon to maintain a highly efficient and agile supply chain, meeting customer demands effectively and consistently (Marr, 2022).

C- Case Study: Coca-Cola

Coca-Cola has deployed vending machines equipped with IoT technology, enabling real-time monitoring of inventory levels and sales metrics. These machines can automatically reorder stock and provide valuable data on consumer preferences and buying patterns. The integration of IoT has improved Coca-Cola's inventory management and enhanced its ability to meet customer demand (Shafique et al., 2018).

1.11.6. Future Directions and Research Opportunities

The integration of IoT in supply chains is still evolving, and there are several areas for future research and development.

A- Data Security and Privacy

Data security and privacy are major concerns in the widespread adoption of IoT, and future research should prioritize the development of strong security protocols and encryption methods to protect sensitive data transmitted by IoT devices (Mishra et al., 2016).

B- Cost-Effectiveness

The high implementation costs of IoT systems can be a barrier for many companies. Research should explore cost-effective solutions and business models that can make IoT more accessible to small and medium-sized enterprises (SMEs) (De Vass et al., 2018).

C- Integration with Emerging Technologies

SCP can be significantly enhanced by integrating IoT with other advanced technologies such as blockchain, AI, and 5G. Future research should explore the synergies among these technologies and their collective impact on improving supply chain operations (Xu et al., 2014).

D- Long-Term Impact on Supply Chain Dynamics

There is a lot of proof that using IoT can help supply chains in the short run. However, we need to do more studies to see how it affects supply chains over a longer time. This includes looking at how IoT influences the strength, sustainability, and creativity of supply chains (Mishra et al., 2016).

1.11.7. Summary

There is a lot of proof that IoT helps supply chains in the short term, but we need more research to see how it affects supply chains over a longer time and how well they perform. This means looking at how the IoT impacts the strength, eco-friendliness, and new ideas in supply chains. To take full advantage of IoT, businesses need to solve the problems by putting it into use. Future research should continue to look at how the Internet of Things is changing supply chain management and how it impacts performance.

1.12. Methods and Models Used in IoT Studies

1.12.1. Empirical Surveys and Structural Equation Modeling (SEM)

A- Study by Ben-Daya, Hassini, and Bahroun (2019)

- **Methods:** Empirical survey and Structural Equation Modeling (SEM)
- **Key Findings:** The research indicated that the IoT plays a crucial role in enhancing supply chain integration through the facilitation of real-time data sharing, which in turn improves decision-making processes and operational effectiveness. Key IoT applications, including real-time tracking and environmental monitoring, were identified as vital components for risk mitigation and the seamless movement of goods.
- **Results:** The empirical evidence showed a strong positive correlation between IoT adoption and improved supply chain performance metrics, including reduced lead times and enhanced delivery reliability.

B- Study by Wamba, Queiroz, and Trinchera (2020)

- **Methods:** Empirical research using survey methodologies, combined with SEM, can effectively evaluate the relationships between factors influencing blockchain adoption and supply chain performance.
- **Key Findings:** The study found that blockchain technology, closely related to IoT in terms of data transparency and security, significantly improves supply chain performance by enhancing data integrity and trust among partners.
- **Results:** The SEM analysis revealed that blockchain adoption, driven by factors such as perceived benefits and technological readiness, positively impacts supply chain performance through improved information sharing and collaboration.

1.12.2. Case Studies and Qualitative Analysis: Study by Ben-Daya et al. (2019)

- **Methods:** Case studies of companies implementing IoT in their supply chains, combined with qualitative analysis.
- **Key Findings:** The study highlighted specific use cases where IoT applications led to significant improvements in supply chain operations. For instance, companies using IoT for real-time shipment tracking and environmental monitoring experienced fewer disruptions and improved customer satisfaction.
- **Results:** Qualitative insights from the case studies indicated that IoT adoption leads to better visibility, proactive issue resolution, and more efficient resource utilization.

1.12.3. Literature Reviews and Conceptual Models: Study by Ivanov, Dolgui, and Sokolov (2019)

- **Methods:** Literature review and conceptual model development.
- **Key Findings:** This research examined the current body of literature regarding the IoT within supply chains and formulated a conceptual framework to demonstrate the influence of IoT on the resilience and risk management of supply chains.

- **Results:** The conceptual framework demonstrated that the IoT enhances supply chain resilience by providing real-time data, which improves risk assessment and management, leading to more robust supply chain operations.

1.12.4. Discussion and Interpretation

A- Enhancements in SCI

The evaluated research consistently demonstrates that SCI is improved by IoT. IoT facilitates improved collaboration among supply chain stakeholders by delivering real-time information regarding the movement and status of products. This immediate access to data fosters proactive decision-making, thereby minimizing the chances of delays and interruptions. Research employing SEM has revealed robust statistical correlations between measures of supply chain integration and the adoption of IoT technologies, underscoring the substantial influence of IoT on enhancing supply chain integration.

Ben-Daya et al. (2019) used SEM to demonstrate that IoT applications, such as real-time tracking and environmental monitoring, are vital for enhancing supply chain integration. These applications improve data exchange and operational coordination, resulting in shorter lead times, increased delivery reliability, and overall improved SCP.

B- Improvements in SCP

IoT significantly improves supply chain performance by optimizing various operational aspects. The empirical surveys and SEM analyses demonstrate that IoT applications such as predictive maintenance and real-time tracking lead to reduced operational costs, improved delivery accuracy, and enhanced customer satisfaction. These improvements are attributed to the increased visibility and data-driven decision-making capabilities enabled by IoT technologies.

For instance, Wamba, Queiroz, and Trinchera (2020) found that blockchain, which enhances data transparency and integrity, positively impacts supply chain performance

through improved collaboration and information sharing. This highlights the complementary role of IoT and blockchain in driving supply chain efficiency and performance.

C- Enhancements in SCA

The ability to quickly adapt to SCA or changes and confusion is another important advantage of IoT. The reviewed research indicates that the IoT provides real-time data and predictive analysis to enhance the response of the supply chain. For example, companies can quickly reroute shipments in response to unexpected disruptions, reducing downtime and maintaining service levels. The use of qualitative case studies in these analyses provides detailed insights into how IoT applications enhance agility in real-world scenarios.

For example, the case studies by Ben-Daya et al. (2019) demonstrated that companies using IoT for real-time shipment tracking were able to respond quickly to disruptions by rerouting shipments and adjusting delivery schedules, thus maintaining high levels of service.

1.12.5. Summary

Performance, integration, and agility are three key benefits of integrating IoT into SCM. In research employing methods such as surveys, SEM and thematic analysis, it has been demonstrated that IoT enhances supply chains by providing real-time data, improving decision-making, and facilitating better coordination between partners. As IoT technology keeps advancing, it is expected to greatly affect SCM, making it more efficient and quicker to respond.

1.13. Researches Gap

Table 1: Researches Gap

Study	Focus Area	Methods	Key Findings	Research Gaps
Ben-Daya, Hassini, & Bahroun (2019)	The influence of IoT on the integration and performance of supply chains	Empirical survey and SEM	IoT enhances supply chain integration and operational efficiency; positive correlation between IoT adoption and improved performance metrics.	Lack of in-depth analysis of specific IoT technologies' impact on different supply chain functions; limited industry-specific insights
Wamba, Queiroz, & Trinchera (2020)	Blockchain adoption and supply chain performance	Survey-based empirical research and SEM	Blockchain improves supply chain performance through enhanced data integrity and collaboration.	Limited focus on IoT-Blockchain synergy; need for more empirical evidence on IoT's specific contributions to supply chain agility
Ivanov, Dolgui, & Sokolov (2019)	Digital technology and supply chain risk management	Digital technology and supply chain risk management	IoT enhances supply chain resilience and risk management through real-time data	Need for empirical validation of conceptual models; lack of detailed case studies on IoT implementation in risk management
Gunasekaran, Patel, &	Framework for supply	Literature review and	Importance of performance	Need for updated frameworks

McGaughey (2004)	chain performance measurement	conceptual framework	metrics in evaluating supply chain integration	incorporating modern technologies like IoT
Beamon (1999)	Supply chain performance measurement	Conceptual analysis	Various metrics for measuring supply chain performance	Outdated metrics that do not account for IoT advancements; need for integration of real-time data analytics
Chopra & Meindl (2016)	Supply chain strategy and operations	Theoretical analysis and case studies	The role that supply-chain integration plays strategically	Limited focus on IoT; need for more contemporary case studies involving IoT
Lambert & Cooper (2000)	Issues in supply chain management	Literature review and conceptual framework	Important problems and difficulties in supply chain administration	Need for exploration of IoT's role in addressing these challenges; integration with modern supply chain strategies

- **Discussion**

The table above identifies several research gaps in the existing literature on IoT in supply chain management:

1. **Specific IoT Technologies:** There is a need for a more detailed analysis of specific IoT technologies and their impact on various supply chain functions (e.g., inventory management, logistics, production).
2. **Industry-Specific Insights:** Current studies often lack industry-specific insights. Research focusing on specific sectors, such as retail, manufacturing, or healthcare, can provide more targeted recommendations and strategies.

3. **IoT-Blockchain Synergy:** Although some studies explore the impact of blockchain on supply chain performance, there is limited research on the synergistic effects of IoT and blockchain technologies working together.
4. **Empirical Validation of Conceptual Models:** Many studies propose conceptual models without empirical validation. There is a need for empirical research to test and validate these models in real-world scenarios.
5. **Updated Performance Metrics:** Existing frameworks for supply chain performance measurement often do not account for advancements in IoT. Developing updated metrics that incorporate real-time data analytics and other IoT capabilities is essential.
6. **Contemporary Case Studies:** There is a lack of contemporary case studies that showcase successful IoT implementation in supply chains. More recent examples can provide valuable insights and practical guidance for businesses.
7. **IoT in Risk Management:** While IoT's role in enhancing supply chain resilience and risk management is acknowledged, there is a need for detailed empirical studies that demonstrate how IoT can be effectively used to mitigate specific risks.

Some studies have already proven the relations between some of the variables but have never measured all of them together in one study. Filling up these gaps will increase knowledge of how IoT affects supply chain management and offer useful advice to companies hoping to use IoT technology to boost productivity.

Table 2: Literature Review Table

Author	Year	Title	Category 1	Category 2	Category 3	Document type	Publication setting	Knowledge type	Key argument(s)	Methodology	
SCI	Chopra, S., & Meindl, P. 2016	Supply Chain Management: Strategy, Planning, and Operation	Supply Chain Strategy	Supply Chain Integration	Operational Efficiency	Book	Academic	Mixed	Emphasizes the strategic importance of supply chain integration.	Mixed	Theoretical analysis and case studies.
	Gunasekaran, A., Patel, C., & McGaughey, R. E. 2004	A framework for supply chain performance measurement	Supply Chain Performance	Supply Chain Integration	Performance Metrics	Journal Article	Academic	Theoretical	Highlights the importance of performance metrics in evaluating supply chain integration.	Qualitative	Literature review and conceptual framework development.
	Beamon, B. M. 1999	Measuring supply chain performance	Supply Chain Efficiency	Supply Chain Integration	Performance Metrics	Journal Article	Academic	Theoretical	Discusses various metrics for measuring supply chain performance.	Quantitative	Conceptual analysis
	Ben-Daya, M., Hassini, E., & Bahrour, Z. 2019	Internet of Things and supply chain management: A literature review	IoT	Supply Chain Integration	Technological Advancements	Journal Article	Academic	Mixed	Reviews the impact of IoT on supply chain integration and performance.	Mixed	Reviews the impact of IoT on supply chain integration and performance.
	Wamba, S. F., Queiroz, M. M., & Trinchera, L. 2020	Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation	Blockchain	Supply Chain Integration	Empirical Research	Journal Article	Academic	Empirical	Investigates the determinants of blockchain adoption and its impact on supply chain performance.	Qualitative	Empirical investigation using survey data and structural equation modeling.
SCP	Yu, W. 2015	Internal and External Integration for Supply Chain Agility and Performance	Agility	Supply Chain Integration	Supply Chain performance	Journal Article	Academic	Empirical	Integration enhances agility and performance.	Quantitative	Empirical Analysis
	Mishra, D., Kumar, S., & Chan, F. T. S. 2016	The Impact of Internet of Things on Supply Chain Management: A Systematic Literature Review	Supply Chain Management	IoT	performance	Journal Article	Academic	Empirical	IoT improves SCM performance.	Qualitative	Systematic Literature Review
	Xu, L., He, W., & Li, S. 2014	Internet of Things in Industries: A Survey	Industries	IoT	Supply Chain	Journal Article	Academic	Theoretical	IoT transforms industries.	Quantitative	Survey of Literature
	Shafiqe, M., Khan, N. I., & Khan, N. 2018	Real-Time Visibility and Tracking in Supply Chain Management: The Role of IoT	Real-Time Tracking	Visibility	Supply Chain Management	Journal Article	Academic	Empirical	IoT improves visibility.	Quantitative	Empirical Analysis
	Whitmore, A., Agarwal, A., & Da Xu, L. 2014	The Internet of Things - A Survey of Topics and Trends	Trends	IoT	Technology Adoption	Journal Article	Academic	Theoretical	IoT adoption is rising.	Quantitative	Survey of Literature
De Vass, T., Shee, H., & Miah, S. J. 2018	The Internet of Things (IoT) and its Impact on Supply Chain Integration and Agility	Agility	IoT	Supply Chain Integration	Journal Article	Academic	Empirical	IoT enhances SCI and agility.	Qualitative	Systematic Literature Review	

Table 3: Literature Review Table

Author	Year	Title	Category 1	Category 2	Category 3	Document type	Publication setting	Knowledge type	Key argument(s)	Methodology
Tanya de Vass, Himanshu Shee, and Shah Miah	2018	The effect of "Internet of Things" on supply chain integration and performance: An organizational capability perspective	Supply Chain Integration	IoT	Organizational Capability	Journal Article	Academic	Empirical	IoT improves supply chain performance by enhancing integration and agility	Quantitative using structural equation modeling (SEM)
Tanya de Vass, Himanshu Shee, and Shah Miah	2018	The effect of "Internet of Things" on supply chain integration and performance: An organizational capability	Supply Chain Integration	IoT	Organizational Capability	Journal Article	Academic	Empirical	IoT enhances supply chain integration and performance through real-time data and communication	Quantitative structural equation modeling
Kyong Lee, Pulam Romzi, Jalal Hanjisha, and Hamdi Alzoubi	2022	Investigating the impact of benefits and challenges of IoT adoption on supply chain performance and	Supply Chain Performance	IoT	Organizational Performance	Journal Article	Academic	Empirical	IoT adoption improves visibility, efficiency, and responsiveness in supply chains.	Empirical study using survey data and statistical analysis
Muhammad Nauman Shafique, Amir Rashid, Ifkhar Shafi Bajwa, Fiana Khurshi, Muhammad Moiruddin Kazmi, and Wasim Ahmed Tabir	2018	Effect of IoT capabilities and energy consumption behavior on green supply chain integration	Green Supply Chain Integration	IoT	Energy Consumption	Journal Article	Academic	Empirical	IoT enhances supply chain integration and sustainability through real-time tracking	Empirical study using survey data and statistical analysis
Hamad Khan and Joel Wisner	2018	Supply chain integration, learning, and agility: Effects on performance	Green Supply Chain Integration	Supply Chain Agility	Supply Chain Performance	Journal Article	Academic	Theoretical	Integration and learning enhance agility, which improves performance	Quantitative structural equation modeling (SEM)
Edmund Praet, Michael Blehl, and Michael A. Smith	2001	International supply chain agility: Tradeoffs between flexibility and uncertainty	Supply Chain Flexibility	Supply Chain Agility	Supply Chain Uncertainty	Journal Article	Academic	Other	Agility involves trade-offs between flexibility and uncertainty.	Case study analysis and qualitative research
Patricia M. Swafford, Soumen Ghosh, and Nagesh Murthy	2008	Achieving supply chain agility through IT integration and flexibility	IT Integration	Supply Chain Agility	Supply Chain Flexibility	Journal Article	Academic	Empirical	IT integration and flexibility are critical for agility.	Empirical study using survey data and structural equation modeling
Rameshwar Dubey, Angappa Gunasekaran, and Stephen J. Childe	2018	Big data analytics capability in supply chain agility: The moderating effect of organizational flexibility	Big Data Analytics	Supply Chain Agility	Organizational Flexibility	Journal Article	Academic	Theoretical	Big data analytics and flexibility enhance agility	Empirical study using survey data and regression analysis
Yahaya Yusuf, Angappa Gunasekaran, Ebun A. Adeleye, and Karikalan Sivaganathan	2004	Agile supply chain capabilities: Determinants of competitive objectives	Agile Capabilities	Supply Chain Agility	Competitive Objectives	Journal Article	Academic	Empirical	Agile capabilities are critical for achieving competitive objectives in supply chains.	Empirical study using survey data and factor analysis

IoT, Retail Industry and Challenges in SCM

1.14. IoT in Retail

In 1999, Kevin Ashton and a team of researchers at the Massachusetts Institute of Technology delivered the initial presentation on the IoT (Ashton, 2009). The data innovation space has seen tremendous upheaval, particularly in the last few years concerning phones and online association methods. Nowadays, almost everyone claims to have a device that is linked to the internet. In five years or less, phones will also likely be connected, thanks to advancements in the IoT. To facilitate the interconnection of various objects, technologies such as RFID, Wi-Fi, Bluetooth, and 4G-LTE are utilized. By 2011, more devices are connected to the internet than there are people in the world. (Jayavardhana Gubbi, 2013). "Artificial Intelligence Market by Products (Hardware, Software), Technology (Machine Learning, Deep Learning, Natural Language Processing, Computer Vision), Business Areas, Industry, and Region - Global Predictions to 2030" A report from Markets and Markets shows expected growth in the artificial intelligence market. A report says that the worldwide AI market is likely to grow to \$1,345.2 billion by 2030. This means it will increase at a rate of 36.8% each year, starting from \$150.2 billion in 2023 (MarketsandMarkets, 2023).

It is the most promising invention of our day, with a wide range of uses. It is altering everything about our way of life, from our driving structure to the way we acquire goods and make demands to the way we energize our houses. It starts with the objects or devices that transfer data to phases that integrate the data, analyze it, and provide it with applications that cater to the demands of each customer and industry. Nowadays, connectivity is the new oxygen, and individual state networks are displaying the raw opium from a variety of angles. The internet creates accommodations for people. Especially about wearable technology for the home and social life. For instance, ensure accuracy in well-being, practice according to instructions and work competence. According to this theory, more people will pursue IoT administrations. Furthermore, by 2025, they will be connected to cars, which will come later.

There won't be any traffic in four very long years; we'll have to tell our grandchildren about this as a wonder we all experienced growing up. By 2030, we won't have to wait patiently for another red light in certain states (Abdelhadi & Akkartal, 2019).

The interconnectedness of these devices, along with their ability to generate valuable insights, is facilitated by IoT. Another enabling factor driving the adoption of IoT is mobile technology (Arirang news, 2017).

The ongoing progress in technologies including 5G, cloud computing, video, the IoT, and AI is expected to facilitate a deeper understanding of the essential characteristics of the sound universe. The new oil will be information, which will cause another "dim gold" rush. Every link that is capable of detecting will function as an oil well, extracting data. The cloud and artificial intelligence processing plants will get this data.

They will gather data, disseminate data, and prudently focus on respect. The customer will get the revised wording about usage and aspiratory TB. This information cycle will serve as the underlying process that propels the universe of sound.

The convergence of availability and AI within the framework of Intelligent Connectivity is creating unprecedented financial and developmental opportunities. Every day, new initiatives, projects, tasks, and services are being introduced, hastening the transition to a computerized economy valued at over \$23 trillion by 2025 and laying the groundwork for the next cycle of financial development (Huawei Technologies Co., 2018).

1.14.1. The Foundational Elements of IoT

Known for their roles in data acquisition and supervisory control, M2M, RFID, WSNs, and SCADA are the main constituents of the Internet of Things. In the section that follows:

- RFID

RFID: Utilizes radio waves to transmit information about an electronic label attached to a product to a central organization, allowing an editor to identify and reject the item.

Individuals' data will be stored in RFID fragments. To use, copy, and distribute line cards, enter doors, log onto computers, and save health information, RFID chips will be

inserted between the quarter round and the forefinger finger. Beginning on August 1, 2017, some employees of various firms have the option to undergo surgery to surgically implant a unique microprocessor chip between their thumb and index finger, beneath their skin(Strickland, 2017).

RFID chips consist of a small electronic device comprising a microprocessor chip functioning as the antenna and a microchip for storing information, allowing for data transmission and reception through the antenna. The company's blog post will be dispatched by the factory within a minute, utilizing trichinous falcate workers to transition the workload away from the break room micro market, which comprises cubicles and self-service vending machines.

With the use of AI technology, employees can now conveniently utilize an implant to electronically unlock doors and access computers without the hassle of typing in a password(Abdelhadi & Akkartal, 2019).

Wal-Mart and the United States Department of Defense were pioneers in adopting RFID technology, conducting tests on its integration within their supply chains and noting positive outcomes. Procter & Gamble and Marks & Spencer United Kingdom are two examples of early adopters. Large-scale RFID initiatives have been used recently. The weapons platform has been designated by DHL for lawful shipment to all 89 Metro Carry & John Cash in France (K.Lim, 2013).

- Wireless Sensor Networks (WSN)

To monitor environmental or physical variables, a wireless sensor network (WSN) is made up of geographically dispersed autonomous sensing units.

An effective, inexpensive, low-power tiny twist for use in remote sensing applications has been made possible by the Holocene technical approach in low-power integrated elec (Chatterjee, 2016) trip circuits and wireless communications.

A Wireless Sensor Network (WSN) is a decentralized system comprising sensor and actuator nodes. The task of sensor nodes is to monitor and analyze the objects or environment

they are placed in, whereas actuator nodes are capable of making changes to the state of objects or the surrounding environment (Fathy, 2018).

The integration of these brokers has enhanced the feasibility of utilizing a sensor-based electronic network with numerous intelligent detectors. This facilitates the collection, processing, analysis, and dissemination of crucial data across diverse environments (Gubbi, Jayavardhana, 2013).

- -SCADA:

A network of automated devices in a facility, like a workplace or construction site, is linked, monitored, and controlled by SCADA (Supervisory Control and Data Acquisition). It relies on closed-loop controller capabilities, intelligent systems, or Cyber-Physical Systems (CPS) data.

Handling all industrial activities' limitations and supervision by hand is unthinkable. An automated tool that can manage, gather entropy, analyze data, and provide reports is used. A SCADA system is presented as the only way to meet all of this demand (Khan, 2018).

- M2M communication:

M2M (Machine-to-Machine communication) involves devices gathering information through a system linked to a central server, which then processes recorded events into actionable data.(Khan, 2018). What separates the IoT from Machine to Machine (M2M):

M2M: Machine-to-machine (M2M): The networking of devices, usually via remote improvements that were previously difficult to implement.

(IoT): The network of several M2M apps that allows information to be exchanged across different industrial sectors (Chatterjee, 2016).

M2M communication might be expanded to include portable systems (such as CDMA EVDO and GSM-GPRS). The versatile system's role in the M2M correspondence is mostly restricted to acting as a vehicle organizer.

Table 4: The Foundational Elements of IoT(Khan, 2018).

<i>Four Pillars of IoT</i>	<i>Short –Range Wireless</i>	<i>Long –Range Wireless</i>	<i>Short –Range Wired</i>	<i>Long –Range Wired</i>
<i>RFID</i>	<i>Yes</i>	<i>Some</i>	<i>No</i>	<i>Some</i>
<i>WSN</i>	<i>Yes</i>	<i>Some</i>	<i>No</i>	<i>Some</i>
<i>M2M</i>	<i>Some</i>	<i>Yes</i>	<i>No</i>	<i>Some</i>
<i>SCADA</i>	<i>Some</i>	<i>Some</i>	<i>Yes</i>	<i>Yes</i>

Intelligent Connectivity (IC) can be made possible by integrating AI into the five major technological advancements: cloud computing, broadband, big data, data centres, and the internet of things, which can elevate the basic network to an intelligent level. When IC is considered a comprehensive architecture, it creates synergy benefits greater than the sum of its parts across each of these five empowering agents.

This revolutionary strategy can spur human ingenuity and advancement while aiding in the shift from a conventional to a digital economy.

This transition offers advantages not only to industry leaders or early adopters but also to newcomers who will gain access to AI and its value for their digital transformation initiatives.

1.14.2. The Five Enabling Technologies of IoT

Therefore, it follows that without mentioning AI, the five enabling developments (cloud, broadband, big data, data centres, and IoT) cannot be fully appreciated.

- Quick Internet: Internet Given its high access speeds, Internet management is the most sophisticated kind of access to the Internet. It is available in four distinct configurations: DSL (Digital Subscriber Line), fibre-optic, link, and satellite. Although dial-up is becoming more and more affordable, most Internet users are

choosing the fastest broadband Internet interface since it is the only non-broadband network connection available (IPbAddress, 2019).

For IoT and AI to become ubiquitous across an economy and offer benefits in all aspects of daily life, high-speed broadband is essential. Broadband networks are crucial for collecting and transferring data, distributing it for processing, and transmitting instructions to smart devices or individuals who need them. Leading nations have an advantage in this regard, as they typically have the fastest and most advanced broadband infrastructure compared to others. Neither the Adopter nations nor the Starter nations will be at risk of being abandoned if there is insufficient broadband. It is suggested that broadband is a crucial investment as it is the foundation of the ICT system.

- *Data Center:* Rich and widely available information is by no means a recent development; nonetheless, the AI study highlights how its force, speed, and assortment are always growing.

While AI might function on a smaller scale even in the absence of these advancements, AI anticipates that information will reveal its full potential. AI frameworks are now using just a small portion of the available data, even though new types of information have emerged in the last several years and the rate at which data is created and altered has significantly increased in that field. This has been dead on the agenda for a good long time. Accordingly, AI would now have a lot of data to absorb, contextualize, and comprehend, even if information quantities stagnated and the cost per unit of information volume and speed remained constant (Gesing, 2018).

The majority of AI frameworks are installed, configured, and maintained on server farms. AI requirements have led to a surge in interest in servers, chips, and data storage, which is changing the server farm market.

For example, massive amounts of data are needed to design, test, and approve the neural net computations used in deep learning, a subset of artificial intelligence.

These kinds of applications are ideal for GPU-based handling, which makes server farms that support GPU-based preparation necessary.

- *Cloud:* Distributed computing, often known as "the cloud," utilizes web-based storage and programming to significantly increase capacity and make large business equipment accessible. In the age of Big Data, this is crucial (AG., 2017). The adaptation issues posed by deep learning models used in AI can be resolved by cloud administrators. Most businesses, excluding governments, telecommunications companies, and a small number of international IT suppliers, are not willing to invest the full required amount for expanding their server farms to accommodate the growing requirements of artificial intelligence. Creating AI-fit frameworks on a large scale can be prohibitively expensive, mostly because preparing computations requires a significant amount of processing power.

Large amounts of modest recording force and capacity are available in distributed computing, which offers useful methods for creating IoT and AI applications. The fundamental framework program that enables AI appropriation across an economy is the cloud combined with a broadband network.

- *Big Data:* The phrase "Enormous Data" refers to extremely large informative indices that may be used to display slants, learning designs, and delineate associations. Saddling Big Data talks to a test and additional avenue for further profit for assembling pioneers. (AG., 2017).

Massive amounts of data are poised to grow as we produce and use more sophisticated material and as daily life and commerce depend more and more on computerized infrastructure. We observe the erratic growth of video-based information for industry, exhilaration, communication, and security.

The generation of information is also being considerably enhanced by the growth of IoT. For AI to be useful, a massive number of terabytes of data must constantly be organized, managed, labelled, and ready. This link will eventually become

circular when AI's analytical and learning capabilities are examined, and AI will enhance the way data is gathered, managed, and considered.

- *Net of Things (NetT)*: installed on physical devices, the Internet of Things consists primarily of sophisticated hardware and software that sends data to consumers and businesses (Chatterjee, 2016). In the case of artificial intelligence systems, the sense organs that collect information and the limbs and legs that respond to commands are the same as the devices that are like a sophisticated brain.

Data provided by IoT sensors helps AI systems understand a specific environment, and decisions made by AI systems are executed by their vehicles and other devices. To fully utilize the functionality of AI in an economy, an IoT sensor network and smart machines are crucial.

1.15. Retail Industry

Manufacturers used to deliver items to stores ahead of demand, and retailers were just the receivers of these supplies. Retailers increasingly keep an eye on product availability in response to known consumer demand. The supply chain is overseen, coordinated, and managed by them from manufacturing to consumption. For the past 20 to 30 years, it has been central to supply chain transformation and retail logistics. (Ferne, 2010)

Retail logistics involves a structured approach to managing and facilitating the movement of goods from suppliers to customers. With a diverse array of products sold by manufacturers, wholesalers, and distributors, there's a demand for organized coordination in transporting these goods until they reach the end consumer. Retail logistics aims to optimize delivery and service quality while reducing costs through effective management and value addition. It's projected that the retail logistics sector will see expansion over time, driven by the ongoing rise in global population and consumer disposable income, as suggested by Ellram in 1989.

As e-commerce continues to grow, effective last-mile delivery is swiftly becoming one of the key differentiators for a business from its rivals. Furthermore, same-day shipping is typical these days, fueling the growth of the same-day delivery market in the United States. Companies are emphasizing the inclusion of same-day delivery capabilities in various industries such as pharmaceuticals, food and beverages (Morganti, Seidel, Blanquart, Dablanc, & Lenz, 2014).

Moreover, along with same-day delivery, customers are expecting a better level of services which is encouraging large retailers such as Walmart and Amazon to feature DIY walk delivery divisions in their firms rather than outsourcing. The logistics market is expected to grow strongly throughout the forecast period due to the continued efforts of logistic companies to deliver economical last-mile deliveries (Barco & Khatib, 2021).

1.15.1. The IoT is Proving Beneficial to Retailers

The effective movement of goods between locations is a fundamental aspect of logistics, and the sector is transforming as a result of developments in the IoT. IoT-enabled sensors and devices facilitate real-time monitoring and tracking of shipments, empowering companies to enhance route efficiency, minimize delays, and expedite delivery processes. But it's not just about tracking shipments - IoT can also monitor the condition of goods, such as temperature and humidity, ensuring they arrive in the best possible condition. The possibilities of IoT in logistics are endless, and it's exciting to see how this technology is revolutionizing the way of moving goods around the world.

As this transition takes place, the ICT industry will have a significant role to play. It will recognize the responsibility for laying the groundwork for the future smart world and thereafter assist all businesses in becoming more intelligent (Koutsoutos & Westerholt, 2005).

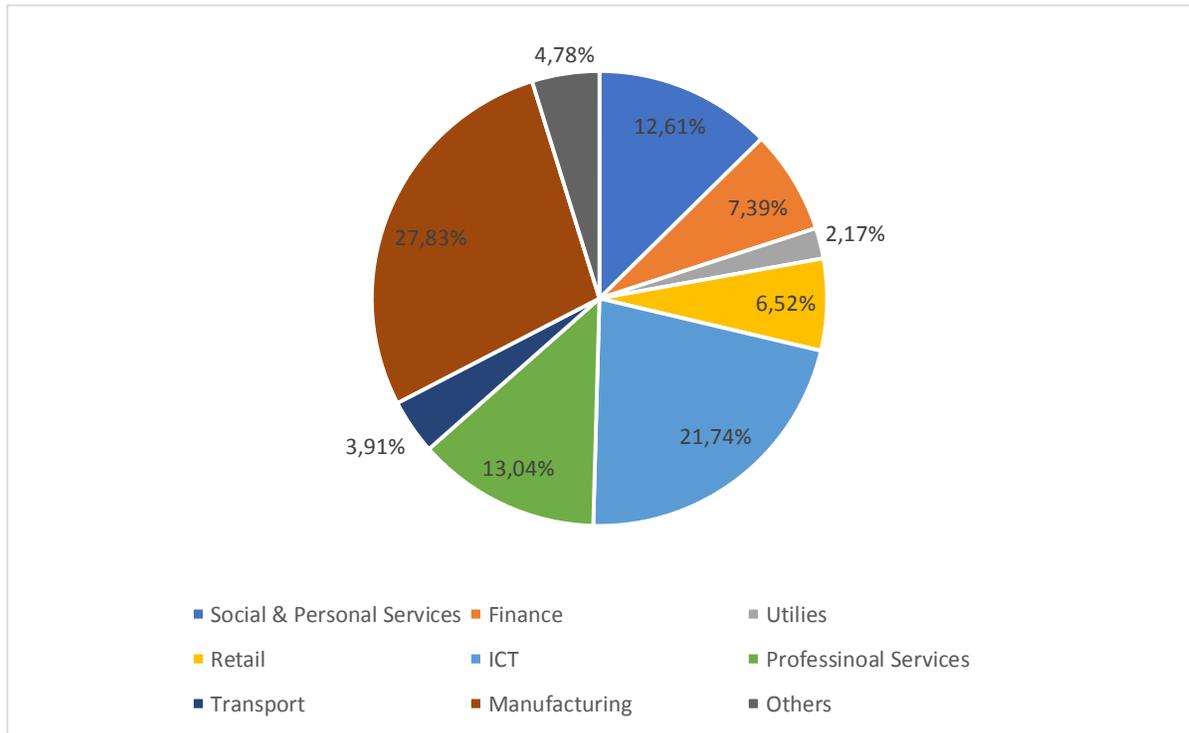


Figure 1: The Digital Economy by 2025.(GIV, 2018)

By 2025, the transport industry will make extensive use of astute innovation, with 100% of new cars being connected to the Internet and over 60 million vehicles linked to 5G networks(GIV, 2018).

ICT and operational innovation (OI) will combine more quickly if insight has influenced the assembly. This will yield benefits for progress, tenacity, the value chain, and the environment as a whole. Urban planners will probably create new avenues for sustainable development in transportation planning, security, and other areas by embracing knowledge in urban areas. This will enable city dwellers to recognize the well-being, comfort, and high standards for daily comforts made possible by an advanced lifestyle.

By 2025, the digital economy is expected to be valued at US\$23 trillion, with the retail sector ranking third among all industries in terms of investment volume. IoT's real-time visibility and communication capabilities can help integrate various supply chain

participants, including manufacturers, suppliers, logistics companies, and retailers(GIV, 2018).

By using the IoT, stores can closely track where their products are and how they are doing as they move through the supply chain. This capability allows them to predict consumer demand more accurately and manage inventory levels effectively with data-driven insights. By using IoT technology, businesses can better control their inventory levels and anticipate future demand, enabling a change from reactive to proactive supply chain management.

This observation holds considerable importance as IoT technology has the potential to fundamentally alter the supply chain, transcending simple improvements in efficiency and visibility. Historically, it was believed that a resilient supply chain was adequate to facilitate the performance of IoT applications and devices. Nevertheless, it has become clear that achieving optimal performance necessitates not only a robust supply chain but also the integration of IoT platforms. The amalgamation of these components has enhanced supply chain efficiency and enabled retailers to monitor and manage data with increased sophistication(Sukkar, 2022).

1.15.2. IoT Retail Benefits by Early Adopters

In a 2016 report on the Internet of Things, Verizon highlighted several applications of IoT in the retail sector. The report indicated that retailers expressed optimism regarding numerous aspects of IoT implementations.

- According to a study by i-scoop. EU in 2023, 77 per cent of retailers acknowledge that the IoT has a significant impact on altering the customer experience.
- Among early adopters in the retail sector, 89 per cent report gaining a heightened understanding of customer preferences and behaviours through IoT technologies.
- Additionally, 77 per cent of early IoT adopters in retail identify opportunities for improved collaboration with both existing and new partners in delivering products and services to customers.

In 2021, the global IoT retail market was assessed at \$28.14 billion, with forecasts indicating an expansion to \$177.90 billion by 2031. This growth represents a compound annual growth rate (CAGR) of 20.3% during the period from 2022 to 2031 (Kashinath G, 2022).

“The retail sector saw positive effects from the COVID-19 pandemic, which spurred significant growth in the IoT market. This increase is largely due to a surge in the adoption of IoT-related strategies, business intelligence, and supply chain management practices. These approaches were crucial for improving customer retention and streamlining operational processes, which in turn contributed to the expansion of the IoT market within the retail industry during this time.” to reach \$177,899.02 million by 2031, registering a CAGR of 20.3% from 2022 to 2031 (Kashinath G, 2022)

- One of the main objectives for many businesses is the adoption of industrial IoT solutions.

The results of a PwC survey carried out in Germany are as follows:

- IoT and smart manufacturing are areas in which 91% of businesses are investing.
- 6% believe their factories have undergone complete digitization.
- 75% of businesses have made investments in digital manufacturing to better satisfy consumer demands.
- In five years, 50% of respondents anticipate ROI from digitalization.
- Over five years, companies anticipate efficiency gains of 12% in total (Kashinath G, 2022).

1.16. Challenges In the Supply Chain

Every industry will undoubtedly encounter certain difficulties while implementing new procedures or systems.

- Market volatility adds uncertainty and risk.

Companies are facing challenges such as heightened competition, evolving regulations, shifts in the geopolitical landscape, and volatility in pricing and supply. These factors test

companies' preparedness to effectively respond and operate in a cost-efficient manner on a global scale(Hajibashi, 2018).

- The expectations of consumers are always rising.

They desire localized, hyper-personalized experiences with individualized products, as well as the ability to purchase, horde, and return items whenever and wherever they like. However, current supply networks are not designed to satisfy unique client needs.

New niche companies are competing with established leaders in many categories by utilizing digital technology to offer more relevant and engaging experiences. Digital disruptors are driving development in several sectors. In an attempt to rise, incumbents are acquiring new skills and abilities (Hajibashi, 2018).

- It's challenging to render omnichannel conflicts.

Numerous well-established organizations are undertaking efforts to revamp their operational processes to provide a cohesive brand experience and ensure seamless fulfilment across various channels. Nonetheless, they encounter difficulties in effectively managing these implementations while also striving to enhance profitability(Hajibashi, 2018).

1.17. Industry of Internet of Things.

Supply chains are now dynamic networks of systems and processes known as digital supply networks, or DSNs, thanks to technology. Another piece of technology that powers a DSN and can help businesses create new opportunities is The IoT in Industry (A.Daecher, 2019).

Various sectors, including finance, insurance, supply chain management, retail, manufacturing, healthcare, education, logistics, and agriculture, stand to gain substantial benefits from the integration of big data and IoT technologies.

Administrators everywhere agree that the IoT is changing all businesses and will never remain an abstract concept. According to a recent survey, 92 per cent of executives think that

IoT will be crucial for their company's long-term success, while 64 per cent of officials think it is essential for their current operations(Barco & Khatib, 2021).

Various Industry 4.0 applications in logistics have notable implications for wireless communications. These encompass tasks like tracking objects, guiding AGVs and drones, utilizing ambient sensors for monitoring, offering remote employee assistance using AR, supervising machines and robots such as palletization machines, and employing video surveillance systems for detecting intrusions or hazards like fires (Barco & Khatib, 2021).

1.18. IoT Trends in Retail

The statement made by Ross Sabolcik, who holds the position of vice president and general manager overseeing industrial and commercial IoT products, suggests that retailers are altering consumer expectations by fusing digital interfaces into real-world experiences(Laboratories, 2023).

The retail sector, similar to numerous other industries, is experiencing a significant transformation as a result of the fourth industrial revolution and prominent societal trends. Among the critical trends influencing the retail landscape are economic recessions, increasing inflation rates, and a crisis in the cost of living, all of which pose considerable challenges.

However, retailers cannot afford to take their foot off the pedal when it comes to continuous digital transformation. This section will explore the top four retail technology trends that every retailer needs to pay close attention to in 2023.

1- Hybrid and Omni-channel Customer Journeys

Hybrid shopping, which brings the best of both online and offline shopping together, is gaining popularity. Creating customer journeys that check all the boxes for both online and offline buying is the aim. Similar to what happens when we visit an online retailer when we buy offline, it's important to know who we are and what we want. It refers to developing immersive online shopping experiences that are similar to those

we enjoy offline in the realm of retail. Cutting-edge technology that allows for customization or virtual and augmented reality solutions might do this (Marr, 2022).

2- Personalization through the Customer Journey

Consumers will continue to respond well to personalization and increasingly expect it as part of their customer journey. With the technology now available, personalization can be applied at scale. As an illustration, companies such as Stitch Fix, a fashion retailer headquartered in California, utilize algorithms to curate clothing selections tailored to individual tastes.

Similarly, sportswear titan Nike introduced its NikeiD service, enabling customers to design entirely personalized sneakers that align with their unique preferences. These instances showcase lifestyle-oriented brands leveraging the increasing desire for personalized and distinctive products that mirror individual personality and style (Bansal 2023).

3- Virtual Reality, AR, and Metaverse Enable Immersive Shopping

Consumers crave great customer experiences, above anything else, and the concept of the metaverse is generating a lot of excitement. The metaverse is an immersive, experiential digital environment where users can work, play, and shop. Brands such as Adidas, Nike, McDonald's, Cheetos, Gucci, and Burberry have established a presence in the metaverse. In 2023, we will see a big push for things like virtual try-ons and virtual dressing rooms. Retailers like Hugo Boss, Walmart, and Amazon have already implemented features that enable customers to virtually try on clothing by utilizing digital representations of themselves. This trend extends upon previous uses of augmented reality technology by companies such as Ikea and Home Depot, which enable customers to visualize how furniture would appear in their rooms before making a purchase (Marr, 2022).

4- Consumers are increasingly favouring cashless, contactless, and self-driving modes of payment and delivery, driving the demand for transaction processes that are both streamlined and efficient. Online purchases that can be picked up in-store (BOPIS) or returned in-store (BORIS) are alternatives to online shopping, and buying online and picking it up curbside (BOPUC) are quickly becoming expected trends. Artificial

intelligence and advanced analytics play a pivotal role in enabling these trends by automating intricate inventory management processes (Kim et al., 2022).

In 2023, we anticipate witnessing a surge in in-store automation, fully autonomous warehouses, and the deployment of automated delivery robots and drones, all powered by AI technology.

To stay on top of these exciting retail technology trends, retailers need to invest in the right infrastructure and continuously innovate. Those who successfully embrace these trends will be well-positioned to deliver the customer experiences that will set them apart in the years ahead (Marr, 2022).

- And there are some other big trends that every retailer needs to prepare for:
- *The first trend* is the shift towards omnichannel retail. The merging of online and offline channels, as well as the emergence of new channels like voice, has made it possible for retailers to collect data across all channels and get a holistic view of their customers. The IoT and sensors make this possible by enabling businesses to gather measurements and data from many sources (Marr, 2022).
- *The second trend* is the creation of smarter services with the use of artificial intelligence. Retailers can now create more sophisticated and AI-enabled services, including recommendation engines and customization, using the data they already have. Machine vision is used to track customers in stores like Amazon Go, where customers are charged automatically. In-store robots like Pepper are used as shop assistants, while online retailers like Little have wine recommendation robots. (Marr, 2022).
- *The third trend* is the need for more immersive experiences. To get people to their physical locations or websites, businesses must offer extra value. For example, Gucci's flagship store, which combines the functions of a museum, art gallery, café, and retail store, charges an admission price. Immersive experiences can be created

using augmented reality, where stores like Nike provide customers with additional information about products.

- *The fourth trend* is "see it like it, buy it." This trend enables customers to purchase products instantly after seeing them on TV shows, YouTube, or influencers' posts. The ability to see something and buy it straight away will become increasingly important. (Marr, 2022).
- *The fifth trend* is the middleman-free subscription model. To obtain data and develop stronger customer relationships, businesses are contacting customers directly. Companies like Dollar Shave Club allow customers to buy directly from them, while Black Socks provides monthly or quarterly delivery of business and work socks. BarkBox offers customized dog food on a subscription basis, while Nike and L'Oréal offer direct-to-consumer services (Marr, 2022).
- *The sixth trend* is autonomous delivery and fulfilment. Retailers must consider their supply chain and use automation to streamline processes. Companies like Ocado have automated warehouses where hive robots work together to create shopping baskets. Autonomous trucks, ships, and drones are used for delivery (Marr, 2021).
- *The seventh trend* is supplying chain transparency. Consumers want to know where their products come from, and retailers must be able to provide this information. Blockchain technology is used to ensure transparency, while companies like Ever Lane provide detailed information about the factories that produce their products (Francisco & Swanson, 2018).

- Finally, *the eighth trend* is sustainability. Retailers need to adapt to the growing concerns of consumers regarding the environmental impact of their operations. Companies like Patagonia and Eileen Fisher are leaders in sustainability, while Ikea is committed to using renewable materials and reducing waste. Retailers that prioritize sustainability will have a competitive advantage in the future (Marr, 2021).

Supply Chain Integrations and Agility

1.19. Supply Chain Integration

Supply chain integration includes managing tactical, strategic, and operational processes cooperatively between and within companies. Its goal is to guarantee smooth and effective flows of goods, data, and money, eventually providing the end user with the most value at the lowest possible cost and fastest possible pace. Numerous studies concur with this definition. (Alfalla-Luque et al., 2013; Huo, 2012; De Vass, Shee, & Miah, 2018). The supply chain integration literature was thoroughly analyzed, focusing on the integration of customers, suppliers, and internal processes.

The primary goal of this dimension is to effectively address customer needs by integrating all available skills, methodologies, and best practices into organized and collaborative frameworks.

Broadly speaking, there are two primary forms of supply chain integration: internal integration, which concentrates on aligning and coordinating activities within the business, and external integration, which entails working with suppliers and consumers. (Pakurár et al., 2019)

The list of Handfield and Nichols (1999, p. 5) The primary drivers of integration include the emergence of new forms of inter-organizational connections, the information revolution, and increased global competitiveness leading to more discerning customers and demand-driven markets (Saber, 2005).

Table 5 explains the differences between traditional and integrated supply chains. Traditional supply chains are characterized by adversarial relationships, a biased focus on

long-term outcomes, and a low emphasis on value-added products. Conversely, an integrated supply chain emphasizes close collaboration, long-term viability, advanced management capabilities, and support for lower levels of business, thereby improving communication and promoting mutual benefits for all stakeholders. "SC" refers to the supply chain, and "SCI" stands for supply chain integration.

Table 5: Differences between traditional SC and integrated SC(Komarov, 2020)

traditional SCs	integrated SCs
<ul style="list-style-type: none"> • tense interactions between clients and providers • Lack of enthusiasm for joint profit and risk sharing • little attention on long-term success • Value-added items are given less consideration in favor of cost and delivery • Inadequate communication among the SC's allies 	<ul style="list-style-type: none"> • a close partnership between suppliers, customers, and OEMs (original equipment manufacturers) • Prioritize sustained achievement and acknowledge the significance of every individual involved. • Tier 1 enterprises help lower-tier firms in order to support SCI. • sophisticated managerial ability to maximize the use of current business capabilities • ISC is focused on increasing income and lowering risks for all of its partners.

The National Academies of Sciences, Engineering, and Medicine characterizes an integrated supply chain as a cooperative network comprising customers and suppliers that employ management strategies to improve their joint performance during the processes of product creation, distribution, and delivery(Mecalux, 2022). Supply chain integration refers to the act of connecting distributors, manufacturers, suppliers, and retailers to ensure a seamless movement of goods and services. This essay will primarily focus on the advantages of integrating supply chains and the various strategies that businesses can employ to achieve these benefits(HAYES, 2023).

The primary aim of SCI is to enhance the uninterrupted movement of products and services throughout the complete supply chain. The overarching purpose of SCM is to

guarantee the punctual distribution of goods to consumers, adhering to financial limitations, and under optimal circumstances. All parties involved in the process must work together and coordinate for supply chain integration to be successful. Enhanced supply chains ultimately lead to lower costs and more efficiency.

To attain supply chain integration, organizations may employ a variety of strategies. One effective method involves the use of IoT technology to create links among various stakeholders within the supply chain. Furthermore, the adoption of Electronic Data Interchange (EDI) can enhance communication between diverse computer systems, thereby promoting smooth data transfer throughout the supply chain. Utilizing a SCM system is an additional strategy for overseeing the various supply chain activities. SCM systems may assist businesses in tracking inventory levels, tracking the status of their orders, as well as maximizing the flow of products and services throughout the supply chain. (Kunrath et al., 2023)

Taking into account the contributions as a result of a huge, vertically integrated organization might be beneficial. But the only things holding the chain's separate businesses together are mutual trust, common goals, and freely signed contracts. In contrast to captive providers—large corporation divisions that often cater primarily to the larger enterprise—unbiased suppliers frequently deal with the competing demands of several clients(Council, 2000a). All supply chains have a degree of integration. The key goal of improving this integration is to align and coordinate the vital resources of each supply chain participant. This alignment addresses the collective needs of the chain, thereby boosting its overall performance(Council, 2000a).

The process of integration entails the deliberate application of management strategies, methodologies, and technologies to link essential competencies and resources throughout the supply chain, thereby leveraging existing business opportunities. Typical goals encompass increasing profitability and reducing risks for all stakeholders involved(Council, 2000a).

Typical unmanaged or minimally managed delivery chains frequently have unfavourable client-supplier relationships and place little emphasis on sharing benefits and risks, this

scenario is characterized by focusing on short-term goals without considering long-term success, prioritizing cost and delivery over value, limited communication channels, and limited interaction between the OEM and suppliers beyond one or two tiers(Council, 2000a).

Generally speaking, integrated delivery chains recognize that all parties involved in a relationship need to enjoy it for a long time and are defined by their use of partnerships with open, honest, and large-scale communication(Telsang, 2015). One way to envision a well-integrated network of independent entities is to liken it to a flock of red-winged blackbirds gracefully soaring over a swamp. Each bird in the flock adjusts its flight, dives, or turns simultaneously without any explicit cue to maintain their competitiveness, supply chain players also need to adapt quickly to changes in the business environment(Komarov, 2020).

Benefits of Supply Chain Integration



Figure 2: Benefits of Supply Chain Integration (Marker, 2023)

Improving SCI is a continuous effort that requires cooperation among Original Equipment Manufacturers (OEMs), customers, and suppliers. This collaboration strengthens their relationships and facilitates the sharing of critical information about key activities at all levels of the supply chain.

Through the provision of mentorship and support to subordinate suppliers, primary suppliers can play a critical role in promoting integration (Team, 2022). Wal-Mart's extensive incorporation of P&G's Pampers product line into its supply chain showcases a case of multi-

level integration. In reaction, P&G and 3M came together to merge their production of adhesive strips with Pampers' manufacturing sites(PRESS, 2000).

- A key benefit of maintaining an integrated supply chain is its ability to enhance overall efficiency and coordination among various stakeholders: (Khurana, 2020)

1. Enhanced cooperation and transparency

To minimize expenses, inefficiencies, lead times, and turnaround times, it is crucial to establish connections between various segments within a unified supply chain. Emphasizing centralization in an integrated supply chain is essential for enhancing transparency throughout the entire organization, rather than permitting disparate functions to function autonomously(Browning 2023). According to a survey carried out by Oracle clients, a significant majority of 82% reported a notable enhancement in their on-time delivery rate through collaborative efforts across the entire organization to develop innovative products. This collaborative approach resulted in improved supply chain management, production efficiency, and overall operational effectiveness(Khurana, 2020).

By integrating the supply chain, organizations may gain a better understanding of the numerous processes involved in the production and delivery of their goods. This can assist them in tracking the status of their orders, keeping an eye on inventory levels, and locating possible bottlenecks. Enhanced visibility can also assist companies in reacting faster to shifts in demand or interruptions in the supply chain(Khurana, 2020).

2. Stay ahead of the curve.

An integrated supply chain with elevated visibility has an increased ability to stay on top of decisions. Achieving consistent delivery and meeting demand effectively would be extremely difficult without the visibility provided by an integrated supply chain(Inspirage, 2016).

Companies can anticipate and act accordingly because of their integrated logistics, delivery chain, product innovation, and monetary strategies.(Khurana, 2020).

3. Flexibility

Increased flexibility is one of an integrated delivery chain's most significant benefit. Chirantan Basu, a contributor to the Houston Chronicle, pointed out that flexibility may be attained by integrating every aspect of a firm(Khurana, 2020).

4. Eliminate waste

A supply chain's sustainability demands dedication and close attention to detail. According to Paul A., AI has advanced significantly in recent years. Myerson, a supply chain management specialist who writes for Inbound Logistics, claims that applying lean approaches makes it easier to find and get rid of supply chain inefficiencies. Additionally, improved agility enables organizations to effectively deal with unforeseen situations (Khurana, 2020).

5. Higher profit margins

When the supply chain runs smoothly, businesses can maintain or even increase their income, making this benefit cumulative with the other four(Inspirage, 2016). Creating and delivering goods more quickly, increasing their hit rate, and increasing their profitability margin may be achieved by organizations by effectively managing an innovative and cooperative supply chain using cloud-based supply chain management systems.(Khurana, 2020).

6. Improved Efficiency

When all parties involved in the supply chain are integrated, they can work together to identify inefficiencies and streamline processes. This can assist lessen lead times, enhance quality, and decrease costs(capital, 2023). Supply chain integration can additionally facilitate prompt responses to fluctuations in demand, diminish inventory levels, and enhance customer service for organizations(Khurana, 2020).

In summary, Businesses looking to get the most out of their supplier networks must integrate their supply chains effectively. Organizations may improve efficiency, boost transparency, and react promptly to changes in demand or supply chain interruptions by

integrating different supply chain actors. Utilizing tools such as supply chain management systems and advanced technologies can help integrate different elements within a company's supply chain. Organizations that effectively achieve this integration are well-positioned to gain a competitive advantage by enhancing their capability to deliver high-quality products to customers while also reducing costs (Khurana, 2020). Two fundamental classifications pertain to SCI. These classifications encompass both internal and external integration (Pakurár et al., 2019).

1.19.1. External Integration

Effective SCM heavily relies on external integration, which encompasses various stakeholders including suppliers, producers, distributors, sellers, and consumers. Effective external integration in the supply chain can optimize operations, reduce costs, enhance agility, and increase customer satisfaction (Huo, Jiang, Jia, & Li, 2009).

External Supply Chains are the networks of activities carried out outside of a company that have a direct or indirect impact on the company, such as supplier failure, changes in law, and natural disasters (Management, 2022).

High external integration is characterized by improved logistics collaboration among the focal business, suppliers, and consumers, as well as the blurring of organizational boundaries among participants in the logistics collaboration. The supply chain functions as a genuine, physical entity thanks to external integration, which gives it a stronger competitive edge (Huo et al., 2009).

- How external integration can benefit supply chain management?

Firstly, through the linkage of diverse systems and information repositories, external integration has the potential to enhance the visibility of supply chains, thereby enabling organizations to acquire real-time insights regarding their supply chain operations. By integrating with suppliers and logistics providers, organizations can get visibility into inventory levels, shipping schedules, and delivery status, allowing them to better manage demand and optimize inventory levels. Similarly, by integrating with customers,

organizations can gain visibility into customer demand and order patterns, allowing them to forecast demand and plan production and logistics accordingly (Javaid 2024).

Secondly, improving cooperation and communication between suppliers and customers through external integration leads to improved performance and increased customer satisfaction. By sharing data and insights in real-time, organizations and their partners can work together more effectively to identify and resolve issues, reduce lead times, and improve delivery accuracy. For example, by integrating with suppliers, organizations can improve supply chain transparency, reduce lead times, and improve product quality by sharing information on order status, production schedules, and quality metrics (Xiande et al., 2011).

Thirdly, external integration can save costs and increase efficiency by optimizing transportation and inventory processes (Chain.io, 2024). Organizations may enhance delivery times, save shipping costs, and optimize transportation routes by connecting with logistics providers and transportation management systems. In a similar vein, companies may better match supply with demand and manage inventory levels by integrating with suppliers and consumers (Khokale, 2023).

Finally, external integration can help organizations comply with government regulations and improve sustainability by connecting with external systems and platforms. For example, by integrating with customs clearance systems, organizations can streamline the import and export process, reducing lead times and ensuring compliance with regulations (Future, 2023). Similarly, by integrating with sustainability and environmental platforms, organizations can track and report on sustainability metrics, such as carbon emissions and waste reduction, improving their reputation and customer loyalty.

All things considered, external integration is essential to supply chain management because it makes it possible for businesses to communicate with vendors, clients, logistics companies, and other supply chain network participants. This promotes increased visibility, cooperation, efficiency, and compliance.

Supply chain external integration entails several cooperative and coordinated operations between a focused business and its external partners. These initiatives aim to ensure the supply chain's entire effectiveness and efficiency.

- Some key activities of supply chain external integration include:

1. Supplier relationship management involves building strong partnerships with suppliers to foster cooperation, enhance communication, and ensure the timely and reliable delivery of materials and components (Lambert, D. M., & Cooper, M. C. 2000).

2. Customer Relationship Management: Establishing robust connections with clientele to acquire a deeper understanding of their requirements, inclinations, and expectations, thus facilitating enhanced demand prediction and customer support (Mentzer, J. T., DeWitt, 2001).

3. High external integration is characterized by improved logistics collaboration among the focal business, suppliers, and consumers, as well as the blurring of organizational boundaries among participants in the logistics collaboration (Ellinger, A. E., Daugherty, P. J., & Keller, S. B. 2000).

4. Vendor-Managed Inventory (VMI): Enhancing inventory accuracy, decreasing stockouts, and lowering holding costs by enabling suppliers to keep an eye on and control inventory levels at the customer's location (Ganeshan, R., & Harrison, T. P. 1995).

5. Joint Product Development: Collaborating with suppliers and customers in the development of new products or product enhancements, leveraging their expertise and resources to create innovative and market-responsive offerings (Narasimhan, R., & Das, A. 2001).

6. Information Sharing: Sharing real-time data and information with external partners, including suppliers, customers, and logistics providers, to enhance visibility, coordination, and decision-making throughout the supply chain (Ohlich, M. T., & Westbrook, R. 2001).

7. Coordinated Production and Delivery Scheduling: Aligning production schedules and delivery timelines with suppliers and customers to optimize resource utilization, minimize lead times, and improve overall supply chain efficiency (Croom, S., & Giannakis, M. 2000).

8. Shared Warehousing and Distribution: Collaborating with partners to share warehouse and distribution facilities, reducing costs, optimizing transportation, and improving responsiveness to customer demands (Ellram, L. M. 1996).

9. Supplier Development: Assisting suppliers in enhancing their capabilities, quality standards, and operational efficiency to ensure a reliable and sustainable supply base (Vonderembse, M. A., Uppal, 2006).

10. Risk management and resilience include working with outside partners to proactively plan and implement contingency measures to detect and reduce supply chain risks, such as interruptions, natural catastrophes, or market uncertainty (Lee, H. L., & Whang, S. 2000).

These initiatives are essential for strengthening the integration and collaboration of many actors in the supply chain network, which in turn fosters improved effectiveness, flexibility, responsiveness, and customer satisfaction.

A- Customer Integration

The process entails merging customers into the SCM system of the organization to offer them up-to-date information on the progress of their orders, enhance delivery speed, and improve customer service.

Moreover, IoT enables suppliers to plan for on-time stock delivery by giving them access to their customers' inventory data. Furthermore, a supplier can share advanced transportation visibility with its clients through the use of IoT (Zhang et al., 2006).

Customer integration, a component of external integration within SCM, pertains to the cooperative endeavours undertaken by a central company to actively involve and engage customers in the various processes of the supply chain (Lambert, D. M., Emmelhainz, M. A., & Gardner, J. T. 1996).

It entails the smooth integration of client preferences, needs, and input into the planning, designing, and carrying out of supply chain operations. The objective is to enhance customer satisfaction, increase customer loyalty, and achieve mutual value creation.

Here are some key aspects of customer integration as part of external integration:

1. **Customer Relationship Management (CRM):** Building and maintaining solid connections with clients is the first step towards customer integration. To do this, one must comprehend their requirements, inclinations, and anticipations. Companies may gather and analyze customer data, such as purchase trends, comments, and complaints, by utilizing CRM tools and methodologies. This allows them to obtain insights that can inform supply chain decision-making (Chen, I. J., & Paulraj, A. 2004).

2. **Demand Forecasting and Planning:** To effectively integrate customers into demand forecasting and planning procedures, they must be actively involved. Companies may learn about future demand patterns, and market dynamics, by collaborating with their customers, and they can change their preferences. This approach reduces the risk of stockouts or excess inventory, enhances the accuracy of demand forecasts, and aligns production and inventory strategies effectively. (Prahinski, C., & Kocabasoglu, C. 2006).

3. Customization and Personalization: Customization and personalization of products or services to meet individual customer requirements is a key element of customer integration. By collaborating with customers, companies can gather specific customization requests or preferences, allowing for tailored product offerings and unique customer experiences. This level of customization can enhance customer satisfaction and loyalty (Hsieh, Y. F., & Yang, C. L. 2009).

4. Co-Creation of Value: Customer integration encourages the active involvement of customers in the co-creation of value within the supply chain. This can involve soliciting customer feedback, engaging them in product design or development processes, or involving them in decision-making related to service offerings. By involving customers in value co-creation, companies can better align their offerings with customer needs, leading to enhanced customer satisfaction and loyalty (Ellinger, A. E., & Chapman, R. L. 2011).

5. Communication and Feedback: Customer integration requires effective communication channels and mechanisms for capturing customer feedback. Companies can utilize various tools, such as online portals, surveys, social media, or customer service interactions, to gather customer feedback on product quality, delivery experience, or overall satisfaction. This feedback helps in identifying areas for improvement and driving continuous enhancement of supply chain processes (Fawcett, S. E., Ellram, L. M., & Ogden, J. A. 2014).

6. Post-Sales Service and Support: Customer integration extends beyond the point of sale. It involves providing comprehensive post-sales service and support to ensure customer satisfaction. This can include timely order updates, proactive communication regarding delivery status, efficient handling of returns or complaints, and responsive customer service. Through the provision of exemplary post-sales assistance, organizations can establish enduring customer relationships and cultivate customer fidelity (Narasimhan, R., & Kim, S. W. 2002).

Supply chains that emphasize customer priorities ought to integrate customer involvement as a fundamental component of external integration. By engaging customers in supply chain processes, organizations can acquire a more profound understanding of client

needs, customize their products and services more adeptly, and provide outstanding customer experiences. This leads to increased customer satisfaction, strengthened brand loyalty, and a competitive edge in the marketplace.

B- Supplier Integration

The operational integration of the supply chain is significantly impacted by supplier integration. The higher level of integration with upstream results in a more responsive supply chain. This means that order fulfilment, inventory control, and supplier collaboration will all be improved by integrating suppliers into the business's supply chain management system. Consequently, to establish partnerships with suppliers that would improve the company's performance or capabilities and satisfy customers' short- or long-term supply demands, the focused business should focus more on supplier development and integration (Huo, Jiang, Jia, & Li, 2009).

To maximize supplier networks and resources and increase consumer satisfaction, businesses must obtain more precise information in a volatile climate (Petersen et al. 2005).

To ensure effective communication and data updates, a procurement organization needs to maintain regular contact with suppliers and keep internal integration processes up-to-date. This practice is crucial because the data accessible to purchasers may not consistently depict current or continuous problems in the market (Narasimhan et al. 2010; Das et al. 2006). The collaboration between a buying company and a supplier can be categorized into two primary dimensions. Firstly, the supplier serves as a provider of components and parts. Secondly, they assume the role of a strategic collaborator, actively sharing their expertise and knowledge.

The advent of the IoT has further enhanced supplier integration by leveraging IoT technology to enable automation, real-time connectivity, and data exchange between the core business and its suppliers. IoT makes it possible to collect, process, and share important supply chain data, which enhances efficiency, visibility, and traceability across the supplier network.

- The following are some crucial elements of the function of IoT in supplier integration as part of external integration:

1. **Supplier Relationship Management:** Building and maintaining solid relationships with suppliers based on mutual respect, cooperation, and benefit is known as supplier integration. Businesses may improve communication, allow for real-time collaboration, and increase transparency with suppliers by utilizing IoT technology. Suppliers may better synchronize their operations by having access to real-time demand information, manufacturing schedules, and inventory levels using IoT-enabled systems(ANIS, MEHMOOD, & ASIF, 2023).
2. **Supplier Performance Measurement:** Supplier integration includes the measurement and evaluation of supplier performance to ensure adherence to quality, delivery, and cost requirements. The IoT has the potential to streamline the gathering of up-to-the-minute information regarding supplier performance indicators, including punctual delivery, product excellence, and stock levels. This valuable data can be leveraged to evaluate supplier performance, pinpoint areas that require enhancement, and foster ongoing supplier development endeavours(Saengchai & Jermittiparsert, 2019a).
3. **Supply Chain Visibility:** Supplier integration aims to enhance the visibility of the supply chain by providing contemporaneous information regarding supplier engagement, inventory quantities, and the status of orders. IoT devices may be used to track and monitor shipments, keep an eye on inventory levels, and record environmental conditions while in transit. Examples of these devices include sensors, RFID tags, and GPS trackers. By facilitating proactive decision-making and enhancing overall supply chain responsiveness, this data may be disseminated throughout the supply chain network(De Vass, 2018).
4. **Collaborative Planning and Forecasting:** To guarantee that supply and demand are in line, supplier integration includes cooperative planning and forecasting with suppliers. Suppliers may modify their production schedules and inventory levels by providing real-time demand data, production plans, and capacity information using IoT-enabled solutions. This cooperative strategy can eliminate stockouts or surplus inventory, save lead times, and optimize inventory.
5. **Supply Chain Risk Management:** Supplier integration includes managing supply chain risks and disruptions. IoT can play a significant role in risk monitoring and mitigation by

providing real-time data on potential disruptions, such as delays in shipments, changes in weather conditions, or equipment failures. With this information, companies can proactively address risks, make alternative plans, and ensure continuity in the supply chain(Zhu et al., 2017).

6. Supplier Collaboration and Innovation: Supplier integration emphasizes collaboration and innovation with suppliers to drive continuous improvement and bring new products or technologies to market. IoT-enabled platforms can make it easy for the focal company and its suppliers to communicate, share data, and solve issues together smoothly. This collaboration can lead to joint innovation initiatives, shared cost savings, and enhanced competitiveness(De Vass, 2018).

In general, supplier relationships are optimized, supply chain visibility is increased, cooperation is improved, and risks are mitigated when supplier integration and IoT technology integration are combined. Businesses may obtain real-time connection, data-driven insights, and improved decision-making skills by utilizing IoT, which will lead to a supply chain ecosystem that is more responsive, efficient, and robust.

C- Logistic Integration

This involves the incorporation of logistics enterprises within the organizational structure of supply chain management, thereby optimizing transportation and storage processes, which results in reduced costs and enhanced productivity(Gep, 2023a). Logistical integration, a component of external integration, involves the efficient synchronization and cooperation of logistical activities across different supply chain participants, including producers, distributors, suppliers, and consumers within the realm of supply chain management(Prajogo & Olhager, 2012b). It entails integrating systems, information, and procedures to improve the supply chain's general effectiveness, responsiveness, and efficiency(Mecalux, 2021).

Logical integration necessitates the dismantling of obstacles that exist between various departments and the formulation of a cohesive strategy for overseeing the movement of products, services, and information throughout the entirety of the supply chain. To attain

shared goals such as the minimization of expenses, the augmentation of transparency, and the enhancement of customer service, supply chain partners must prioritize collaborative efforts alongside the exchange of resources and data (Mecalux, 2021).

- Here are some key aspects of logistic integration as part of external integration:

1. **Information Sharing:** Real-time information exchange between supply chain participants is necessary for logistical integration. Data on inventory levels, manufacturing schedules, travel arrangements, and consumer demand are all included in this. Supply chain participants are better able to make choices and react swiftly to changes in supply or demand when they have access to fast and reliable information. (Fawcett, S. E., & Magnan, G. M. 2002).

2. **Collaborative Planning:** Logistic integration encompasses collaborative planning processes like collaborative forecasting and demand planning. Supply chain partners collaborate to generate precise demand forecasts, synchronize production and inventory plans, and coordinate logistics activities. This aids in minimizing forecasting errors, optimizing inventory levels, and guaranteeing product availability at the appropriate time and location (Christopher, M. 1998).

3. **Coordinated Order Fulfillment:** Logistic integration enables the coordination of order fulfillment activities across the supply chain. This includes coordinating production schedules, managing inventory levels, and coordinating transportation and logistics operations.

By synchronizing these activities, supply chain partners can minimize lead times, reduce stockouts, and improve order fulfillment rates (Mentzer, J. T., Stank, T. P., & Esper, T. L. 2008).

4. **Shared Resources:** Supply chain partners share assets and resources as part of logistic integration. This might involve pooling resources for manufacturing, transportation, and even warehousing. Supply chain participants can maximize resource usage, cut expenses, and raise

overall operational efficiency by pooling resources (Bowersox, D. J., Closs, D. J., & Cooper, M. B. 2007).

5. Performance Measurement: Establishing performance assessment criteria and distributing performance data across supply chain participants are prerequisites for logistic integration. By engaging in this systematic evaluation, individuals can critically analyze the efficacy of the supply chain, pinpoint domains that necessitate improvement, and implement requisite measures to augment the comprehensive performance of the supply chain (Hertz, S., & Alfredsson, M. 2003).

6. Joint Decision-Making: Logistic integration fosters joint decision-making among supply chain partners. This involves involving key stakeholders in the decision-making process, such as suppliers, manufacturers, distributors, and customers. By involving all relevant parties, supply chain decisions can be more aligned with overall business objectives, leading to better outcomes and improved supply chain performance. (Stock, J. R., & Lambert, D. M. 2001)

Overall, logistic integration as part of external integration is essential for creating a collaborative and synchronized supply chain. By integrating logistical activities, sharing information, and aligning processes, supply chain partners can enhance efficiency, responsiveness, and customer satisfaction.

D- Government and Regulatory Compliance

This involves integrating with external systems and platforms to comply with government regulations, such as customs clearance, safety and environmental standards, and labour laws.

Government and regulatory compliance, as an integral component of external integration within the paradigm of supply chain management, pertains to the conformity and alignment of supply chain methodologies with pertinent legal statutes, regulatory frameworks, and standards established by governmental agencies and regulatory entities. It involves ensuring

that supply chain processes, operations, and products comply with legal requirements, safety standards, environmental regulations, and other applicable guidelines.

As the IoT advances, supply chain management has become increasingly reliant on adherence to government regulations and compliance standards. The collection, analysis, and transmission of real-time data via IoT technologies can be utilized for monitoring and ensuring compliance with various regulations and standards throughout the supply chain.

Here are some key aspects of government and regulatory compliance as part of external integration, along with the role of IoT:

1. **Regulatory Compliance Monitoring:** Government and regulatory compliance requires continuous monitoring and adherence to applicable regulations, such as product safety, labelling, customs regulations, trade restrictions, and environmental standards. IoT can assist in real-time monitoring and data capture to ensure compliance. IoT sensors, for example, are capable of monitoring and recording temperature, humidity, and various other environmental conditions throughout the processes of transportation and storage, thereby ensuring adherence to regulatory standards for sensitive items such as pharmaceuticals and food products (Kannan, V. R., & Tan, K. C. 2015).
2. **Traceability and Serialization:** Compliance frequently entails traceability and serialization requirements, particularly in industries like pharmaceuticals, automotive, or food. IoT devices like RFID tags or barcodes facilitate the tracking and tracing of products across the supply chain. This helps in maintaining accurate records, ensuring product authenticity, preventing counterfeiting, and complying with regulations related to product identification, recalls, and warranties (Berman, B., & Thelen, S. 2004).
3. **Safety and Quality Standards:** Compliance with safety and quality standards, such as ISO certifications, industry-specific regulations, or international standards, is critical for supply chain operations. IoT-enabled gadgets may track and gather data in real-time on variables like vibration, pressure, and temperature to make sure that products fulfil quality standards. Additionally, IoT-based quality control systems can automate inspection processes, identify

non-compliant products, and trigger corrective actions to maintain regulatory compliance (Filimonau, V., & Dickinson, J. 2010).

4. Customs and Trade Compliance: Government and regulatory compliance in supply chain management includes adherence to customs regulations, trade agreements, and import/export procedures. IoT-based tracking systems can provide real-time visibility of shipments, ensuring accurate documentation, timely customs clearance, and compliance with trade regulations. (Ali, S. M., & Yang, L. 2015).

Furthermore, IoT technologies can assist in automating documentation processes, reducing errors, and facilitating efficient customs compliance.

1.19.2. Internal Integration

When we talk about internal integration in supply chain management, we're talking about how different departments, units, and activities inside a company work together seamlessly to produce effective and efficient operations. When combined with IoT technologies, internal integration becomes even more powerful in enhancing operational performance, decision-making, and overall supply chain productivity. This can be achieved through a multitude of methodologies, encompassing:

- **Direct connection:** This is the most common method, and involves connecting IoT devices directly to the organization's network. This can be done using a variety of wired or wireless protocols.
- **Cloud-based integration:** By linking IoT devices to a cloud-based platform, this technique offers a secure means of communication between the devices and the internal systems of the company.
- **Edge computing:** This methodology encompasses the integration of Internet of Things (IoT) devices with an edge-computing architecture, which constitutes a compact, decentralized computational framework situated in proximity to the devices. This approach has the potential to boost performance and decrease latency (Gcore, 2023).

1.20. Supply Chain Agility

Supply chain agility refers to its ability to quickly and effectively adjust to changes in supply, demand, or market conditions.(GEP, 2023b). To fulfil consumer demands and market dynamics, the supply chain must be responsive and flexible enough to modify and alter its operations, procedures, and resources (Aavenir, 2023).

In today's dynamic business environment, where variables like shifting consumer tastes, market upheavals, and world events may have a big influence on supply chain operations, supply chain agility is essential. Agile supply chains help businesses manage uncertainty, reduce risk, and take advantage of opportunities(McBeth, 2023).

- **Customer Agility**

Customer agility is said as follows: " A company must have the capability to swiftly identify and capitalize on customer-driven opportunities for innovation and competitive initiatives." (Wamba, 2022). As a component of SCA, customer agility describes an organization's capacity to adapt quickly to the shifting needs and preferences of its clientele. It entails comprehending client demands, matching goods and services to those needs, and ensuring a smooth customer experience through the supply chain(Y., 2022).

- **Organization Agility**

Organizational agility is referred the capacity of a company to swiftly adjust to shifts in the market, consumer needs, and business environment. Boosting supply chain efficiency entails cultivating an innovative, adaptable, and continuous improvement culture inside the company(Rui Bi, 2013).

Methodology

This study examined data from 315 professionals, including managers and employees, using structural equation modelling to ascertain how the IoT affects critical supply chain performance factors, particularly integration and agility.

1.21. Theoretical Framework

This PhD thesis's theoretical foundation is based on pertinent research that explores the connection between SCP management and information technology. A notable investigation carried out by Zhang and colleagues (2011), titled "Does ICT Influence Supply Chain Management and Performance? A review of survey-based research," provides valuable insights into this domain. Some studies have already proven the relations between some of the variables but have never used all of them together in one study. This research establishes a foundational framework for understanding and exploring the interrelations among IoT capabilities, the processes of supply chain integration, supply chain agility, and overall performance metrics. This interrelationship is depicted in Figure 6 of the conceptual model. A survey instrument was rigorously designed and disseminated to enterprises engaged in the retail sector within Turkey to empirically validate the associations posited by the theoretical framework. The primary objective of the survey was to gather empirical data that would enable a thorough examination of the proposed relationships among the pertinent components. Utilizing the SPSS AMOS 23 software application, structural equation modelling (SEM) was employed to analyze the collected data and assess the hypothesized correlations. (Byrne, 2013).

The SEM analysis followed a two-step approach commonly adopted in structural equation modelling. Firstly, to make sure the constructs were reliable, consistent, and one-dimensional, the measurement model was evaluated. Statistical studies including composite reliability evaluations and alpha reliability assessments were used in this study (Anderson & Gerbing, 1988; Huo, 2012; Hair et al., 2014; Yu et al., 2013). Subsequently, the structural model was examined, focusing on the verification of the structural relationships between the constructs. This verification was accomplished through the variance-covariance approach,

which allows for the evaluation of how the constructs interact and influence each other (Wang et al., 2006; Yu et al., 2013).

By the use of a thorough SEM investigation and a broad theoretical framework. This study's primary objective is to investigate and comprehend the intricate connections among performance, SCA, SCI, and capabilities of IoT. Validating the measurement and structural models using robust statistical methods is expected to offer valuable insights into the proposed relationships and contribute to the progress of knowledge in the field.

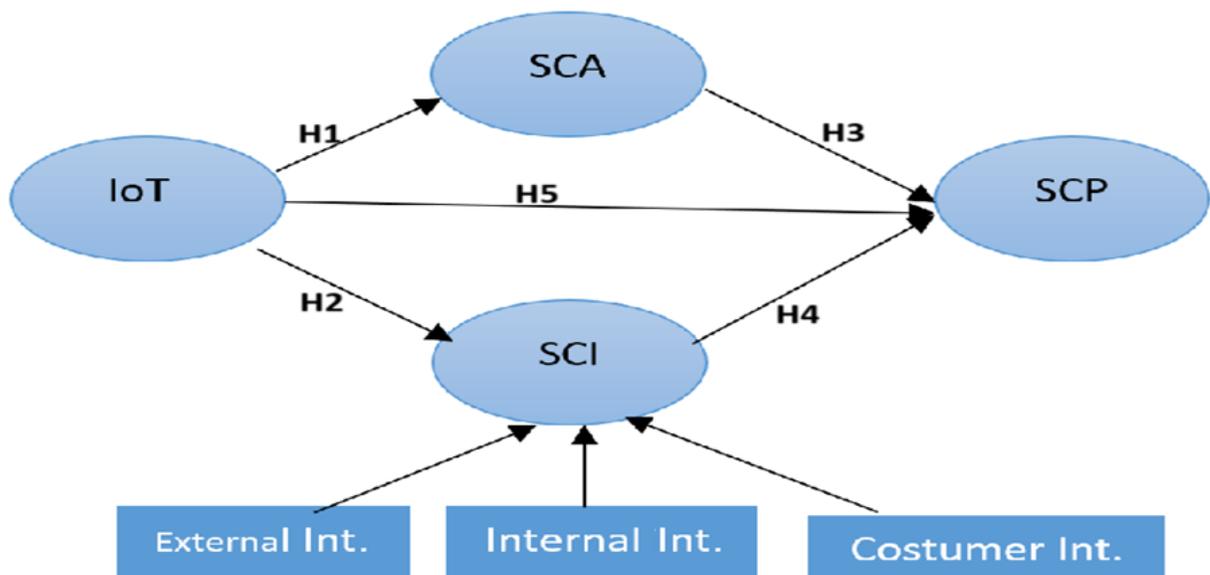
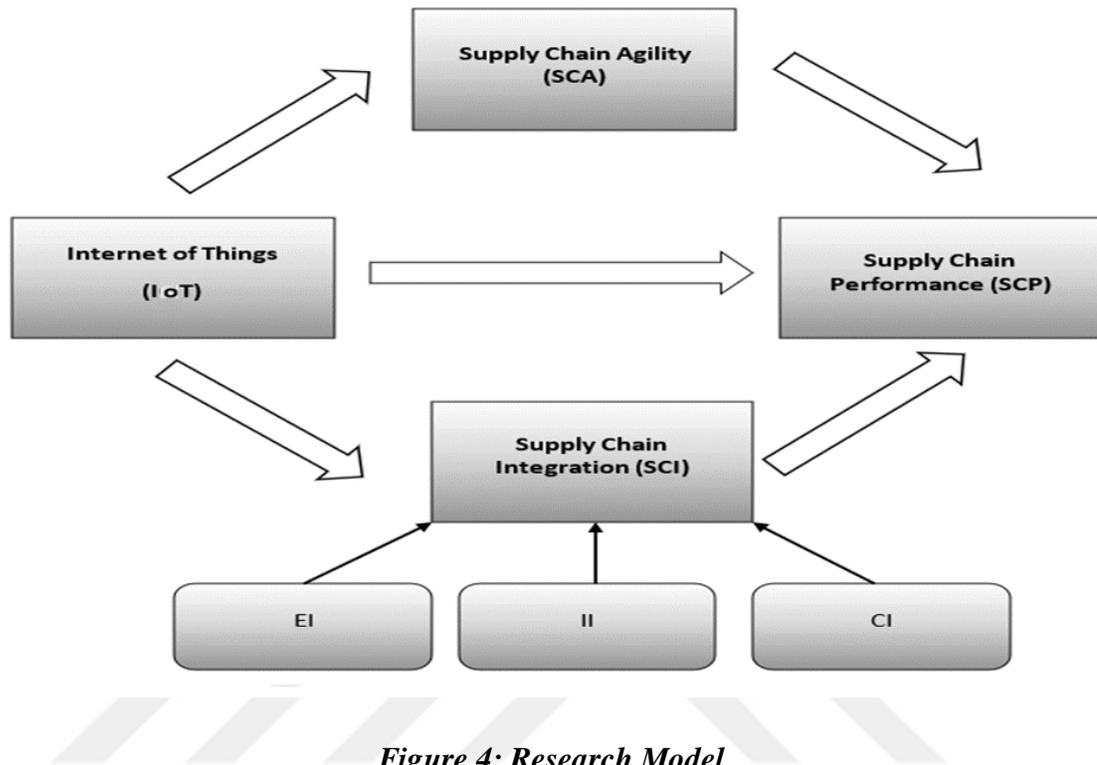


Figure 3: The Theoretical Framework

1.22. Research Model

For the research carried out in the statistical survey model, the research model can be visualized as in Figure 5 in line with the research objectives and hypotheses.



1.23. Hypotheses of The Research.

The objective of the research endeavour is to ascertain whether the efficacy of supply chain operations is directly influenced by the Internet of Things, or if factors such as supply chain integration and agility exert an indirect influence. The conceptual frameworks about supply chain management, performance metrics, and the Internet of Things are constructed upon the foundation of extant scholarly literature.

1. Direct Impact Hypothesis:

Hypothesis 1 (H1): The influence of the Internet of Things on the efficacy of supply chain operations is unequivocally advantageous.

According to this theory, supply chain performance will increase when IoT technologies are adopted and put into practice. It suggests that greater visibility, real-time tracking, and

effective data interchange are made possible by IoT, leading to increased operational effectiveness, cost savings, and customer satisfaction.

2. Mediation Hypotheses:

Hypothesis 2 (H2): The relationship between the efficacy of supply chain operations and the Internet of Things is contingent upon the degree of integration within the supply chain.

Hypothesis 3 (H3): The relationship between the Internet of Things and supply chain performance is mediated by supply chain agility.

These mediation theories suggest that supply chain integration and agility have an impact on the relationship between supply chain performance in the Internet of Things.

In line with hypothesis H2, IoT enables smooth cooperation and integration across supply chain players, enabling efficient information sharing, synchronization, and coordination. This leads to improved SCP. According to H3, IoT makes supply chains more agile by facilitating adaptive decision-making, real-time monitoring, and predictive analytics. The supply chain's capacity to rapidly and effectively adapt to changing consumer needs, disruptions, and uncertainties leads to enhanced SCP.

Through an examination of the mediation hypotheses, the research seeks to understand how IoT affects the efficacy of the supply chain. This study provides insightful information on the functions of supply chain agility and integration.

In essence, these theories have a vital function in laying the foundation for the investigation and guiding the exploration of the relationships between IoT, SCP, SCI, and SCA. To confirm the theories and achieve a better understanding of the influence of the IoT on the efficiency of supply chains in the Turkish retail sector, the research study will involve collecting information from selected retail companies.

As seen in Figure 4, the conceptual framework's representation of the research constructs' hierarchical linkages is examined by the hypotheses.

- **Hypotheses Development**

Several theories may be developed to investigate how IoT affects supply chain performance, integration, and agility. These theories provide a platform for additional research since they are supported by actual data and current literature.

Hypothesis 1: IoT positively impacts supply chain agility.

Supporting Literature:

1. **Lee, Romzi, Hanaysha, and Alzoubi (2022)** showed that IoT adoption leads to better visibility, efficiency, and responsiveness in supply chains. The study emphasized the role of IoT in providing real-time information that enhances the agility of supply chain operations.

Hypothesis 1 Example:

H1: IoT positively impacts SCA by providing real-time visibility and predictive analytics.

Hypothesis 2: IoT positively impacts supply chain integration.

Supporting Literature:

1. **De Vass, Shee, and Miah (2018)** have shown that by supplying real-time data and enabling smooth communication amongst supply chain stakeholders, IoT greatly improves SCI. The study found that IoT-enabled integration improves coordination and collaboration, leading to more efficient supply chain operations.
2. **Shafique et al. (2018)** the significance of the Internet of Things (IoT) in augmenting supply chain integration has been emphasized through its capacity to facilitate real-time monitoring and tracking of commodities. The research demonstrated that IoT technologies significantly improve visibility and transparency within the supply chain, thereby promoting enhanced integration and collaboration among stakeholders.
3. **Ben-Daya, Hassini, and Bahroun (2019)** examined how IoT is being used in SCM and discovered that by improving partner coordination and information sharing, IoT

greatly enhances SCI. The study emphasized that IoT facilitates real-time data exchange, leading to improved decision-making and operational efficiency.

4. **Wang, Chen, and Xue (2020)** explored the impact of IoT on SCI in the manufacturing sector. The study found that IoT adoption leads to better integration of supply chain processes, improving overall performance and responsiveness.

Hypothesis 2 Example:

H2: IoT has a good effect on SCI by giving participants in the chain access to real-time data and enabling smooth communication.

Hypothesis 3: Supply Chain Agility guarantees the relationship between IoT and Supply Chain Performance.

Supporting Literature:

1. **Dubey, Gunasekaran, and Childe (2018)** discovered that the connection between IoT deployment and organizational performance is considerably mediated by supply chain agility. The study showed that IoT-enabled real-time data and predictive analytics improve supply chain agility, allowing companies to respond more quickly and effectively to changes in the business environment.
2. **Khan and Wisner (2019)** emphasized that agility is a critical capability for maintaining competitiveness in dynamic markets. The study found that IoT technologies enhance agility by providing real-time information and enabling faster decision-making.

Hypothesis 3 Example:

H3: Supply chain agility mediates the relationship between IoT and supply chain performance, enhancing the positive impact of IoT on overall efficiency and responsiveness.

Hypothesis 4: The link between IoT and supply chain performance is mediated by supply chain integration.

Supporting Literature:

1. **De Vass, Shee, and Miah (2018)** highlighted that SCI significantly enhances the positive impact of IoT on SCP. The study found that integrated supply chains can respond more quickly to changes in demand and supply conditions, reducing lead times and improving service levels.
2. **Wamba (2022)** demonstrated that supply chain integration is crucial for leveraging IoT capabilities to improve overall SCP. The study found that IoT-based integration improves coordination and collaboration among supply chain partners, thereby increasing overall efficiency and effectiveness.

Hypothesis 4 Example:

H4: The link between IoT and supply chain performance is mediated by supply chain integration, which amplifies the benefits of IoT on general responsiveness and efficiency.

Hypothesis 5: The adoption of IoT leads to improved supply chain performance through enhanced supply chain Agility and Integration.**Supporting Literature:**

1. **Prater, Biehl, and Smith (2001)** highlighted the importance of visibility and predictive analytics in achieving SCA and SCP. The study showed that IoT technologies provide the necessary real-time data and predictive capabilities to improve overall SCP.
2. **Christopher (2000)** emphasized that visibility and predictive analytics are crucial for minimizing lead times and meeting customer expectations. The study found that IoT-enabled real-time information enhances decision-making and operational efficiency.

Hypothesis 5 Example:

H5: The adoption of IoT leads to improved SCP through enhanced visibility and predictive analytics, enabling better decision-making and operational efficiency.

- **Summary**

The aforementioned theories are supported by empirical data and a body of literature, offering a foundation for more research on the effects of IoT on supply chain performance, integration, and agility. These theories provide a framework for analyzing the intricate connections between IoT adoption, SCA, SCI and overall performance. They also emphasize the critical role that IoT plays in improving supply chain capabilities.

1.24. The Research Method

This PhD thesis's research methodology includes a clearly defined research design that covers the study's overarching strategy and plan of action. The study design functions as a framework for choosing acceptable techniques and protocols for data collection, measurement, and analysis, as recommended by Cooper and Schindler (2014).

Examining the link between SCP, the dependent variable, and the mediated elements of SCI, IoT, and AI is the primary goal of this study. To accomplish this goal, the investigator will gather in-depth data on these variables.

The utilization of AMOS software will enable the analysis of the data, thereby facilitating the application of structural equation modelling (SEM). As a robust statistical method, SEM can examine the relationships between latent and observed variables in a theoretical model. This method assists in understanding the interplay of variables and provides a quantitative assessment of theories.

Numerous crucial processes will be involved in the SEM study, including path analysis, confirmatory factor analysis, multiple regression, correlation and covariance analysis, and bootstrapping. These methods will shed light on the connections between the variables being studied (Byrne, B. M. 2013).

SEM best practices and guidelines will be strictly adhered to throughout the study process, guaranteeing thorough analysis and interpretation. Based on empirical data and theoretical arguments, the SEM model will be improved through model formulation,

identification, estimate, testing, and change (Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. 2016).

By using this particular research technique, the study aims to improve knowledge of the relationships between SCP, SCI, and artificial intelligence. Using AMOS software to implement SEM will enhance the precision and reliability of the results, offering valuable insights for both academic and industrial fields.

- When measuring mediating effects in research, there are several commonly used methods.

1- **Kenny and Baron's Method:** This approach is often used to assess mediation: it uses AI technology to run various regression analyses to study both the direct effect of an independent variable on a dependent variable and the indirect effect of an independent variable on a dependent variable via a mediator. When examining the statistical significance of the indirect effect, it is important to consider the importance of the mediated effect. According to mediation theory, SCP is influenced by both SCI and flexibility (Baron, R. M., & Kenny, D. A. 1986).

2- **Sobel Test:** The Sobel test is a statistical method used to assess the significance of the indirect impact. It determines if the indirect impact and zero differ noticeably from one another. For the Sobel test, it is assumed that the indirect effect's sampling distribution is nearly normal.

It is decided that the indirect impact is significant if the computed p-value is less than a predefined significance level (e.g., 0.05) (Sobel, M. E. 1982).

3- **Bootstrapping:** A non-parametric resampling method called bootstrapping is utilized to determine the indirect effect's sampling distribution. The process entails taking many samples from the dataset to generate bootstrap samples and figuring out the indirect impact of each sample. Confidence interval estimation is made possible by the indirect effect distribution that is produced by this procedure. The mediating

impact is deemed significant if zero appears in the confidence interval (Preacher, K. J., & Hayes, A. F. 2004).

- **When comparing these methods, there are a few considerations:**

- Baron and Kenny's approach is straightforward to implement but does not provide formal statistical tests of significance for the mediating effect.
- The Sobel test is a parametric test that assumes normality of the sampling distribution, which may be a limitation in certain cases.
- Bootstrapping is a robust and versatile method that does not rely on distributional assumptions, making it suitable for non-normal data or small sample sizes.

The particular study setting, the properties of the data, and the preferences of the researchers all influence the technique chosen. It is advised that you speak with a methodological specialist or statistician to choose the best approach for your research.

1.25. Population and Sampling

Population and sampling are important concepts in research methodology, particularly in sample-based studies.

The term "population" refers to the whole set of people, things, or entities that the researcher is interested in because they have particular qualities. In your case, the population represents Turkish companies in Istanbul. It is the target group from which you want to draw conclusions or generalize your findings (Creswell, J. W., & Creswell, J. D. 2017).

- Research studies often utilize a range of sampling techniques:
 1. **Random Sampling:** The process of selecting people unbiasedly from a population, with each member having an equal chance of being selected for the sample, is known as random sampling. This method lessens the possibility of selection bias and helps ensure that the sample is a true reflection of the population (Sekaran, U., & Bougie, R. 2016).
 2. **Stratified Sampling:** Stratified sampling is a technique that entails dividing the

population into similar subgroups, known as strata, and subsequently selecting samples from each stratum based on their proportionate representation in the population. This approach guarantees that the sample accurately reflects important subgroups present in the population. For instance, when dealing with a population comprising various age brackets, stratified sampling would entail choosing participants from each age group to ensure inclusivity (Sekaran, U., & Bougie, R. 2016).

3. **Cluster Sampling:** Cluster sampling is a method that involves dividing the population into groups, such as geographic regions or organizational units. Then, a random selection of these clusters is made to comprise the sample. This method is especially helpful in circumstances where it is difficult or impossible to compile a comprehensive list of every member of the population. The clusters being geographically dispersed can make it more cost-effective (Creswell, J. W., & Creswell, J. D. 2017).
4. **Systematic Sampling:** Systematic sampling is the process of selecting individuals from a population at regular intervals. The random selection of starting point leads to the inclusion of every *n*th individual in the sample. Implementing this approach is simple and leads to a representative sample in cases where there is no identifiable pattern within the population. (Fowler, F. J., Jr. (2013).
5. **Convenience Sampling:** The researcher selects individuals who are easily accessible and available for convenience sampling. Despite its frequent utilization due to its ease and efficiency in gathering data, this approach may introduce bias as the chosen participants might not accurately reflect the entire population. In studies that aim for high generalizability, convenience sampling is not typically recommended (Babbie, E. R. 2016).
6. **Snowball Sampling:** Using non-random methods to find beginning participants—such as recommendations from current participants—is known as snowball sampling. The "snowball" effect is then created when these individuals assist in enlisting new members. When researching groups that are difficult to reach or when the population

of interest is tiny, this approach might be helpful(Hair, 2010).

The objectives of the study, the characteristics of the population, the resources at hand, and the required degree of representativeness all have an impact on the selection process. It is essential to carefully weigh the benefits and drawbacks of each method and choose the one that will work best for the study. However, due to logistical, financial, and time constraints, it may not be feasible or even viable to examine the whole population. As a result, samples—a subset of the population—are frequently chosen by researchers.

A sample is a meticulously chosen representative portion of the population that provides information about the characteristics and actions of the larger population (Sekaran, U., & Bougie, R. 2016).

Choosing the right sampling procedure and sample size are crucial steps in the sample selection process. To get reliable and precise results, it's critical to have a sufficient sample size, especially given the limitations of the resources at hand. The sampling technique selection must be in line with the research objectives, population characteristics, and available resources (Babbie, E. R. 2016). Each method of sampling has its distinct benefits and constraints, and the selection of a method depends on the specific nature of the study and the traits of the population under investigation (Saunders, M., Lewis, P., & Thornhill, A. 2019).

Selecting a representative sample of businesses in Istanbul, Turkey can provide valuable information and insights that apply to a broader audience. It is essential to guarantee the accuracy and dependability of the results by ensuring that the sample accurately represents the entire population(Hair, 2010).

315 is the sample size because there are 17,547 retail businesses in Turkey and 3,666 people, which is the number of retail businesses in Istanbul(Zoominfo, 2023).

The computation of sample size, per Krejcie – Morgan (1970). most quantitative research projects. There was a 5% significance level and a 95% confidence interval.

$$N = \frac{\frac{z\alpha}{2}NP(1-P)}{d^2 (N-1) + \frac{z\alpha}{2}(1-P)} \quad n = \frac{1.96(3666) \times 0.5(1-0.5)}{(0.0025)^2 \times (3666-1) + 1.96(1-0.5)} \approx 348$$

Where:

n: Sample size calculation

N: Population size research $Z_{\alpha/2}$: at $\alpha=0.05=1.96$

Prevalence of NOC knowledge, $P= 50\%$

d: The error rate allowed $d=0.25\%$

1.26. Data Gathering and Measures.

In this research, the data gathering method chosen was a questionnaire, which is a widely used and standard method in the social sciences. Questionnaires are particularly useful when dealing with large numbers of people and aim to gather information from a target group by asking them a set of standardized questions.

The survey utilized in this study was created using measurements and concepts employed in prior research. This method guarantees that the survey collects important data and permits the ability to compare and analyze findings in various studies. Through the use of predetermined metrics, the survey can offer valuable information on how IoT affects the integration, agility, and performance management of supply chains in Turkish retail businesses. This portion of the study aims to acquire valid and sound measurement instruments before conducting hypothesis testing with Confirmatory Factor Analysis and Cronbach's Alpha Reliability Analysis (Kline, 2010, pp. 97-98).

The questionnaire utilizes AI technology to convert ideas into measurable factors, making it more effective in evaluating the impact of IoT on critical aspects of the supply chain. The current objective is to convert abstract concepts and ideas into specific, quantifiable indicators. The questions in the survey are designed to be easily understandable and accurate, making it simpler for participants to understand and answer them. AI technology helps to accomplish this. The survey comprises a mix of closed-ended questions and Likert scale items. Respondents are allowed to express their level of concurrence or

discord on a spectrum (ranging from strongly agree, agree, neutral, disagree, strongly disagree) in Likert scale inquiries, whereas in closed-ended queries, they are presented with predetermined response choices. This amalgamation allows researchers to collect both quantitative and qualitative information.

The main aspects of the IoT's influence on SCI, SCA, and SCP management are covered by the questionnaire's design. It has question sections devoted to each dimension, each of which covers pertinent subtopics and indicators. Before becoming live, the questionnaire was put through a validation procedure that involved a small-scale pilot test with participants to evaluate its reliability, understandability, and clarity. Revisions and enhancements are implemented in response to input gathered throughout the test process.

Overall, the survey serves as a systematic and standardized tool for collecting information from a significant number of Turkish retail businesses. In the realm of Turkey's retail industry, it provides academics with a valuable opportunity to acquire significant knowledge regarding the interconnections among IoT, supply chain integration, supply chain agility, and supply chain performance management.

- The questionnaire is divided into five broad parts:

Part **I** respondent's background information including company's name, job title, experience in the position, educational background, business ownership, business activism, employee count, geographic reach of the business, number of clients, number of suppliers, and date of business (IoT) launch.

Part **II** depicts an Internet of Things cluster made up of twelve components. After a thorough evaluation of previous research, it was decided to quantify the influence of the IoT on SCP using a 5-point Likert scale. These components were verified in settings akin to those found in studies conducted in the same field as this one (Lee, Romzi, Hanaysha, & Alzoubi, 2022).

Part **III** concerns the Agility of the Supply Chain Factor, which was composed of seven elements. Likert Scale was used to measure these parts, such as (1= strongly disagreed, 2=Disagree, 3=Neutral, 4=Agree, and 5= strongly agreed).

Part **IV** discusses the integrated supply chain factor. The third, fourth, and fifth statements, respectively, represent the customer, supplier, and internal integration sections. A Likert scale was used to measure these components; 1 meant strongly disagreed, 2 disagreed, 3 neutral, 4 agreed, and 5 highly agreed. The statements were grouped into short sections to reduce the possibility of boredom, which could cause the respondents to stop answering the questions. The subdivision was also helpful in the process of creating the study hypotheses.

Part **V**, the Supply Chain Performance Management (SCPM) factor, with nine components, was covered in Part V. These components were measured using the Excellent Scale, which goes from 1 = Extremely Poor to 5 = Excellent. The design of the questionnaire ensures that responders will adhere to the clear and detailed instructions.

The method for managing factor structures that are defined or well-known and predetermined in the original scales, is developed through the utilization of resources, or factor structures that are predicted (Barabara G. Tabachnick & Linda S. Fidell, 2013, pp. 737-748).

Table 6: Variables and sources of measurement items

<i>The Variables</i>	Determinants (measurement items)
Internet of Things	<ol style="list-style-type: none"> 1. To enable identification at the individual item level. 2. To enable identification at the unit level (e.g., container/box/pallet). 3. To automatically capture data for monitoring, tracking, and tracing supply chain entities and people. 4. Assessment of supply chain functions, protocols, and sustainability factors. 5. To remotely manage supply chain processes. 6. To enable autonomous decision-making within the supply chain. 7. To offer real-time data for optimizing supply chain operations 8. To furnish real-time insights into supply chain operations. 9. To offer extensive datasets and diverse data for applying data analytics in tactical and strategic decision-making. 10. To improve the sharing of information among both internal departments and external partners within the supply chain. 11. To streamline decision-making processes within and outside the organization within the supply chain. 12. To bolster communication and coordination among stakeholders.

<p>Supply Chain Agility</p>	<p>1. Supply Chain Agility My company consistently strives to enhance delivery reliability.</p> <p>2. My company demonstrates agility in identifying environmental threats promptly.</p> <p>3. We regularly enhance products and customer service levels.</p> <p>4. We can efficiently allocate resources to address various demands.</p> <p>5. Typically, we can swiftly access the necessary data for decision-making.</p> <p>6. We are well-prepared and skilled in adapting to upcoming market changes.</p> <p>7. We frequently receive relevant information from our customers and suppliers.</p>
<p>Supply Chain Integration</p>	<p style="text-align: center;">Customer integration</p> <p>1. We have a high level of information sharing with major customers about market information.</p> <p>2. We share information with major customers through information technologies.</p> <p>3. We have a high degree of joint planning and forecasting with major customers to anticipate demand visibility.</p> <p>4. Our customers provide information to us in the procurement and production processes.</p> <p>5. Our customers are involved in our product development processes.</p> <p style="text-align: center;">Supplier integration</p>

	<ol style="list-style-type: none"> 1. We share information with our major suppliers through information technologies. 2. We have a high degree of strategic partnership with suppliers. 3. We have a high degree of joint planning to obtain rapid response ordering processes (inbound) with suppliers. 4. Our suppliers provide information to us about production and procurement processes. 5. Our suppliers are involved in our product development processes
	<p>Internal integration</p>
	<ol style="list-style-type: none"> 1. We have a high level of responsiveness within our plant to meet other departments' needs. 2. We have an integrated system across functional areas of plant control. 3. Within our plant, we emphasize information flows amongst purchasing, 4. inventory management, sales, and distribution departments. 5. Within our plant, we emphasize physical flows among production, packing, warehousing, and transportation departments.
<p>Supply Chain Performance</p>	<ol style="list-style-type: none"> 1. Improve product quality 2. Improve supply chain delivery reliability 3. Improve perfect order fulfilment (deliveries with no errors). 4. Improve fill rates 5. Improve supply chain flexibility (react to product changes, volume, mix). 6. Reduce the cash-to-cash cycle time.

	<p>7. Reduce the total supply chain management cost.</p> <p>8. Reduce the cost of goods sold.</p> <p>9. Improve value-added productivity (sales per employee).</p>
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December	Confidence Level
$r < 0.50$	Insufficient Confidence Level
$0.50 < r < 0.70$	Generally Accepted Confidence Level
$0.70 < r < 0.80$	Highly Reliable
$0.80 < r < 0.90$	Very Reliable
$0.90 < r$	Perfectly Reliable

1.27. Analysis and Test Model

- Analysis of the Structural Validity and Reliability of the Internet of Things Scale

In the DFA application for the Internet of Things scale, it was seen that the path coefficient of the item named IOT10 was statistically significant, but the standardized coefficient was small. ($\beta = 0.321$, $p < 0.05$). Upon reviewing the CFA model fit indices following the revisions, it was seen that the model fit was attained after the item's removal from the scale. The DFA chart of the final scale structure is as in Figure 6.

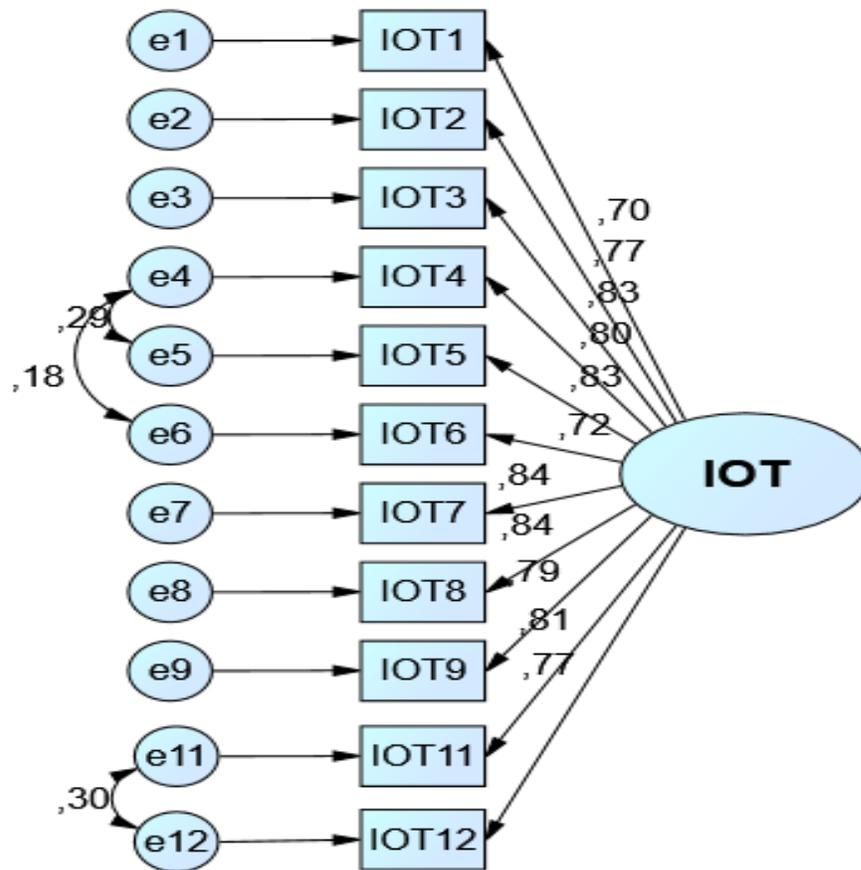


Figure 5: Internet of Things Scale DFA Chart

CFA and reliability analysis findings are as in Table 9.

Table 7: Internet of Things Scale CFA Findings

Article	Scale	β	Std. β	SE	t	p	r
IOT12	← IOT	1,000	0.77 0	-	-	-	

IOT11	1,016	0.81 1	0.05 5	18,648** *	[0.000]	
IOT9	0.983	0.79 1	0.06 5	15,087** *	[0.000]	
IOT8	1,096	0.83 9	0.06 8	16,227** *	[0.000]	
IOT7	1.032	0.83 7	0.06 4	16,183** *	[0.000]	0.94 9
IOT6	0.913	0.72 4	0.06 7	13,571** *	[0.000]	
IOT5	1,045	0.83 0	0.06 5	16,014** *	[0.000]	
IOT4	1.038	0.80 0	0.06 8	15,274** *	[0.000]	
IOT3	1,081	0.83 2	0.06 7	16,077** *	[0.000]	
IOT2	1,087	0.77 0	0.07 4	14,611** *	[0.000]	
IOT1	0.892	0.69 8	0.06 9	13,009** *	[0.000]	

Model Fit Indices

$\chi^2(41)=91.931^{***}$	GFI=0.950	NFI=0.96	RFI=0.955	RMSEA=0.06
[0.000]		6	3	

$\chi^2/DF=2.242$	AGFI=0.91	TLI=0.97	IFI=0.981	CFI=0.981
	9	4		

***(1%), ** (5%), *(%10) represent statistical significance at the significance level, - 1 path is determined as a basis for the scale and SE, t and p statistics of the basic path are not calculated. Std. β : Standardized Coefficient, SE: Standard Error, (includes test degrees of freedom in brackets.) [inside square brackets include significance (p) values.] r= Cronbach's Alpha.

The statistical significance of the path coefficients for all the remaining items on the scale is observed at the 1% significance level ($p < 0.01$). Furthermore, it is worth noting that all the standard path coefficients surpass the threshold of 0.5 (J.Hair et al., 2009).

The hypothesis that the population covariance and sample covariance are equivalent at a significance level of 1 is refuted by the Chi-square test, as can be seen by looking at the model fit indexes. AI technology can be used to paraphrase the text in English. This test assesses the degree of coherence between the sample and population covariance matrices ($\chi^2(41) = 91.931, p < 0.01$). AI technology can be used to rephrase the text in English as:

"While the suitability of the model may not be optimal, it is recognized that the Chi-Square test is greatly affected by the size of the sample. Therefore, other model fit measures are considered more crucial in evaluating the fitness of the model." (Barabara G. Tabachnick & Linda S. Fidell, 2013, p. 764)¹

When other model fit indices are examined, it is seen that χ^2/DF and RMSEA values are within the reference ranges indicating acceptable model fit, while other AGFI, GFI, NFI, RFI, CFI, IFI values are within reference ranges indicating perfect model fit. The Cronbach's Alpha reliability coefficient, which demonstrated a perfect fit with a score above 0.90, was calculated using AI technology to confirm the scale's strong reliability and structural validity.

¹yield Tabachnick, B. G., & Fidell, L. S. (2013). *Using Multivariate Statistics: Pearson New International Edition*. Pearson. ^a statistically significant χ^2 statistic.

The study's findings showed that the 11-item scale, which gauges one dimension, is a valid and dependable instrument for measuring.

- **Supply Chain Integration Scale Structural Validity and Reliability Analysis**

The SCI scale is included in the research model with a secondary structure. For this reason, second-degree confirmatory factor analyzes of confirmatory factor analyses of the scale were performed ²(Kline, 2010, pp. 319-320). The DFA diagram for the final scale structure is as in Figure 7.

²By comparing the first-degree and second-order CFA analyzes of the scale, it was decided that the second-order structure of the research model was appropriate, since no significant difference was observed in terms of model fit.

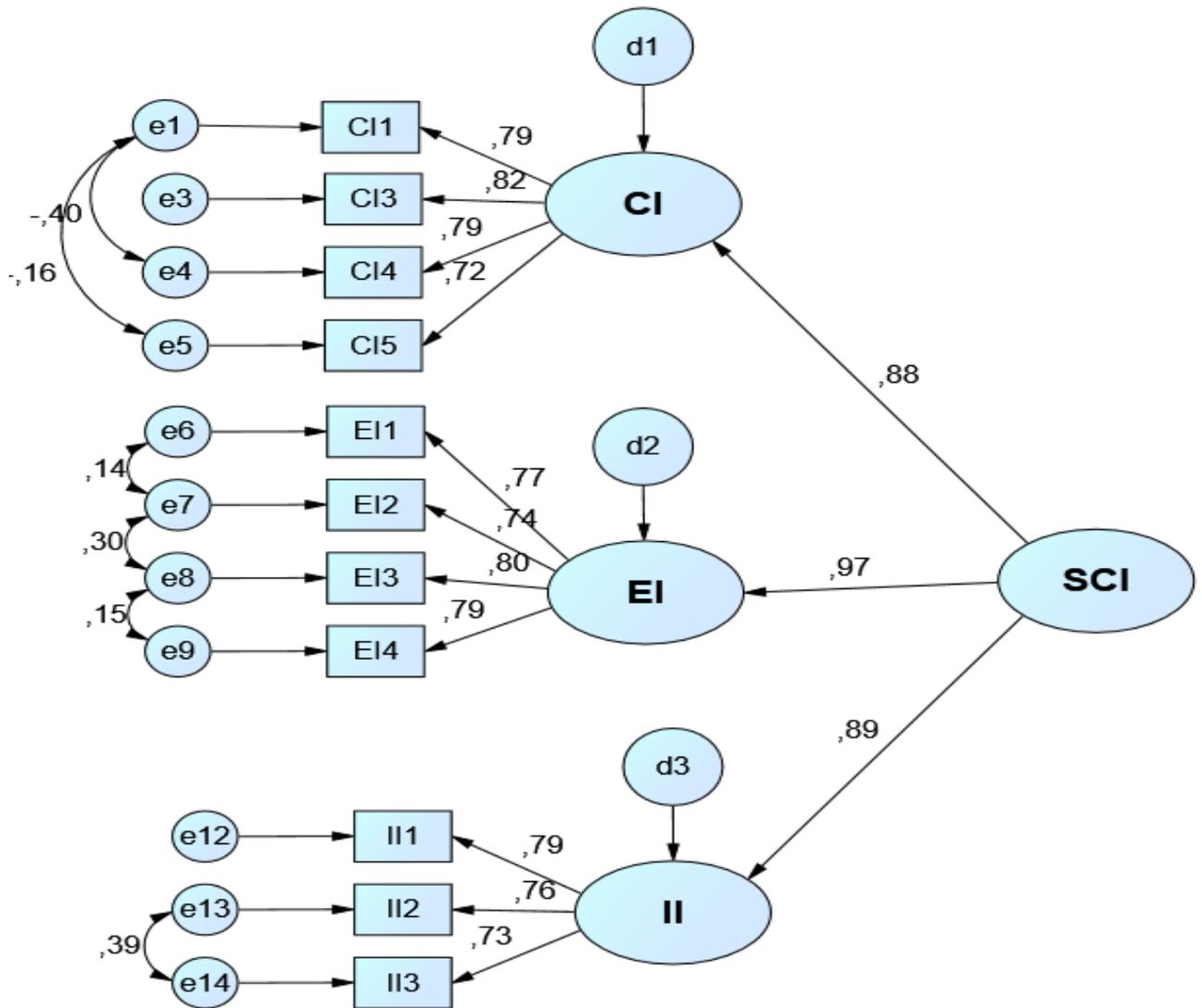


Figure 6: Supply Chains Integration Scale CFA Chart

During the CFA analysis applied to the scale, the coefficients of some items were found to be statistically significant but small. ($\text{Std. } \beta < 0.5, p < 0.01$). The items in question are as follows; CI2, EI5. Item EI6 was found to be in close relationship with the items in the other factor. ³These 3 items were excluded from the scale.

CFA and reliability analysis findings are as in Table 10.

Table 8: Supply Chains Integration Scale CFA Findings

Article	Scale/Sub-Dimension	β	Std. β	SE	t	p	R
CI		0.747	0.876	0.061	12,271****	[0.000]	
EI	◀ SCI	0.787	0.966	0.053	14,793****	[0.000]	0.924
II		0.730	0.889	0.059	12,299****	[0.000]	
CI5		1,000	0.720	-	-	-	
CI4	◀ CI	1,030	0.793	0.080	12,812****	[0.000]	0.842
CI3		0.985	0.818	0.074	13,370****	[0.000]	
CI1		1.013	0.795	0.083	12,182****	[0.000]	
EI4		1,000	0.792	-	-	-	
EI3	◀ EI	1.061	0.796	0.066	16,014****	[0.000]	0.875
EI2		1.002	0.736	0.077	12,983****	[0.000]	
EI1		1.023	0.766	0.074	13.757****	[0.000]	
II3		1,000	0.732	-	-	-	
II2	◀ II	1,019	0.761	0.064	15,924****	[0.000]	0.839
II1		1,040	0.785	0.086	12,081****	[0.000]	
Model Fit Indices							
$\chi^2(35)=84,883****$		GFI=0.953	NFI=0.960	RFI=0.937	RMSEA=0.06		
[0.000]					7		
$\chi^2/DF=2.425$		AGFI=0.91	TLI=0.962	IFI=0.976	CFI=0.976		
		0					

****(1%), ** (5%), *(%10) represent statistical significance at the significance level, - 1 path is determined as a basis for the scale and SE, t and p statistics of the basic path are not calculated. Std. β : Standardized Coefficient, SE: Standard Error, (includes test degrees of freedom in brackets.) [inside square brackets include significance (p) values.] r= Cronbach's Alpha

Size at the 1% significance level. (Std. $\beta > 0.5$, $p < 0.01$) (J.Hair et al., 2009) The equality of the universe covariance matrix and sample covariance matrix is rejected at the 1% significance level when model fit indices are analyzed ($\chi^2(35) = 84,883$, $p < 0.01$), but χ^2/DF , RFI and RMSEA values from other model fit indices are acceptable, GFI, It is seen that AGFI, NFI, TLI, IFI and CFI values are within reference ranges indicating perfect fit. Upon examining the Cronbach's Alpha reliability coefficients of the various components, it is observed that each one exhibits very high reliability. ($0.80 < r < 0.90$, and the reliability level of the scale indicates a perfectly reliable measurement tool ($r > 0.90$). It has been seen that it can measure the second-degree latent structure with its dimension, which is structurally valid and at a high level of reliability.

- Supply Chain Agility Scale Structural Validity and Reliability Analysis

The standardized path coefficients of the items SCA1 and SCA2 in the DFA process applied to the scale were determined to be statistically significant at the 1% significance level, but less than 0.5. Afterwards, it was seen that an acceptable and higher model fit was achieved. After the said items are excluded from the scale, the scale DFA chart is as in Figure 8.

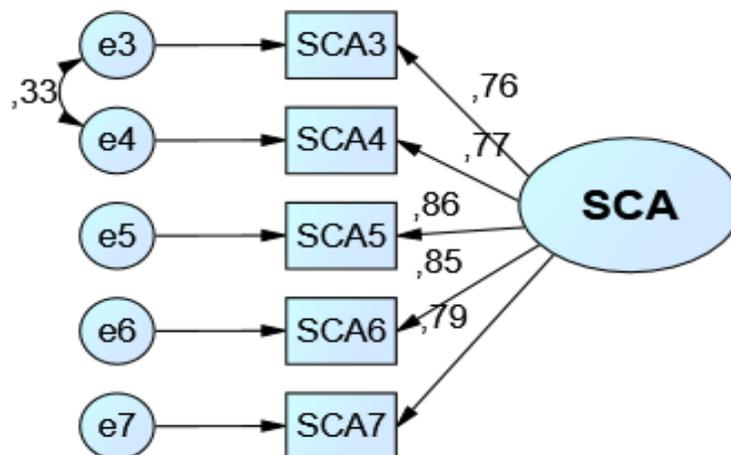


Figure 7: Supply Chains Agility Scale DFA Chart

The findings are as in Table 11.

Table 9: Supply Chains Agility Scale CFA Findings

Article	Scale	β	Std. β	SE	t	p	r
SCA7		1,00	0.78			-	
		0	7				
SCA6	← SCA	1,22	0.85	0.07	16.279**	[0.000]	
		4	2	5	*		
SCA5		1.12	0.86	0.06	16,518**	[0.000]	0.90
		9	3	8	*		7
SCA4		1.03	0.76	0.07	14.288**	[0.000]	
		8	7	3	*		
SCA3		0.94	0.76	0.06	14.200**	[0.000]	
		3	3	6	*		
Model Fit Indices							
χ^2	GFI=0.993	NFI=0.995	RFI=0.986	RMSEA=0.03			
(04)=5.417[0.247]				4			
$\chi^2/DF=1,354$	AGFI=0.97	TLI=0.999	IFI=0.999	CFI=0.999			
	4						

***(1%), ** (5%), *(%10) represent statistical significance at the significance level, - 1 path is determined as a basis for the scale and SE, t and p statistics of the basic path are not calculated. Std. β : Standardized Coefficient, SE: Standard Error, (includes test degrees of freedom in brackets.) [inside square brackets include significance (p) values.] r= Cronbach's Alpha.

The table shows that all of the standardized path coefficients are greater than 0.5 and that all of the path coefficients of the scale's items are statistically significant at the 1% significance level ($p < 0.01$). The Chi-Square test findings indicate that there is no evidence to reject the notion that the population covariance is equal to the sample covariance ($\chi^2(4) =$

5.417, $p > 0.10$). Furthermore, when analyzing the other indicators of model fit, it is evident that they all fall within the expected values, suggesting an ideal fit for the model. The scale demonstrates exceptional reliability as indicated by the calculated Cronbach's Alpha coefficient, affirming its effectiveness as a measurement tool.

- **Evaluation of the Structural Validity and Reliability of the Supply Chain Performance Scale**

The DFA analysis performed on the scale revealed that item SCP7 was statistically significant at the 1% significance level, despite not having a significant impact on the standardized coefficient. ($\beta < 0.5$, $p < 0.01$) Upon reviewing the model fit indices following the revisions, it became evident that the item's removal from the scale was the only way to attain a satisfactory and improved model fit. Once the item has been removed from the scale, the scale DFA chart looks like Figure 9.

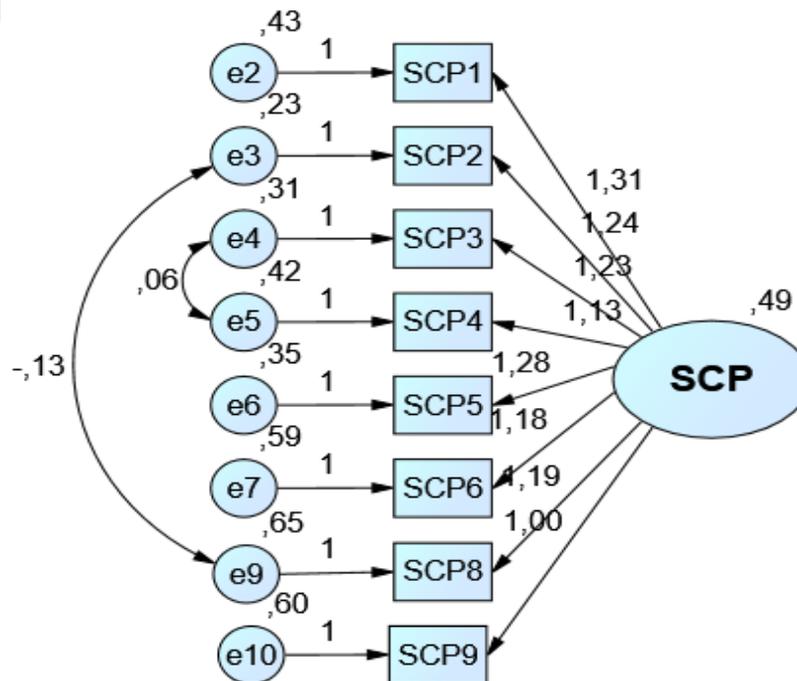


Figure 8: Supply Chains Performance Scale DFA Chart

CFA findings and Reliability analysis findings are in Table 12.

Table 10: Internet of Things Scale CFA Findings

Article	Scale	β	Std. β	SE	t	p	r
SCP9		1,000	0.672	-	-	-	
SCP8		1,189	0.719	0.103	11,572***	[0.000]	
SCP6		1,176	0.731	0.099	11,855***	[0.000]	
SCP5	← SCP	1,276	0.834	0.096	13,301***	[0.000]	
SCP4		1.133	0.776	0.091	12.475***	[0.000]	0.912
SCP3		1.231	0.841	0.092	13.386***	[0.000]	
SCP2		1.242	0.877	0.090	13,809***	[0.000]	
SCP1		1,306	0.814	0.100	13.023***	[0.000]	
Model Fit Indices							
$\chi^2(18)=44,682^{***}$ [0.000]		GFI=0.963	NFI=0.974	RFI=0.959	RMSEA=0.069		
$\chi^2/DF=2.482$		AGFI=0.926	TLI=0.975	IFI=0.975	CFI=0.984		

***(1%), ** (5%), *(%10) represent statistical significance at the significance level, - 1 path is determined as a basis for the scale and SE, t and p statistics of the basic path are not calculated. Std. β : Standardized Coefficient, SE: Standard Error, (includes test degrees of freedom in brackets.) [inside square brackets include significance (p) values.] r= Cronbach's Alpha.

Upon closer examination of the table, it can be seen that all of the standard path coefficients have exceeded 0.5, and at the 1% significance level ($p < 0.01$), the path coefficients for every last scale item are statistically significant.

According to the Chi-Square test, which evaluates the fit of the universe covariance matrix and the sample covariance matrix, the model fit indices show that the hypothesis of universe covariance and sample covariance equality is rejected at the 1% significance level. ($\chi^2(18)=44,682$, $p < 0.01$) When other model fit indices are examined, χ^2/DF and RMSEA values are in the reference ranges indicating acceptable model fit, while other AGFI, GFI, NFI, RFI, CFI, and IFI values are in reference intervals indicating perfect model fit. Was

found to be. A perfect fit is indicated ($r > 0.90$) by Cronbach's Alpha reliability coefficient calculated for the scale.

Consistent with the previously mentioned results, a scale was determined to be an instrument of measurement consisting of eight items and a single dimension, which possesses structural validity and high measurement reliability.

1.28. Data Analysis

After the appropriate numerical coding, the data gathered from the questionnaires used in the research were first imported into the Microsoft Excel package and then moved to the IBM SPSS 25.0 edition.

All structural equation model (SEM) analyses were conducted using IBM SPSS AMOS version 25.0, whereas IBM SPSS version 25.0 was utilized for all other analyses.

Mahala Nobis distances were calculated (Barabara G. Tabachnick & Linda S. Fidell, 2013, pp. 73-76) To identify multiple outliers, the dataset was thoroughly examined. No single or multiple extreme values or missing values were detected in the dataset. Consequently, the analyses proceeded with the existing sample.

The first part of the findings section begins with the presentation of the study sample's descriptive and demographic results. The tests and descriptive statistics that follow assess how closely the scale and its sub-dimensions adhere to a normal distribution. The study's hypotheses are assessed in the sections that follow by using the structural equation model analysis. It is crucial to emphasize that the scale's structural validity and reliability, as well as the factor structures used in the structural equation model, have been previously validated.

Considering the relationships to be examined in the research, it is seen that there are direct and indirect effects involving multiple internal and external variables. For this reason, it has been decided to use the Structural Equation (Kline, 2010) Model, which is known to be non-restrictive on the number of internal and external variables.

Baron and Kenny (1986) were the pioneers in introducing the concept of mediating effect in literature. The researchers suggested using this mechanism to explain the connection between the variables that depend on each other and those that are not influenced by others.

Numerous statistical studies have also been incorporated into this concept. The mediating effect, which investigates how an independent variable influences a dependent variable through a possible correlation mechanism, can be studied with AI technology. The correlation mechanism is what Baron and Kenny (1986) defined as the mediating variable in this situation (Baron & Kenny, 1986, p. 1176).

It will be useful to examine Figure 10 to understand the mediator effect mechanism more easily.

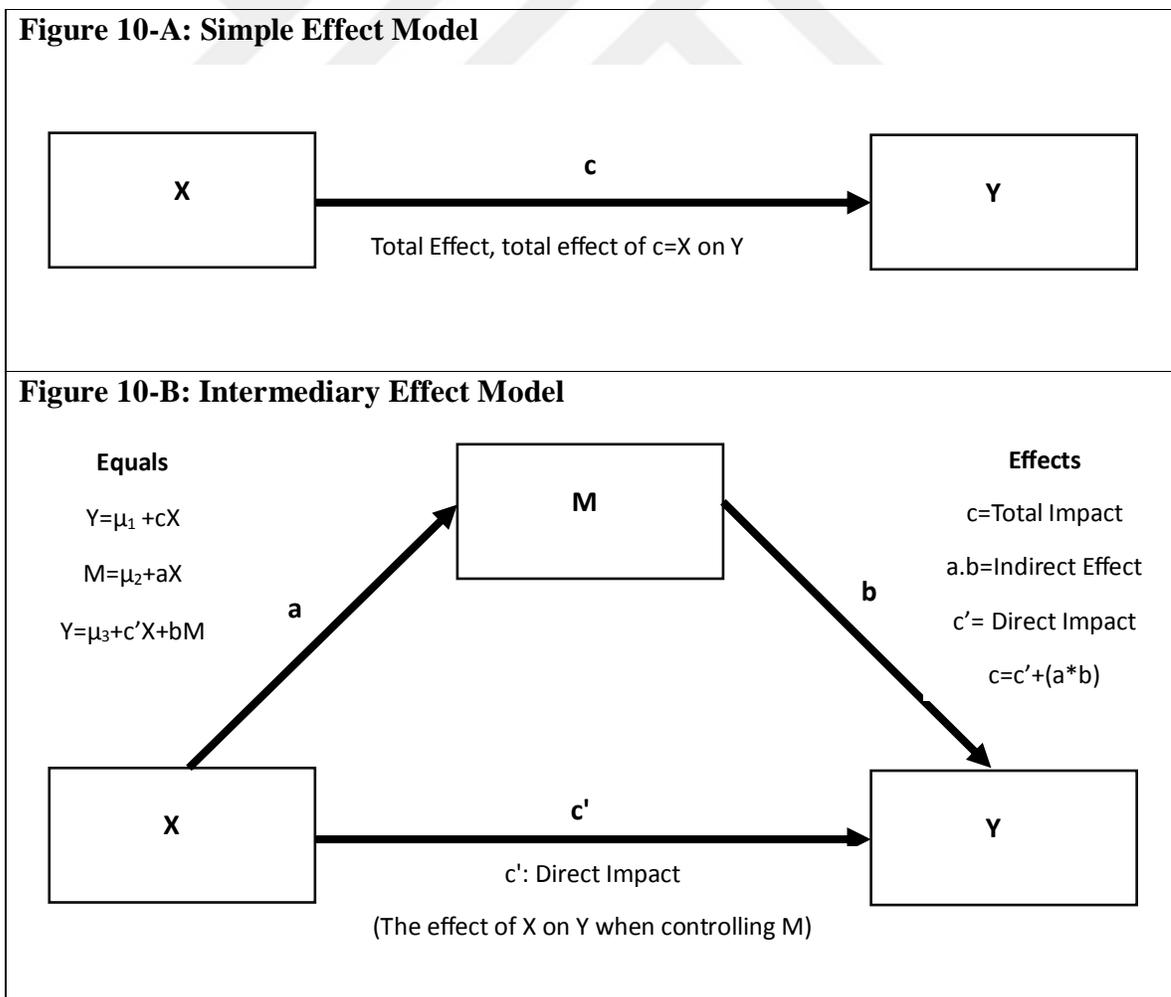


Figure 9: Simple and Mediation Models (Preacher et al., 2007)

Baron and Kenny (1986) suggest examining the existence of the correlation mechanism, that is, whether there is a mediating effect, depending on whether the following 4 conditions are fulfilled (Baron & Kenny, 1986, p. 1177).

Condition 1: The independent variable's overall effect on the dependent variable (path c) shouldn't be zero (statistically significant).

Condition 2: The independent variable must have a statistically significant effect on the mediating variable (path a).

Condition 3: The effect of the mediator variable on the dependent variable (path b) must be non-zero (statistically significant).

Condition 4: It is expected that the relationship between the independent and dependent variables will weaken or vanish when the mediating variable is incorporated into the model. Partial mediation results from the intervening variable's ability to lessen the impact of the independent variable on the dependent variable. Complete mediation happens when the impact vanishes and is equal to zero.

It is evident that the evaluation and comparison of two regression analysis findings—the mediator variable, the dependent and independent variables in the first stage, and the dependent and independent variables in the second stage—form the basis of Baron and Kenny's (1986) mediating effect analysis.

In the field of research, Preacher, Rucker, & Hayes (2007), Muller, Judd, & Yzerbyt (2005), Hayes (2018), and Baron and Kenny (1986) are recognized for introducing the idea of mediation in scholarly works. However, the traditional method they proposed, known as the causal steps approach, received significant criticism in subsequent years.

Five topics may be used to organize Baron and Kenny's (1986) criticisms of the conventional technique in mediation effect analysis known as the causal stages approach. (Hayes, Preacher, & Rucker, 2007)

First criticism: Baron and Kenny (1986) state that a dependent variable's overall impact on an independent variable must be statistically significant.

Criticism 2: If there is no discernible correlation between the independent variable and the mediating variable, the indirect effect might still be significant based on the current methodology. Contrary to what they claim, Baron and Kenny (1986) argue that for mediation to be established, the independent variable must have a statistically significant impact on the mediating variable.

Baron and Kenny (1986) emphasized the importance of the mediator variable having a statistically significant effect on the dependent variable, regardless of the accuracy of the current method.

It is said that the effect coefficient should be used to measure it. According to the current methodology, the indirect impact is minor when the effect size is near 0.01; medium when the effect size is near 0.09; and big when the effect size is near 0.25.

The fact that Baron and Kenny (1986) employed the Sobel test to determine the relevance of the indirect impact path is another criticism levelled against their methodology.

However, the reliability is decreased when the Sobel test is used since it is known to be effective under the assumption of normality because the sample distribution for the indirect impact is frequently asymmetrical. Thanks to the confidence intervals generated by the Bootstrap methodology, the contemporary method can determine the statistical significance of the indirect impact after correcting for bias and skewness.

In response to the criticisms outlined, Hayes (2018) introduced a method termed modern mediation effect analysis. This approach involves computing the indirect effect coefficient and drawing inferences based on this coefficient. The method described assesses the significance of the indirect effect coefficient by using confidence intervals derived from thousands of resampled datasets via the Bootstrap technique. This method tackles the Sobel test's drawbacks, such as its stringent presumptions and asymmetric non-normality characteristics (Hayes, 2018).

The mediation relation in Hayes's 2018 modern mediation analysis is determined through the indirect effect coefficient ($a*b$), not by relying on the first three conditions laid out in Baron and Kenny's (1986) framework. The significance of the coefficient mentioned is

assessed through the Bootstrap method, which is highly reliable in handling the asymmetric properties of the mediation model.

1.29. Hypotheses Test Model

In this part of the research, there are analyses of the hypothesis testing model established with the scale forms, whose structural validity has been proven before, to test the research hypotheses.

The diagram illustrating the SEM for the hypothesis test model can be observed in Figure 11, displaying standardized coefficients.

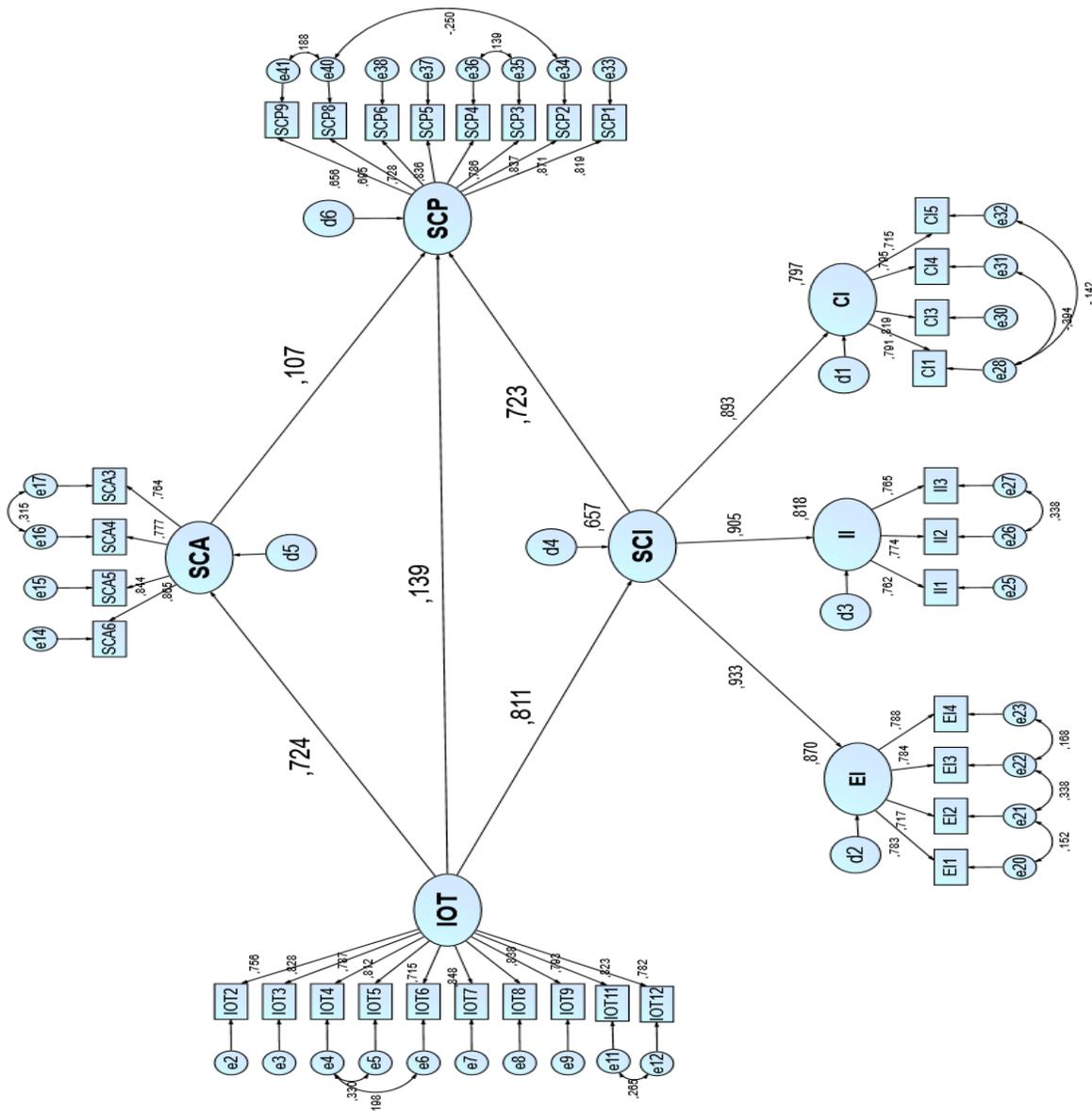


Figure 10: Hypothesis Test Model Structural Equation Model Chart

As the figure illustrates, all variables are dependent on the IOT variable, the SCP variable is endogenous for all variables, and the mediating variables SCA and SCI are exogenous for the SCP variable and internal for the IOT variable. The absence of constraints on the number of endogenous and exogenous variables in structural equation models Facilitates the investigation of both direct and indirect effects with a single model in these models, where the effects of mediator variables are also aimed to be examined(Kline, 2010). Was estimated

using bootstrapping and 2000 resampling with the Maximum Likelihood Estimator. As recommended, bootstrapping confidence intervals were employed to assess the statistical significance of the indirect effect coefficients. Given that the AMOS program is known to not compute the individual indirect effects of the mediating variables when the mediating effect model contains multiple mediating variables, a phenomenon known as parallel mediation, the Stat Wiki plugin created for Individual Indirect Effects from the online environment was used to calculate the individual indirect effects.⁴

Results, Discussions and Conclusion

1.30. Results

Three key findings emerged from the study:

1. The correlation between SCP and the IoT was found to be significant, indicating that IoT technologies contribute to improving SCP.
2. Working together and making decisions collectively with supply chain partners has been linked to enhanced SCP. This highlights the significance of collaboration and coordination among stakeholders in the supply chain to achieve superior results.
3. According to the study, IoT can be beneficial for a business if it is integrated with supply chain participants efficiently, even though it did not significantly affect SCP directly or indirectly. To fully reap the benefits of IoT, critical elements like agility, trust, shared visions, and shared information are essential. The study's findings also demonstrated that internal and external integration had varying effects on SCP, underscoring the complexity of those effects. The results of this study provide insight into the complex connection between IoT, supply chain integration, agility, and performance, highlighting the significance of efficient collaboration and integration within the supply chain ecosystem. The study examined the role of SCA and SCI in mediating SCP.

⁴AMOS plugin name “Specific Indirect Effects_Path. Amos Estim and VB”, plugin link:

http://statwiki.gaskination.com/index.php?title=Main_Page

SCA was found to mediate the relationships between IoT and supply chain performance. Additionally, when mediated by SCI, IoT was found to have a notable impact on SCP. This finding further supports the mediating relationship between SCA, SCI, and SCP, which has been previously supported by other studies.

Table 13 presents the descriptive and demographic results of the study sample.

Table 11: Demographic and Descriptive Findings

Sector	Responses	Percent	Market Type	Responses	Per cent
Public	42	13.3%	Local	168	53.3%
Private	327	86.7%	International	29	9.2%
			Local And International	118	37.5%
Production	76	24.1%			
Service	160	50.8%			
Production &Service	79	25.1%			

IoT Usage Period

Less than 10 Years	191	60.60%
Between 10-15 Years	64	20.30%
Between 16-20 Years	18	5.70%
Between 21-25 Years	18	5.70%
Over 26 Years	24	7.60%

Education

Middle and Primary Education	9	2.90%
High school	16	5.10%
Associate Degree	44	14.10%
License	192	61.70%
Undergraduate	50	16.10%

Number of Employees

Less than 1000	190	60.30%
Between 1000-1500	34	10.80%
Between 1501-2000	74	5.40%
More than 2001	190	23.50%
Total Responses	315	100%

Number of Corporate Customers

less than 100	92	29.20%
Between 100-151	14	4.40%
Between 151-200	30	9.50%
More than 201	179	56.80%

Number of Suppliers

Less than 15	92	29.20%
Between 15-20	52	16.50%
more than 21	171	54.30%

Years in current position

less than 10 years	236	74.90%
Between 10- 15 years	53	16.80%
Between 15-20 years	13	4.10%
More than 20 years	13	4.10%

86.7% of the institutions in which the sample is employed are private (n=273), and 13.3% are public (n=42). This is the distribution of the institutions based on the distinction between public and private. Sample distribution based on years of employment at the institution: 74.9% fewer than ten years (n = 236); 16.8% between ten and fifteen years (n = 53); 4.1% between sixteen and twenty years (n = 13); and 4.1% fewer than twenty-one years (n = 13). The distribution of the sample according to education level is as follows; 2.9% Secondary and Primary Education (n=9), 5.1% High School (n=16), 14.1% Associate Degree (n=44), 61.7% Undergraduate (n=192), 16.1% Post Graduate (n=50). According to the production and service division, the sample's participating institutions are distributed as follows: 24.1% for production (n = 76), 50.8% for service (n = 160), and 25.1% for both production and service (n = 79).

The sample sampled institutions' employee counts are distributed as follows: 60.3% fewer than 1000 (n = 190), 10.8% between 1000 and 1500 (n = 34), 5.4% between 1501-2000 (n = 17), and 23.5% exceeding 2001 (n = 74). Based on their target markets, the sample's partner institutions are distributed as follows: 53.3% are local (n = 168), 9.2% are international (n = 29), and 37.5% are both local and international (n = 118). The breakdown of the sample's working institutions based on the number of corporate clients is as follows: 29.2% have fewer than 100 clients (n = 92), 4.4% have between 100 and 151 clients (n = 14), 9.5% have between 150 and 200 clients (n = 30), and 56.8% have more than 201 clients (n = 179). Based on the number of suppliers, the sample's partner institutions are distributed as follows: 29.2% have fewer than 15, 16.5% have between 15 and 20 (n = 52), and 54.3% have more than 21 (n = 171).

The breakdown of the sample's working institutions based on the length of time spent using ICT is as follows: 60.6% fewer than ten years (n = 191), 20.3% between ten and twenty years (n = 64), 5.7% between sixteen and twenty years (n = 18), 5.7% between twenty-one and twenty-five years (n = 18), and 7.6% over twenty-six years (n = 24).

Model findings are as in Table 14.

Table 12: Hypothesis Test Model SEM Findings

Direct Effect Findings								
Path	Internal		extrinsic	Coefficient	Std. Coefficient	SE	CR	p
a ₁	SCA	←	IOT	0.811	0.724	0.069	11,801***	[0.000]
a ₂	SCI	←	IOT	1,536	0.811	0.147	10,443***	[0.000]
c'	SCP	←	IOT	0.105	0.139	0.061	1,708*	[0.088]
b ₂	SCP	←	SCI	0.289	0.723	0.034	8.592***	[0.000]
b ₁	SCP	←	SCA	0.073	0.107	0.036	2.041 **	[0.041]
Indirect Effect Findings								
Path	Effect		Coefficient	Std. Coefficient	95% LCI	95% UCI		P
a ₁ *	IOT →SCA		0.059	0.078**	0.011	0.118		[0.041]
b ₁	→SCP							
a ₂ *	IOT →SCI →SCP		0.444	0.586***	0.342	0.554		[0.001]
b ₂								
Model Fit Indices								
$\chi^2(474)=924.736***$ [0.000]				GFI=0.850	NFI=0.893	RFI=0.880	RMSEA=0.069	
$\chi^2/DF=1.951$				AGFI=0.822	TLI=0.938	IFI=0.938	CFI=0.955	

***(1%), ** (5%), * represents statistical significance at the significance levels (10%) (test degrees of freedom are shown in parentheses). The test degrees of freedom are shown in brackets. CR stands for critical ratio, SE is for standard error, and 95% LCI and 95% UCI are the lower and upper critical values, respectively, determined with a 95% confidence level. Symbols involved in the introduction of the mediation technique are those indicated by the Path expression.

Since the significance level is 1%, it is evident from examining the table that the theory that the covariance matrix of the universe is equal to the covariance matrix of the sample is

false. AI technology indicates that, at a significance level of $p < 0.01$; the value of f^2 divided by degree of freedom (DF) is 924.736. When taking into account additional fit indices, like the Comparative Fit Index (CFI), it is found that the model fits perfectly. Additionally, the other model fit indices fall within the acceptable range of fit standards. In line with these findings, it can be said that the model is an acceptable hypothesis model with a higher fit.

- When the coefficients for the direct effects estimated in the model are examined;

At a significance level of 1%, there is clear evidence that the IOT variable has a significant and positive effect on the SCA variable ($p < 0.01$, $a_1 = 0.724$). This suggests that the level of IoT implementation can be used as a reliable indicator to predict SCA positively. In simpler words, the supply chain's flexibility is impacted by how much companies adopt the IoT.

The IOT variable has a significant and positive impact on the SCI variable ($p < 0.01$, $a_2 = 0.811$) at the 1% significance level. Based on the level of IoT deployment, SCI can be anticipated to be positive. SCI can be increased or decreased depending on the extent to which businesses use the IOT.

Using AI technology, the data suggests that there is a significant positive correlation between the IoT and SPC at a 10% significance level, with a p-value of 0.10. The level of integration of IoT in the supply chain has the potential to improve its performance, as stated. The supply chain's effectiveness is impacted by the varying degrees of IoT utilization across different companies. In simpler terms, how businesses use IoT affects how well the supply chain performs.

There is clear and statistically significant evidence of an impact on the SCI variable, with a confidence level of 99% ($p < 0.01$, $b_2 = 0.723$). This indicates that there is a strong correlation between the integration of supply chain processes and the overall performance of the supply chain. The overall performance of a company is greatly influenced by the extent of integration within its supply chains.

The SCA variable has a significant and positive impact on the SPC variable, with a significance level of 5% ($p < 0.05$, $b_1 = 0.107$). This suggests that the ability of a supply chain

to quickly adapt has the potential to accurately anticipate its performance. The efficiency of a company's supply network greatly depends on the flexibility of its supply chain.

According to the analysis of indirect effects obtained from the coefficients estimated in the model, and considering the statistical significance at the 5% level, the SCA variable plays a significant role in mediating the relationship between IOT and SCP.

The statistical analysis revealed a significant relationship between SCA and the positive effects of Internet adoption on SCP within organizations. This suggests that a portion of the benefits derived from firms' internet adoption levels can be attributed to the agility of their supply chains ($p < 0.05$, $a_1 * b_1 = 0.078$).

Using AI, it was discovered that the SCI variable, with a computed value of 0.586 for the product of ($a_2 * b_2$), plays a significant role as a mediator in the relationship between IOT and SCP ($p < 0.01$) at a 1% significance level. This implies that the supply chain must be included to maximize the advantages of businesses using the internet to improve SCP. In other words, companies utilizing the IoT—which is made possible by SCI—are the reason why supply chains perform better.

Comparing the sizes of the indirect effects, it's evident that the indirect effect coefficient for the SCI variable is significant, while the one for the SCA variable is relatively small. This pattern is mirrored in the direct effect coefficients as well. Thus, it can be inferred that SCI exerts a greater influence than SCA in terms of both secondary impacts on the level of internet adoption and the direct prediction of SCP.

Table 15 displays the descriptive statistics and normal distribution test statistics that were computed for the scales.

Table 13: Variable Descriptive and Normal Distribution Statistics

Statistics	IOT	SCI	SCA	SCP
Average	3.848	3.889	4.010	4.018
Median	4,000	4,000	4,200	4.130
Maximum	5,000	5,000	5,000	5,000
Minimum	1,000	1,000	1,000	1,000
Std. Deflection	0.932	0.825	0.942	0.872
Skewness (S)	-1.060	-1.099	-1.291	-1.229
Kurtosis (K)	4.128	4,742	4.642	4.810
Jarque -Bera	75,739*** [0.000]	103,230*** [0.000]	122.905*** [0.000]	122,337*** [0.000]
Number of Observations	315	315	315	315

***(1%), ** (5%), * represent statistical significance at (10%) significance levels, [brackets contain test degrees of freedom.]

The IoT variable has a mean of 3.848 and a standard deviation of 0.932, indicating atypical distribution characteristics. It has a range of 1.000 as the minimum and 5.000 as the maximum ($p < 0.01$, JB= 75.739).

There is no extreme skewness or kurtosis in the variable ($|s| < 2$, $2 < K < 5$), according to the analysis of its skewness and kurtosis. Furthermore, the median value is quite similar to the mean.⁵

With a standard deviation of 0.825 centred around a mean of 3.889, the SCI variable has an anomalous distribution between a minimum of 1,000 and a maximum of 5,000. ($p < 0.01$, JB= 103.230) When the variable's skewness and kurtosis values are looked at, it is seen that

⁵It is known that normal distribution is a rare ideal situation with the normal distribution tests performed with the data collected with the help of scales for social sciences. It is recommended in the literature to look at the skewness coefficients for these kinds of data, and if there isn't any noticeable skewness, it's reasonable to assume that the normal distribution assumption is met. Tabachnick, B. G., & Fidell, L. S. (2013). *Using Multivariate Statistics*. Pearson. . In general, ± 1.5 or ± 2.0 values for $S=0$, $K=3$ values in the ideal normal distribution are considered to be non-significant skewness and kurtosis. George, D., & Mallery, M. (2010). *SPSS for Windows Step by Step: A Simple Guide and Reference, 17.0 update (10a ed.)*. Pearson. , Hair, F. W. (2013). *Multivariate Data Analysis*. Pearson Education Limited.

there is no excessive skewness or kurtosis. ($|s| < 2$, $2 < K < 5$) The median value for the variable is close to the mean.

The SCA variable, with a standard deviation of 0.942 and an average of 4.010 (JB=122.905, $p < 0.01$), displays peculiar distribution patterns between 1.000 and 5.000. There is no discernible skewness or kurtosis when looking at the variable's skewness and kurtosis measurements. ($|s| < 2$, $2 < K < 5$) The variable's median value is near the mean.

The range of the SCP variable is between 1,000 and 5,000, with a distribution that has a distinct average of 4.018 and a standard deviation of 0.872. Further statistical analysis indicates that the JB statistic is 122.337, and it has a p-value of less than 0.01, indicating its significance. Analysis of the skewness and kurtosis values suggests that there is no notable skewness or kurtosis observed ($|s| < 2$, $2 < K < 5$). Additionally, the median value of the variable closely approximates the mean.

As can be seen, the variables are not normally distributed according to the normal distribution tests, but they do not have excessive skewness and kurtosis. Variable histograms and box-plot graphics are presented in the appendices. (Appendix 3 and 4) In this study, the Bootstrapping method was used with 2000 resamplings to prevent inconsistency and efficiency losses that may be caused by kurtosis, although it is not excessive since it is aimed to analyze the research model with structural equation models (Preacher et al., 2007). Furthermore, the necessity of the Bootstrapping approach due to the statistical importance of the indirect effects has been crucial in implementing the aforementioned strategy (Kline, 2010, pp. 61-62).

The matrix between the variables is as in Table 16.

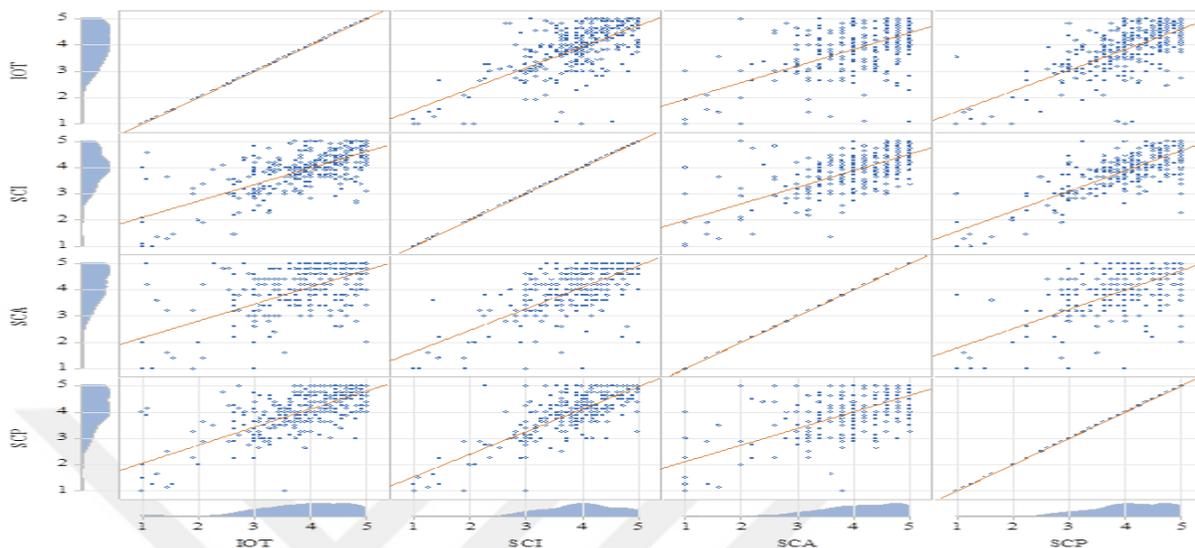
Table 14: Correlation Matrix Between Variables

	IOT	SCI	SCA	SCP
IOT	1,000			
	-			
SCI	0.708*** [0.000]	1,000		
		-		
SCA	0.637*** [0.000]	0.717*** [0.000]	1,000	
			-	
SCP	0.735*** [0.000]	0.810*** [0.000]	0.682*** [0.000]	1,000
				-

***(1%), ** (5%), * show statistical significance at significance levels of 10%; test degrees of freedom are included in brackets.

With a significance level of 1%, it is clear from the data in the table that every variable looked at in the study shows positive and statistically significant correlations. SCP and SCI ($R_{XY} = 0.810$, $p < 0.01$), SCP and IOT ($R_{XY} = 0.735$, $p < 0.01$), and SCA and SCI ($R_{XY} = 0.717$, $p < 0.01$), SCI, respectively, showed the highest correlation. SCP and IOT ($R_{XY} = 0.708$, $p < 0.01$), SCP and SCA ($R_{XY} = 0.682$, $p < 0.01$), and SCA and IOT ($R_{XY} = 0.637$, $p < 0.01$) all show a pattern of correlation. Comparable correlational relationships can also be seen in Graph 1's scatter matrix.

Graphic 1: Variable Scatterplots Matrix



When the scatter plot is examined, fitted regression lines with a positive slope similar to the correlation pattern and rising in proportion to the severity of the correlational relations between the variables are seen.

To ascertain whether the variables about the Internet of Things scale, supply chain integration scale, supply chain agility scale, and supply chain performance scale exhibited variations contingent upon the descriptive characteristics of the employees and the organizations with which they were affiliated, the study incorporated tests for the comparison of group means. In this context, the disparities regarding the group mean under examination were meticulously analyzed to ascertain whether the scales of the study demonstrated variability concerning descriptive attributes such as sector type (public/private), educational background, tenure in the current position, industry classification, employee count, business size, corporate client quantity, supplier count, and the duration of information technology utilization by the organization. Given that certain group memberships ($n < 30$) were inadequate to satisfy the assumptions inherent to parametric testing and that the scale data did not conform to a normal distribution, non-parametric testing methodologies were employed to investigate the differences in group means (Karagöz, 2016).

The Mann-Whitney U test was employed to analyze the disparities between two distinct groups, whereas the Kruskal-Wallis H test was utilized to assess the variances among more than two groups.

The null and alternative hypotheses about the Mann-Whitney U test are articulated as follows;

$H_0: \mu_1 = \mu_2$ (There is no difference between the two group means.)

$H_1: \mu_1 \neq \mu_2$ (There is a difference between the two group means.)

All data points, regardless of their group affiliations, are given rank values in ascending order when calculating the U statistic for the Mann-Whitney U test. The difference between the groups' maximum possible rank sum and the observed rank sum is used to calculate the U value. In this case, T1 and T2 are the rank sums related to the first and second groups, respectively, and U1 and U2 are calculated as shown in equations 1 and 2.

$$U_1 = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - T_1 \quad (1)$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - T_2 \quad (2)$$

The Mann-Whitney U critical value table serves as the basis for decision-making, with the lesser of U1 and U2 being employed as the U statistic. In contrast, the test exhibits a characteristic of large samples and tends to approximate a normal distribution when the sample size exceeds 20 and the number of individuals within the groups surpasses 10. In this context, the Z statistic, calculated utilizing the Z table as outlined in equation 3, is applied.

$$Z = \frac{U - \mu}{\sigma} \quad \text{Here} \quad \mu = \frac{n_1 n_2}{2} \quad \text{And} \quad \sigma = \sqrt{\frac{n_1 n_2 (n_1 n_2 + 1)}{12}} \quad (3)$$

It is calculated as follows.

The null and alternative hypotheses for the Kruskal Wallis H Test are as follows;

$H_0: \mu_1 = \mu_2 = \dots = \mu_k$ (There is no difference between the k group means.)

$H_1: \mu_1 \neq \mu_2 \neq \dots \neq \mu_k$ (At least one of the k group means is different from the others.)

Starts by assigning magnitude orders to the observations, similar to the Mann-Whitney U test. T_j represents the mean rank for each group ($j=1, 2, \dots, k$) and the H statistic is calculated as in equation 4.

$$H = \frac{12}{N(N+1)} \sum_{j=1}^k \frac{T_j^2}{n_j} - 3(N+1) \quad (4)$$

The calculated test statistic is compared to the Kruskal-Wallis H test critical value, which yields a conclusion about the hypothesis. On the other hand, the distribution starts to resemble the Chi-Square distribution when the total number of participants in each group is greater than five, at which point the hypothesis is assessed concerning the Chi-Square critical value. When the Kruskal-Wallis H test results in a difference between the group mean, Mann-Whitney U tests were then carried out in pairs to identify which group or groups the difference was observed to have originated from.

- **Difference Analysis**

The findings of the Mann-Whitney U test testing the differences between public and private sector employees are shown in Table 17.

Table 15: Findings of the Mann Whitney U Test Testing the Differences Between Public and Private Sector Employees

Variable	Sector	N	\bar{X}	SS	\bar{r}	MWU Test
Internet of Things	Public	42	3,543	0.920	122.46	Z(1)=-2.719*
	Special	273	3,894	0.926	163.47	[0.007]
Supply Chain Integration	Public	42	3,790	0.860	144.55	z(1)=-1.030
	Special	273	3,904	0.820	160.07	[0.303]
Supply Chain Agility	Public	42	3,838	1,102	146.73	Z(1)=-0.867
	Special	273	4,037	0.914	159.73	[0.386]

Supply Chain	Public	42	3,887	0.857	141.99	Z(1)=-1.229
Performance	Special	273	4,036	0.874	160.46	[0.219]

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, Z: Z test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.]

The Internet of Things scale average shows a statistically significant difference ($Z(1)=-2.719$, $p<0.05$) between public sector employees (3.543 ± 0.920) and private sector employees (3.894 ± 0.926) at the 5% significance level. Examining the averages reveals that employees in the private sector are more likely to have adopted the Internet of Things.

In terms of the supply chain integration scale average, there is no statistically significant difference ($z(1)=-1.030$, $p>0.05$) between employees in the public sector (3.790 ± 0.860) and private sector (3.904 ± 0.820) at the 5% significance level.

In terms of the supply chain agility scale average, there is no statistically significant difference between employees in the public sector (3.838 ± 1.102) and private sector (4.037 ± 0.914) at the 5% significance level. ($p>0.05$, $Z(1)=-0.867$).

(± 0.874) employees in terms of supply chain performance scale average. ($Z(1)=-1.229$, $p>0.05$).

Table 18 displays the results of the Kruskal Wallis H test, which was used to look at variations based on how long an employee had been in their current position.

Table 16: Kruskal Wallis H Test Findings Testing Differences Based on Experience in the Workplace

Variable	Experience	N	\bar{X}	SS	\bar{r}	KWH Test
Internet of Things	Less than 10 Years	23	3,85	0.88	156.3	$\chi^2(3)=1.371$
		6	3	2	9	

	Between 10-15 Years	53	3,806	1,057	158.47	
	Between 16-20 Years	13	3,706	1,242	156.58	
	More Than 21 Years	13	4,056	1,003	186.69	[0.712]
	Less than 10 Years	23	3,886	0,776	155.46	
	Between 10-15 Years	53	3,897	0,962	163.29	$\chi^2 (3) = 0.841$
Supply Chain Integration	Between 16-20 Years	13	3,783	1,324	168.85	
	More Than 21 Years	13	4,098	0,458	171.65	[0.840]
	Less than 10 Years	23	3,996	0,914	154.32	
	Between 10-15 Years	53	4,147	0,929	175.67	$\chi^2 (3) = 2.820$
Supply Chain Agility	Between 16-20 Years	13	3,908	1,328	166.46	
	More Than 21 Years	13	3,862	1,094	144.31	[0.420]
	Less than 10 Years	23	3,996	0,847	154.72	
	Between 10-15 Years	53	4,113	0,900	170.92	$\chi^2 (3) = 2.271$
Supply Chain Performance	Between 16-20 Years	13	3,702	1,353	144.73	
	More Than 21 Years	13	3,702	1,353	144.73	[0.518]

More Than 21 Years	13	4,27	0.46	177.7
		9	8	3

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, χ^2 : Chi-Square test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.]

Among employees who have worked for less than 10 years (3.853±0.882), between 10 and 15 years (3.806±1.057), between 16 and 20 years (3.706±1.242), and more than 21 years (4.056±1.003), there is no statistically significant difference ($\chi^2(3)=1.371$, $p>0.05$) in terms of the Internet of Things scale means.

There is no statistically significant difference ($\chi^2(3) = 0.841$, $p>0.05$) in the supply chain integration scale means between employees who have been working for less than 10 years (3.881±0.776), between 10 and 15 years (3.897±0.962), between 16 and 20 years (3.783±1.324), and more than 21 years (4.098±0.458) at the 5% significance level.

Between employees who have been working for less than 10 years (3.993±0.914), between 10 and 15 years (4.147±0.929), between 16 and 20 years (3.908±1.328), and more than 21 years (3.862±1.094) in terms of supply chain agility scale means, there is no statistically significant difference at the 5% significance level ($\chi^2(3)=2.820$, $p>0.05$).

The study found no statistically significant difference ($p>0.05$) in the supply chain performance scale means between employees who have worked for less than 10 years (3.997±0.848), between 10 and 15 years (4.113±0.9), between 16 and 20 years (3.702±1.353), and more than 21 years (4.279±0.468) at the 5% significance level.

The results of the Kruskal Wallis H test, which was used to look at variations based on the employees' educational attainment, are displayed in Table 19.

Table 17: Kruskal Wallis H Test Findings Testing Differences Based on Education Levels

Variable	Education	N	\bar{X}	SS	\bar{r}	KW H Test	MWU Test
Internet of Things	1.) Secondary and Primary Education	9	3,283	1,025	98.89	$\chi^2 (4) = 10.554^*$	5>1, 2, 3, 4
	2.)High School	16	3,653	0.933	131.59		
	3.)Associate Degree	44	3,779	0.852	144.31		
	4.) License	192	3,845	0.948	156.00		
	5.) Above Graduate Degree	50	4,129	0.824	184.37	[0.032]	
Supply Chain Integration	1.) Secondary and Primary Education	9	3,919	0.829	151.61	$\chi^2 (4) = 0.183$	-
	2.)High School	16	3,915	0.939	163.81		
	3.)Associate Degree	44	3,934	0.676	157.90		
	4.) License	192	3,872	0.868	155.53		
	5.) Above Graduate Degree	50	3,895	0.782	154.41	[0.996]	
Supply Chain Agility	1.) Secondary and Primary Education	9	4,089	1,316	183.50	$\chi^2 (4) = 3.177$	-
	2.)High School	16	3,638	1,248	131.94		
	3.)Associate Degree	44	4,159	0.813	166.63		
	4.) License	192	3,985	0.948	152.59		
	5.) Above Graduate Degree	50	4,116	0.820	162.50	[0.529]	
Supply Chain Performance	1.) Secondary and Primary Education	9	4,028	0.706	146.17	$\chi^2 (4) = 1.562$	-
	2.)High School	16	3,906	0.893	142.56		

3.)Associate Degree	44	3,974	0.930	152.88	
4.) License	192	3,997	0.904	154.97	
5.) Above Graduate Degree	50	4,180	0.691	168.76	[0.816]

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, χ^2 : Chi-Square test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.], -: Pairwise comparisons were not required for KW H tests where no difference was found.

Based on averages from the Internet of Things, employees with secondary and primary school education (3.283 ± 1.025), high school education (3.653 ± 0.933), associate degree education (3.779 ± 0.852), undergraduate education (3.845 ± 0.948), and undergraduate education and above (4.129 ± 0.824) have statistically significant differences or differences at the 5% level of significance. $\chi^2(4) = 10.554$, $p < 0.05$. The averages of the employees with undergraduate and above education were found to be higher than those of all other employees, following pairwise comparisons to identify the group or groups of education from which the difference originated. In this instance, it can be claimed that employees with undergraduate degrees and above have adopted the Internet of Things to a greater extent than employees with lower education levels. Employees with varying educational backgrounds do not differ in this regard in a way that is statistically significant.

Regarding supply chain integration averages, there is no statistically significant difference ($\chi^2(4) = 0.183$, $p > 0.05$) between employees with secondary and primary school (3.919 ± 0.829), high school (3.915 ± 0.939), associate degree (3.934 ± 0.676), bachelor's degree (3.872 ± 0.868), and bachelor's degree and above (3.895 ± 0.782) education levels.

In terms of supply chain agility averages, there is no statistically significant difference ($\chi^2(4) = 3.177$, $p > 0.05$) between employees with secondary and primary school (4.089 ± 1.316), high school (3.638 ± 1.248), associate degree (4.159 ± 0.813), bachelor's degree (3.985 ± 0.948), and bachelor's degree and above (4.116 ± 0.82).

Between employees with secondary and primary school (4.028+-0.706), high school (3.906+-0.893), associate degree (3.974+-0.93), bachelor's degree (3.997+-0.904), bachelor's degree and above (4.18+-0.691) education levels, there is no statistically significant difference in supply chain performance averages at the 5% significance level ($\chi^2(4)=1.562$, $p>0.05$).

Table 20 displays the results of the Kruskal Wallis H test, which was used to look at variations based on the industries in which the company operates.

Table 18: Kruskal Wallis H Test Findings Testing Differences Depending on Sectors

Variable	Sector	N	\bar{X}	SS	\bar{r}	KWH Test
Internet of Things	Production	76	3,80	0,96	156.3	$\chi^2(2)= 5.905$
			6	4	9	
	Service	16	3,79	0.85	158.4	
		0	8	8	7	
	Production and Service	79	3,98	1,03	156.5	[0.052]
Supply Chain Integration	Production	76	3,77	0.90	155.4	$\chi^2(2) = 4.006$
			8	3	6	
	Service	16	3,89	0.76	163.2	
		0	2	4	9	
	Production and Service	79	3,98	0.86	168.8	[0.135]
Supply Chain Agility	Production	76	3,86	1,00	154.3	$\chi^2(2)= 4.982$
			6	3	2	
	Service	16	4,02	0.86	175.6	
		0	1	9	7	
	Production and Service	79	4,12	1,01	166.4	[0.083]

	Production	76	3,91	1,01	154.7	
			1	9	4	$\chi^2 (2) = 3.921$
Supply Chain	Service	16	3,99	0.80	170.9	
Performance		0	5	8	2	
	Production and	79	4,15	0.83	144.7	[0.141]
	Service		8	6	3	

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, χ^2 : Chi-Square test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.]

At the 5% significance level, there is no statistically significant difference in the Internet of Things averages between employees of manufacturing (3.806±0.964), service (3.798±0.858), and manufacturing and service (3.987±1.038) companies ($\chi^2 (2) = 5.905$, $p > 0.05$).

When it comes to supply chain integration averages, workers from businesses in the manufacturing (3.778±0.903), service (3.892±0.764), and production and service (3.988±0.863) sectors do not differ statistically significantly at the 5% significance level ($\chi^2 (2) = 4.006$, $p > 0.05$).

In terms of supply chain agility averages, there is no statistically significant difference ($\chi^2 (2) = 4.982$, $p > 0.05$) between the employees of the manufacturing (3.866±1.003), service (4.021±0.869), and production and service (4.127±1.014) sectors' companies.

When it comes to supply chain performance averages, employees of businesses in the manufacturing (3.911±1.019), service (3.995±0.808), and manufacturing and service (4.158±0.836) sectors do not differ statistically significantly at the 5% significance level ($\chi^2 (2) = 3.921$, $p > 0.05$).

Table 21 displays the results of the Kruskal Wallis H test, which was used to look at variations based on the number of employees in the company.

Table 19: Kruskal Wallis H Test Findings Testing Differences Based on Number of Employees

Variable	Number of Employees	N	\bar{X}	SS	\bar{r}	KW H Test
Internet of Things	Less Than 1000	19	3,81	0.93	154.3	$\chi^2(3) = 2.109$ [0.550]
		0	8	1	3	
	Between 1000-1500	34	4,05	0.83	178.9	
			1	1	0	
	Between 1501-2000	17	3,80	0.99	156.2	[0.550]
			7	6	4	
	More Than 2001	74	3,84	0.96	158.2	
			0	8	2	
Supply Chain Integration	Less Than 1000	19	3,83	0.81	149.9	$\chi^2(3) = 4.819$ [0.186]
		0	5	4	1	
	Between 1000-1500	34	4,11	0.58	181.3	
			0	2	8	
	Between 1501-2000	17	3,80	0.93	154.6	[0.186]
			7	3	5	
	More Than 2001	74	3,94	0.91	168.8	
			2	4	0	
Supply Chain Agility	Less Than 1000	19	3.97	0.95	154.6	$\chi^2(3) = 2.209$ [0.530]
		0	5	2	1	
	Between 1000-1500	34	4,16	0.71	166.4	
			5	3	4	
	Between 1501-2000	17	3,82	1,02	137.8	[0.530]
			4	7	5	
	More Than 2001	74	4,07	0.99	167.4	
			3	1	5	

	Less Than 1000	19	3,98	0.85	153.7	
		0	8	4	2	$\chi^2 (3)= 1.379$
	Between 1000-1500	34	4,14	0.66	166.8	
Supply Chain			7	9	7	
Performance	Between 1501-2000	17	4,08	1,06	174.1	
			8	6	5	[0.710]
	More Than 2001	74	4,01	0.95	161.2	
			0	8	1	

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, χ^2 : Chi-Square test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.]

Regarding the Internet of Things averages, employees working in companies with fewer than 1000 (3.818 ± 0.931), between 1000 and 1500 (4.051 ± 0.831), between 1501 and 2000 (3.807 ± 0.996), and more than 2001 (3.840 ± 0.968) employees do not differ statistically significantly at the 5% significance level ($\chi^2 (3)=2.109$, $p > 0.05$).

At the 5% significance level, there is no statistically significant difference in supply chain integration averages between employees working in companies with less than 1000 employees (3.835 ± 0.814), between 1000 and 1500 employees (4.11 ± 0.582), between 1501 and 2000 employees (3.807 ± 0.933), and more than 2001 employees (3.942 ± 0.914) ($\chi^2 (3)=4.819$, $p > 0.05$).

There is no statistically significant difference ($\chi^2 (3)=2.209$, $p > 0.05$) in supply chain agility averages between employees working in companies with less than 1000 employees (3.975 ± 0.952), between 1000 and 1500 employees (4.165 ± 0.713), between 1501 and 2000 employees (3.824 ± 1.027), and more than 2001 employees (4.073 ± 0.991). There is no statistically significant difference ($\chi^2 (3)=1.379$, $p > 0.05$) in supply chain performance averages between employees working in companies with less than 1000 employees (3.988 ± 0.854), between 1000 and 1500 employees (4.147 ± 0.669), between 1501 and 2000 employees (4.088 ± 1.066), and more than 2001 employees (4.01 ± 0.958) (between 1000 and 1500 employees).

Table 22 presents the results of the Kruskal Wallis H test, which was used to look at variations based on the firm's size about the market it operates in.

Table 20: Kruskal Wallis H Test Findings Testing Differences Based on Size in Terms of Market Where Business is Done

Variable	Sunday	N	\bar{X}	SS	\bar{r}	KWH Test
Internet of Things	Local	16	3,81	0.94	153.8	$\chi^2 (2)=$ 1.839 [0.399]
		8	2	3	1	
	International	29	4,04	0.86	178.4	
			4	2	8	
Supply Chain Integration	Local And	11	3,85	0.93	158.9	$\chi^2 (2)=$ 5.224 [0.073]
	International	8	0	4	3	
	Local	16	3,81	0.79	147.5	
		8	8	9	8	
Supply Chain Agility	International	29	4,06	0.91	180.5	$\chi^2 (2)=$ 3.010 [0.222]
			9	3	7	
	Local And	11	3,94	0.83	167.2	
	International	8	5	5	9	
Supply Chain Performance	Local	16	3,93	0.96	150.4	$\chi^2 (2)=$ 1.490
		8	6	0	1	
	International	29	4,01	0.94	156.2	
			4	9	6	
Supply Chain	Local And	11	4,11	0.91	169.2	$\chi^2 (2)=$ 1.490
	International	8	5	1	4	
	Local	16	4,00	0.84	155.6	
		8	2	6	5	
Performance	International	29	4,15	0.91	177.5	$\chi^2 (2)=$ 1.490
			1	8	5	

Local And	11	4,00	0.90	156.5	[0.475]
International	8	2	0	3	

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, χ^2 : Chi-Square test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.]

Employees of businesses operating in local (3.812±0.943), international (4.044±0.862), and both local and international (3.850±0.934) markets do not differ statistically significantly in terms of the Internet of Things average at the 5% significance level ($\chi^2(2)=1.839$, $p>0.05$).

Employees of businesses operating in local (3.818±0.799), international (4.069±0.913), and local and international (3.945±0.835) markets do not differ statistically significantly in terms of supply chain integration average at the 5% significance level ($\chi^2(2)=5.224$, $p>0.05$).

Employees of businesses operating in local (3.936±0.960), international (4.014±0.949), and both local and international (4.115±0.911) markets do not differ statistically significantly in terms of supply chain agility average ($\chi^2(2)=3.010$, $p>0.05$).

Between employees of companies operating in local (4.002±0.846), international (4.151±0.918), and local and international (4.002±0.900) markets, there is no statistically significant difference in supply chain performance average ($\chi^2(2)=1.490$, $p>0.05$).

The findings of the Kruskal Wallis H test, which was conducted to examine the differences depending on the number of corporate customers with which the companies do business, are shown in Table 23.

Table 21: Kruskal Wallis H Test Findings Testing Differences Based on the Number of Corporate Customers

Variable	Number of Customers	N	\bar{X}	SS	\bar{r}	KWH Test
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Internet of Things	1.) Less Than 100	92	3,71 0	0,93 1	142.7 3	$\chi^2 (3)= 3.671$	-
	2.)Between 100-151	14	3,82 5	1,13 3	165.1 8		
	3.) Between 151- 200	30	3,90 9	0,93 4	165.5 5		
	4.)More Than 201	17 9	3,91 0	0,91 6	164.0 2		
Supply Chain Integration	1.) Less Than 100	92	3,69 4	0,82 2	133.3 9	χ^2 (3)=9.842 *	4> 1
	2.)Between 100-151	14	3,90 9	1,05 5	167.1 1		
	3.) Between 151- 200	30	3,90 9	0,82 9	159.5 0		
	4.)More Than 201	17 9	3,98 4	0,79 6	169.6 9		
Supply Chain Agility	1.) Less Than 100	92	3,85 2	1,02 8	143.8 3	$\chi^2 (3) =$ 3.876	-
	2.)Between 100-151	14	4,00 0	1,08 7	161.1 4		
	3.) Between 151- 200	30	3,96 0	0,93 9	151.4 2		
	4.)More Than 201	17 9	4,10 1	0,87 9	166.1 4		
Supply Chain Performance	1.) Less Than 100	92	3,89 1	0,87 8	143.5 8	$\chi^2 (3)= 3.724$	-
	2.)Between 100-151	14	3,91 1	1,01 4	148.3 9		

3.) Between 151-	30	4,03	0.96	165.0	
200		8	7	8	
4.)More Than 201	17	4,08	0.84	164.9	[0.710]
	9	4	0	8	

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, χ^2 : Chi-Square test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.]

In terms of Internet of Things averages, there is no statistically significant difference ($\chi^2(3)=3.671$, $p>0.05$) among employees of companies with corporate customers less than 100 (3.710 ± 0.931), 100 to 151 (3.825 ± 1.133), 151 to 200 (3.909 ± 0.934), and more than 201 (3.910 ± 0.916).

The employees of companies with less than 100 (3.694 ± 0.822), 100 to 151 (3.909 ± 1.055), 151 to 200 (3.909 ± 0.829), and more than 201 (3.984 ± 0.796) corporate customers differ statistically from one another in terms of supply chain integration averages ($\chi^2(3)=9.842$, $p<0.05$). The employees of businesses operating with more than 201 corporate customers were found to be at a higher level than the employees of businesses operating with fewer than 100 corporate customers in the pairwise comparisons conducted to identify the group or groups that are the source of the difference. Put differently, the supply chain integrations of businesses that have the greatest number of corporate clients are superior to those of businesses that have the lowest number of corporate clients. In this regard, there isn't a statistically significant difference between the other companies.

In terms of supply chain agility averages, there is no statistically significant difference ($\chi^2(3)=3.876$, $p>0.05$) between the employees of companies with corporate customers less than 100 (3.852 ± 1.028), 100 to 151 (4.000 ± 1.087), 151 to 200 (3.96 ± 0.939), and more than 201 (4.101 ± 0.879).

When it comes to supply chain performance averages, employees of businesses with corporate customers fewer than 100 (3.891 ± 0.878), 100 to 151 (3.911 ± 1.014), 151 to 200

(4.038±0.967), and more than 201 (4.084±0.84)0 do not differ statistically significantly ($\chi^2(3)=3.724$, $p>0.05$).

Table 24 displays the results of the Kruskal Wallis H test, which was used to look at variations based on how many business suppliers each company had.

Table 22: Kruskal Wallis H Test Findings Testing Differences Depending on the Number of Suppliers

Variable	Number of Suppliers	N	\bar{X}	SS	\bar{r}	KW H Test	
Internet of Things	1) Less than 15	92	3,65	0.97	137.3	$\chi^2(2)=8.367$ *	3>1
			2	6	4		
	2)Between 15-20	52	3,85	0.77	152.2		
			7	5	6		
	3)More Than 21	17	3,95	0.94	170.8		
			1	0	0		
Supply Chain Integration	1) Less than 15	92	3,69	0.84	133.0	$\chi^2(2) =$ 15.351*	3>1 , 2
			6	9	2		
	2)Between 15-20	52	3,81	0.69	142.3		
			1	5	0		
	3)More Than 21	17	4,01	0.83	176.2		
			1	6	0		
Supply Chain Agility	1) Less than 15	92	3,76	1,06	135.6	$\chi^2(2) =$ 14.033	3>1 , 2
			5	0	7		
	2)Between 15-20	52	3,88	0.87	140.0		
			5	1	0		
	3)More Than 21	17	4,18	0.86	175.4		
			1	0	1		
Supply Chain Performance	1) Less than 15	92	3,82	0.89	135.9	$\chi^2(2)=13.793$ *	3>1 , 2
			3	8	5		

2)Between 15-20	52	3,91	0.76	139.8	
		8	7	5	
3)More Than 21	17	4,14	0.86	175.3	[0.001]
	1	9	9	8	

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, χ^2 : Chi-Square test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.]

At the 5% significance level, there are statistically significant differences in the Internet of Things averages between employees of businesses with less than 15 suppliers (3.652 ± 0.976), between 15 and 20 suppliers (3.857 ± 0.775), and more than 21 suppliers (3.950 ± 0.940) ($\chi^2(2) = 8.367$, $p < 0.05$). The employees of businesses dealing with more than 21 suppliers had higher averages than the employees of businesses dealing with less than 15 suppliers, according to pairwise comparisons used to identify the group or groups causing the difference. In this instance, it can be concluded that employees of businesses with the greatest number of suppliers have adopted the Internet of Things to a greater extent than employees of businesses with the lowest number of suppliers.

When it comes to supply chain integration means, employees of businesses dealing with fewer than 15 suppliers (3.696 ± 0.849), between 15 and 20 suppliers (3.811 ± 0.695), and more than 21 suppliers (4.016 ± 0.830) differ statistically significantly at the 5% level of significance ($\chi^2(2) = 15.351$, $p < 0.05$). Employees of businesses dealing with more than 21 suppliers had higher means than employees of all other businesses, according to pairwise comparisons used to identify the group or groups causing the difference. In this instance, it can be claimed that businesses with the greatest number of suppliers have a higher degree of supply chain integration than other businesses.

At the 5% level of significance, there are statistically significant differences in supply chain agility averages between employees of businesses with less than 15 suppliers (3.765 ± 1.06), between 15 and 20 suppliers (3.885 ± 0.871), and more than 21 suppliers (4.180 ± 0.861) (χ^2

(2)=14.033, $p < 0.05$). Employees of businesses dealing with more than 21 suppliers had higher averages than employees of all other businesses, according to pairwise comparisons used to identify the group or groups causing the difference. In this instance, it can be claimed that businesses with the greatest number of suppliers have a higher degree of supply chain agility than other businesses.

Regarding supply chain performance averages, employees of businesses dealing with fewer than 15 suppliers (3.823 ± 0.898), 15–20 suppliers (3.918 ± 0.767), and more than 21 suppliers (4.149 ± 0.869) exhibit statistically significant differences at the 5% significance level ($\chi^2(2) = 13.793$, $p < 0.05$). Employees of businesses dealing with more than 21 suppliers had higher averages than employees of all other businesses, according to pairwise comparisons used to identify the group or groups causing the difference. In this instance, it can be claimed that businesses with the greatest number of suppliers have better supply chains than other businesses.

Table 25 displays the results of the Kruskal Wallis H test, which was used to look at variations in the length of time that businesses have been using information technology.

Table 23: Kruskal Wallis H Test Findings Testing Differences Based on ICT Usage Duration

Variable	ICT Usage Period	N	\bar{X}	SS	\bar{r}	KW H Test	MWU Test
Internet of Things	1) Less than 10 Years	191	3,790	0.925	150.74	$\chi^2(4) = 3.746$ [0.441]	-
	2) Between 10-15 Years	64	3,963	0.818	166.69		
	3) Between 16-20 Years	18	3,889	1,017	164.92		
	4) Between 21-25 Years	18	3,914	1,290	185.17		

	5)More than 26 years	24	3,917	0.942	167.04			
Supply Chain Integration	1) Less than 10 Years	191	3,805	0.825	147.59	$\chi^2 (4)= 7.184$		
	2) Between 10-15 Years	64	4,016	0.774	172.35			
	3)Between 16-20 Years	18	3,970	1,030	174.39			
	4)Between 21-25 Years	18	3,914	0.863	162.19			
	5)More than 26 years	24	4.133	0.722	187.15		[0.127]	
Supply Chain Agility	1) Less than 10 Years	191	3,910	0.927	145.34	$\chi^2 (4)=16.012$ *		
	2) Between 10-15 Years	64	4,234	0.878	183.49			
	3)Between 16-20 Years	18	4,322	1,018	200.89			3 and 2>1, 4
	4)Between 21-25 Years	18	3,667	1,160	129.64			
	5)More than 26 years	24	4.233	0.827	179.85		[0.003]	
Supply Chain Performance	1) Less than 10 Years	191	3,930	0.842	146.00	$\chi^2 (4) = 10.541^*$		
	2) Between 10-15 Years	64	4,209	0.856	182.67			2>1
	3)Between 16-20 Years	18	3,993	0.975	157.56			

4)Between 21-25 Years	18	4,215	1,021	191.03	
5)More than 26 years	24	4,052	0.913	163.27	[0.032]

*(5%) symbolizes significance at the significance level, \bar{X} : Mean, SD: Standard Deviation, \bar{r} : rank average, χ^2 : Chi-Square test statistic, (the test in parentheses contains the degree of freedom.), [the test in square brackets contains the significance value.], -: Pairwise comparisons were not required for KW H tests where no difference was found.

When it comes to Internet of Things averages, there is no statistically significant difference ($\chi^2(4)=3.746$, $p>0.05$) among company employees whose ICT usage period is less than 10 years (3.790+-0.925), between 10 and 15 years (3.963+-0.818), between 16 and 20 years (3.889+-1.017), between 21 and 25 years (3.914+-1.29), and more than 26 years (3.917+-0.942).

Employees of companies whose ICT usage period is less than 10 years (3.805+-0.825), between 10 and 15 years (4.016+-0.774), between 16 and 20 years (3.970+-1.030), between 21 and 25 years (3.914+-0.863), and more than 26 years (4.133+-0.722) do not differ statistically significantly in terms of supply chain integration averages at the 5% significance level ($\chi^2(4)=7.184$, $p>0.05$).

The employees of companies whose ICT usage period is less than 10 years (3.910+-0.927), between 10 and 15 years (4.234+-0.878), between 16 and 20 years (4.322+-1.018), between 21 and 25 years (3.667+-1.160), and more than 26 years (4.233+-0.827) have statistically significant differences in supply chain agility averages ($\chi^2(4)=16.012$, $p<0.05$). The supply chain agility averages of the employees of the companies with ICT usage duration between 16 and 20 years and the employees of the companies with ICT usage duration between 10 and 15 years were found to be higher than those of the companies with ICT usage duration of less than 10 years and the employees of the companies with ICT usage duration between 21 and 25 years in the pairwise comparisons conducted to identify the group or groups that are the source of the difference. There was no discernible variation in the other pairwise comparisons.

The employees of the companies with ICT usage durations of less than 10 years (3.930+-0.842), between 10 and 15 years (4.209+-0.856), between 16 and 20 years (3.993+-0.975), between 21 and 25 years (4.215+-1.021), and more than 26 years (4.052+-0.913) show statistically significant differences, or differences at the 5% significance level, in terms of supply chain performance averages. $P < 0.05$, with $\chi^2(4) = 10.541$. The supply chain performance averages of employees of companies with ICT usage durations of 10 to 15 years were found to be higher than those of employees of companies with ICT usage durations of less than 10 years, based on pairwise comparisons conducted to identify the group or groups responsible for the observed difference. In the other comparisons, no statistically significant difference was discovered.

Note: The survey's overall Cronbach's Alpha coefficient is 0.976, indicating perfect reliability. However, I would like to clarify that this statistic only applies to the single measurement tool (sometimes a sub-dimension, sometimes a scale for scales used as totals) and that the reliability measure in question has meaning for the entire survey.

Table 24: Hypothesis Results

Key Findings	Hypothesis	Description	Accepted	P-Value
IoT Impact	H1	Significant positive influence on supply chain Agility	Accepted	***[0.000]
	H2	Significant positive influence on supply chain Integration	Accepted	***[0.000]
	H5	Significant positive influence on supply chain Performance	Accepted	*[0.088]
Integration	H3	Significant positive influence as mediators on supply chain Performance	Accepted	***[0.001]
Agility	H4	Significant positive influence as mediators on supply chain Performance	Accepted	***[0.041]

***(1%), ** (5%), * represents statistical significance at the significance levels (10%) (test degrees of freedom are shown in parentheses).

6.2. Discussion

The study's findings show that, in Turkey's retail industry, IoT deployment greatly improves SCP through improvements to SCI and SCA. The SEM-based quantitative analysis verifies that IoT has a beneficial effect on these variables. The adoption of IoT specifically improves supply chain partners' coordination, decision-making, and real-time visibility.

6.2.1. Comparison with Existing Literature

A- IoT and Supply Chain Performance

The results of this study align with the body of literature that already exists and emphasize how IoT can improve SCP. As with the research conducted by Shafique et al. (2018) and de Vass, Shee, and Miah (2018), this study demonstrates that IoT offers real-time data and insights that facilitate better decision-making, lower costs, and increase efficiency. De Vass et al. (2018), for example, discovered that IoT makes it easier to integrate different supply chain components by providing real-time visibility and communication capabilities. This results in improved inventory management, accurate demand forecasting, and overall supply chain coordination.

Moreover, the study supports the findings of Shafique et al. (2018) who emphasized that IoT adoption can significantly reduce operational costs and improve supply chain reliability and responsiveness by enabling automated tracking and monitoring of goods. This study corroborates these insights by showing how IoT enhances visibility across the supply chain, allowing for real-time tracking of goods from production to delivery. This ensures transparency and quick responses to disruptions, which is crucial for maintaining high service levels and meeting customer expectations.

Furthermore, the study aligns with the work of Mishra et al. (2016), who highlighted the role of IoT in predictive maintenance. The continuous monitoring of equipment and vehicles enabled by IoT allows companies to predict potential failures and perform maintenance before breakdowns occur, thereby minimizing disruptions and extending the lifespan of assets. This proactive approach to maintenance leads to significant cost savings, as confirmed by the findings of this research.

B- IoT and Supply Chain Integration

This study corroborates the findings of previous research by demonstrating that IoT significantly enhances SCI. As de Vass, Shee, and Miah (2018) observed, IoT facilitates real-time visibility and communication, which are crucial for integrating various supply chain components. This study further supports the notion that IoT plays a critical role in both internal and external integration.

Internal integration, as discussed by Zhao et al. (2011), involves the synchronization of processes within an organization. This study found that IoT enables real-time data sharing among departments such as procurement, production, and sales, facilitating better coordination and decision-making. For example, production schedules can be adjusted based on real-time demand signals from the sales department, reducing lead times and minimizing inventory costs.

External integration, emphasized by Huo (2012), involves strategic information sharing, mutual planning, and collaboration with suppliers and customers. This study found that IoT technologies enable real-time tracking and monitoring of shipments, allowing companies to share accurate delivery information with their customers. This transparency improves trust and collaboration, leading to better demand forecasting and inventory management.

The integration of IoT with ERP and CRM systems, as highlighted in the literature, was found to be essential for improving coordination and collaboration among supply chain

partners. This study confirms that the integration of IoT with these systems facilitates better performance monitoring, ensuring that suppliers meet quality and delivery standards.

C- IoT and Supply Chain Agility

The study's findings on supply chain agility are consistent with the literature, particularly the works of Khan and Wisner (2019) and Prater et al. (2001). The research demonstrates that IoT enhances agility by providing real-time visibility, enabling predictive analytics, and supporting adaptive supply chain strategies.

For instance, Fulfilment (2023) highlighted that real-time data visibility allows companies to monitor the status and location of products throughout the supply chain, enabling quicker responses to any disruptions or changes in demand. This study confirms that IoT-enabled sensors can detect changes in environmental conditions that may affect product quality, such as temperature fluctuations during transportation. Immediate alerts allow companies to take corrective actions, such as rerouting shipments or adjusting storage conditions, to prevent spoilage or damage.

Jiga (2023) emphasized the role of predictive analytics powered by IoT data in enhancing SCA. According to this study, by examining past sales data, industry trends, and outside variables, IoT data helps businesses forecast demand fluctuations and optimize inventory levels. By being proactive, this strategy reduces overstock and stockouts and improves SCA overall.

According to this study, by examining past sales data, industry trends, and outside variables, IoT data helps businesses forecast demand fluctuations and optimize inventory levels. By being proactive, this strategy reduces overstock and stockouts and improves SCA overall.

6.2.2. Empirical Evidence and Mediating Roles

The empirical evidence from this study supports the mediating roles of SCI and SCA in the relationship between IoT and SCP. The findings echo those of de Vass, Shee, and Miah (2018), and Wamba (2022), who highlighted that strong integration and agility capabilities amplify the positive impact of IoT on SCP.

The present investigation bolsters the significance of cultivating robust integration competencies, as proposed by de Vass et al. (2018). To truly reap the rewards of IoT, supply chain partners must collaborate, a strong IT infrastructure must be built, and lines of communication must be established. The relationship between IoT adoption and organizational performance is also mediated by SCA, as shown by Wamba (2022), indicating that companies with agile supply chains are better positioned to take advantage of IoT capabilities.

Lee et al. (2022) investigated the mediating function of SCI in the connection between IoT and SCP in a different study. Their conclusions—which are supported by this study—are that better performance results from the efficient integration of IoT technologies with supply chain operations, which improves visibility, coordination, and responsiveness.

6.2.3. Future Research Directions

This study found no substantial evidence to support prior research that suggested a direct correlation between IoT, SCI, SCA, and firm performance. Consequently, more research is required to fully evaluate these four variables. Future research could examine various theoretical perspectives, such as the Resource-Based View (RBV), Practice-Based View (PBV), and Mixed-Based View (MBV) in the context of supply chain performance, as suggested by Wernerfelt (1984), although the primary focus of this study was on the mediating role of SCA in the relationship between IoT and SCP.

The study identifies several areas for future research:

- **Emerging Technologies:** looking into how to combine IoT with cutting-edge technologies like edge computing, blockchain, and artificial intelligence to improve supply chain efficiency. Future studies should look into how these technologies work together with IoT to provide safer data sharing, automation, and more sophisticated predictive analytics.
- **Standardization and Interoperability:** creating uniform frameworks and protocols to guarantee the smooth integration of IoT systems and devices throughout the supply chain. Research ought to concentrate on encouraging cooperation between technology suppliers, standard-setting bodies, and regulatory agencies as well as industry-wide standards.
- **Sustainable IoT Solutions:** Exploring sustainable practices for managing the lifecycle of IoT devices, focusing on energy efficiency and reducing electronic waste. Future research should investigate the development of energy-efficient IoT technologies and sustainable practices such as recycling and reuse of devices.
- **SME Adoption:** Researching cost-effective IoT solutions tailored for small and medium-sized enterprises (SMEs) to democratize the benefits of IoT. Government incentives and support programs can play a crucial role in facilitating IoT adoption among SMEs. Additionally, case studies and pilot projects can provide practical insights into overcoming implementation challenges for smaller businesses.

6.2.4. Recommendations

Based on the findings, the following strategic recommendations are made for retail businesses in Turkey:

- **Invest in IoT Technologies:** Make investments in IoT systems and devices a priority to improve data-driven decision-making and real-time visibility. To increase coordination and collaboration among supply chain partners, businesses should concentrate on integrating IoT with current ERP and CRM systems.
- **Enhance Integration Capabilities:** Develop strong internal and external integration capabilities by creating a robust IT infrastructure, establishing clear communication

channels, and fostering collaboration among supply chain partners. This will ensure better coordination and responsiveness to market changes.

- **Foster Agility:** Develop adaptive supply chain strategies that leverage IoT data for predictive analytics and process automation. This will enable businesses to anticipate demand fluctuations, optimize inventory levels, and quickly respond to disruptions.
- **Address Implementation Challenges:** To safeguard confidential information and adhere to data protection laws, make sure strong data security measures are in place. Invest in employee training programs to give staff members the know-how to effectively manage and use IoT technologies. Look for scalable IoT solutions, especially for SMEs, to get past integration and cost obstacles.

1.2. Conclusion

By presenting empirical data on the beneficial effects of IoT on supply chain performance, integration, and agility within the Turkish retail industry, this study adds to the body of literature. By addressing existing gaps and offering strategic insights, the research highlights the significant role of IoT in creating sustainable, efficient, and responsive supply chains. Future research should continue to explore the integration of emerging technologies with IoT and develop innovative solutions to further enhance supply chain management.

Our research has shown a strong connection between IoT and SCP. We have also discovered that IoT can greatly influence SCP, particularly when combined with SCA and SCI. To improve SCP, managers should promote better communication, information sharing, and training within the organization. It is also important to focus on streamlining and integrating processes with trading partners.

Supply chain integration progresses, making trading partners more flexible and quicker to react to environmental shifts. Retailers should anticipate increases in their market share and profitability as a result. These findings emphasize how vital it is to foster cooperation, integration, and communication to improve SCP and overall business success. IoT has applications in the field of supply chain management. Among many other advantages, it can

be used to track goods, control inventory, keep track of suppliers and customers, and reduce theft and improper handling (McBeth, 2023). In essence, "a series of linked suppliers and customers" is how the supply chain is conceptualized (Akkartal & Aras, 2021) covering all activities involved in the movement and delivery of goods, from the point of raw materials to the final consumer, as well as the information and financial flows related to these activities (de Lima et al., 2022; Sergio G. Lazzarini et al., 2001).

IoT significantly facilitates the integration of various supply chain participants, including manufacturers, suppliers, logistics companies, and retailers. This is made possible by the IoT's real-time visibility and communication capabilities. Retailers can use IoT, for instance, to monitor the whereabouts and conditions of goods as they move through the supply chain. They can use this information to forecast demand and manage inventories more effectively.

- **Summary of Findings**

The quantitative analysis using Structural Equation Modeling (SEM) revealed several key findings:

1. **Impact of IoT on SCI and SCA:** IoT deployment greatly improves real-time data visibility and connectivity, which boosts supply chain agility and integration. This is in line with research in the literature, which demonstrates that IoT improves supply chain partners' coordination and communication (De Vass et al., 2018; Shafique et al., 2018).
2. **Role of SCI and SCA in SCP:** The supply chain can respond and adapt to changes in the market more quickly with increased integration and agility, which boosts overall performance. These results are consistent with earlier studies showing that, in a dynamic market, SCI and SCA are essential for preserving competitive advantage and satisfying customer demands (Yu, 2013; Zhao et al., 2011).
3. **Mediating Effects:** The mediating roles of SCI and SCA in the relationship between IoT and SCP were also identified by the study. This implies—and is backed by

empirical data in the literature—that the advantages of IoT for SCP are realized through its impact on integration and agility (De Vass et al., 2018; Wamba, 2022).

4. Internet of Things (IoT) Adoption:

- A significant difference was found between public and private sector employees, with private sector employees more likely to adopt IoT ($p < 0.05$).
- Employees with higher education levels (undergraduate and above) had adopted IoT more extensively than those with lower education levels ($p < 0.05$).
- Companies with more than 21 suppliers had a higher IoT adoption rate than those with fewer suppliers ($p < 0.05$).

5. Supply Chain Integration:

- There was no significant difference in supply chain integration based on the sector, employee experience, or education level.
- However, businesses with more than 201 corporate customers had higher supply chain integration compared to those with fewer than 100 customers ($p < 0.05$).
- Companies with more than 21 suppliers showed significantly higher supply chain integration than those with fewer suppliers ($p < 0.05$).

6. Supply Chain Agility:

- No significant differences were found between sectors, employee experience, or education level.
- However, companies with IoT usage durations of 10 to 20 years had higher supply chain agility than those with less than 10 years of IoT use ($p < 0.05$).
- Companies with more than 21 suppliers showed significantly higher supply chain agility than those with fewer suppliers ($p < 0.05$).

7. Supply Chain Performance:

- No significant differences were found between sectors, employee experience, or education levels.
- Companies with IoT usage durations between 10 and 15 years had significantly higher supply chain performance compared to those with less than 10 years of IoT use ($p < 0.05$).

- Companies with more than 21 suppliers had significantly better supply chain performance than those with fewer suppliers ($p < 0.05$).

- **Implications and Attachments**

By showcasing the correlation between IoT, the integration of the supply chain, the agility of the supply chain, and the achievement of business success within the retail industry of Turkey, this study contradicts accepted assumptions. It challenges assumptions that there might not be a relationship of this kind.

The retail sector experiences positive outcomes in terms of flexibility, integration of supply chains, and overall business performance due to a broader understanding of the effects of IoT implementation.

These results might lead to more research in this area by encouraging scholars to reevaluate existing theories about how technology supply chain dynamics and company outcomes interact.

- **Practical Implications;**

The results of this study have practical implications for retail industry practitioners and policymakers. Stakeholders can invest in IoT technologies and strategies that support supply chain agility and integration by being aware of the critical role that IoT plays in improving supply chain performance. This may result in higher customer satisfaction, lower operating expenses, and a more competitive market position.

The report provides information for industry experts in Turkey, highlighting the importance of IoT technology investments for enhancing supply chain integration, agility, and ultimately corporate success.

By using these insights to inform their decision-making processes, retailers can improve supply chain operations and increase company performance by taking infrastructure investments and integration plans into account.

Understanding the important direct link that the study uncovered may help retailers create supply chain management plans that encourage flexibility and allow for speedier reactions to changes in the market and consumer requirements. The report highlights the real benefits of using technology in supply chain management, emphasizing how it can give businesses a competitive edge and promote long-term growth in the retail industry.

- **Contributions to Literature**

- Through the presentation of empirical data, this research advances our understanding of IoT implementation, supply chain incorporation, flexibility, and organizational success within Turkey's retail industry.
- The study provides strong empirical evidence in favour of the theoretical relationships proposed by the authors between supply chain dynamics, IoT adoption, and organizational outcomes. The study's findings significantly advance our understanding of this specific field of study.
- By providing a more thorough understanding of how IoT technology impacts supply chain efficiency in retail, this study seeks to close a knowledge gap and advance our knowledge of the subject.
- By examining how IoT technology impacts the effectiveness of supply chains in the retail industry, this study contributes to the body of current research and advances our understanding of this subject.

- **Similarities with Previous Studies:**

1. **IoT's Role in Enhancing Integration and Agility:** Similar to earlier research (De Vass et al., 2018), your study validates that the IoT greatly enhances supply chain integration and agility by enabling real-time visibility and communication throughout the supply chain. Your study and previous research highlight how IoT facilitates improved decision-making processes, predictive analytics, and teamwork.

2. **Supply Chain Performance Improvements:** Previous research (Shafique et al., 2018), for example, shows that the adoption of IoT reduces costs and boosts efficiency to improve supply chain performance overall. In line with previous research, your findings support this by demonstrating how IoT improves SCP through increased integration and agility.
 3. **Empirical Evidence of IoT Impact:** Your work and earlier research (Lee et al., 2022, for example) both stress the significance of empirical testing. Your findings are given more credibility because your use of SEM to quantify the relationships between IoT, SCI, and SCA is consistent with studies that used comparable methodologies.
- **New Contributions:**
 1. **Focus on Türkiye's Retail Sector:** Although IoT has been studied in a variety of international contexts in previous research, your study closes a big gap by concentrating on the Turkish retail sector. Since this market has not been thoroughly studied before, your research provides fresh information on how IoT technologies affect supply chain performance in Türkiye.
 2. **Comprehensive Examination of SCI, SCA, and SCP:** In contrast to previous research that frequently concentrates on specific facets of supply chain management, your study integrates the effects of IoT on supply chain integration and agility as well as their combined impact on performance. This comprehensive method offers a more thorough comprehension of the interactions between these elements.
 3. **Application of SEM for In-Depth Analysis:** While other studies (De Vass et al., 2018) have employed structural equation modelling (SEM), your utilization of this model to investigate particular variables in the Turkish retail industry adds a fresh perspective to the current corpus of literature. This thorough investigation offers fresh empirical data in favour of IoT's beneficial effects on SCI, SCA, and SCP, especially in the retail sector.

Through the integration of current conceptual models with empirical, practical research conducted in Turkey's retail industry, your study adds significant value to the body of knowledge and offers practical recommendations for practitioners in the field.

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Institutional Review Board Statement: This study was carried out with the approval of the ethics committee received from the Yeditepe University Social and Human Sciences Ethics Committee (Ethics Committee Decision No. 41/2023, Date of Approval 26.05.2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Data Availability Statement: Data can be requested from the Correspondence author when necessary.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

(IoT)	Internet of Things
(SCI)	Supply Chain Integration
(SCA)	Supply Chain Agility
(ICT)	Information and Communication Technologies
(SCs)	Supply Chains
(CFA)	Confirmatory factor analysis
(CFI)	comparative fit index
(GFI)	The goodness of the fit index
(RMSEA)	Root mean square error of approximation

Appendix

Appendix 1 (Questioner)

SECTION 1: GENERAL INFORMATION (Boirwais M.H .2013).

In this section, the researcher would like to know about your company in general.

1. Company Sector: Private Public

2. Your job title: _____

3. Your experience in the current job: Less than 10 years 10 - 15 years
 16 -20 years more than 20 years

4. Your educational qualification: _____

5. Please indicate the type of your company:

- Manufacturing.
- Services.
- Both of them.

6. Please indicate the size of your company in terms of employees:

- Less than 1000 employees.
- 1000 – 1500 employees.

1501 – 2000 employees.

More than 2000 employees.

7. Please indicate the geographic scope of your company's operations:

- a. Local (e.g: Tubrek, Alzewetina, Albrika, rasalanof, Alzawia).
- b. Worldwide (e.g., Chain, UK, Australia, Italy, and Japan).
- c. Both of them.

8. Please indicate the following:

i. The total number of customers:

A. less than 100 B. 100-150 C. 51 – 200 D. More than 200

ii. The total number of suppliers:

A. less than 15 B. 15-20 C. More than 20

9. When did you start using Information technologies in your company?

- A. Less than ten years B. 10 years – 15 years
- C. 16 years - 20 years D. 21 years - 25 years
- E. More than 25 year

SECTION 2: IoT Adoption

In this section, the researcher aims to assess the level of IoT adoption within your company. Please select a number on the scale below each question to indicate your agreement level with the statements.

The Internet of Things, the term IoT refers to a network of interconnected computing devices, machines, objects, animals, or individuals. These entities can transmit information through a network without the need for direct communication between people or between people and computers, all thanks to their unique identification codes.

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

IoT Adoption(Lee, Romzi, Hanaysha, & Alzoubi, 2022)		Degree of Agreement				
** IoT Adoption helps my company to.....		1	2	3	4	5
1	To enable identification at the individual item level.	1	2	3	4	5
2	To enable identification at the unit level (e.g., container/box/pallet).	1	2	3	4	5
3	To automatically capture data for monitoring, tracking, and tracing supply chain entities and people.	1	2	3	4	5
4	Assessment of supply chain functions, protocols, and sustainability factors.	1	2	3	4	5
5	To remotely manage supply chain processes.	1	2	3	4	5
6	To enable autonomous decision-making within the supply chain.	1	2	3	4	5
7	To offer real-time data for optimizing supply chain operations	1	2	3	4	5
8	To furnish real-time insights into supply chain operations.	1	2	3	4	5
9	To offer extensive datasets and diverse data for applying data analytics in tactical and strategic decision-making.	1	2	3	4	5
10	To improve the sharing of information among both internal departments and external partners within the supply chain.	1	2	3	4	5

1	To streamline decision-making processes within and outside the organization	1	2	3	4	5
1	within the supply chain.					
1	To bolster communication and coordination among stakeholders.	1	2	3	4	5
2						

SECTION 3: Supply Chain Agility

The researcher is attempting to gauge your company's supply chain agility in this section. Using the following scale, please circle the appropriate number next to each statement to indicate how much you agree with it.

Supply chain agility refers to expeditiously adjusting its approach, particularly in the areas of procurement, inventory management, and delivery, to effectively address the swiftly changing requirements of the supply chain.

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

Supply Chain Agility(Macclever & Annan and Seth, 2017)

** By applying IoT Adoption in Supply Chain Agility		Degree of Agreement				
1	My company consistently strives to enhance delivery reliability.	1	2	3	4	5
2	My company demonstrates agility in identifying environmental threats promptly.	1	2	3	4	5
3	We regularly enhance products and customer service levels.	1	2	3	4	5
4	We can efficiently allocate resources to address various demands.	1	2	3	4	5
5	Typically, we can swiftly access the necessary data for decision-making.	1	2	3	4	5
6	We are well-prepared and skilled in adapting to upcoming market changes.	1	2	3	4	5
7	We frequently receive relevant information from our customers and suppliers.	1	2	3	4	5

SECTION 4: Supply chain integration

The researcher is attempting to gauge your company's supply chain integration in this section. Using the following scale, please circle the appropriate number next to each statement to indicate how much you agree with it.

Supply chain integration refers to a process wherein all entities involved in the product fulfilment process are consolidated into a unified system.

	1	2	3	4	5
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Customer integration(Seo, 2014)					Degree of Agreement
**	By applying IoT Adoption in our Customer integration				
1	We extensively exchange market information with our key customers.				1 2 3 4 5
2	We utilize information technologies to share data with major customers.				1 2 3 4 5
3	We collaborate with key customers to conduct comprehensive joint planning and forecasting to anticipate demand visibility.				1 2 3 4 5
4	Our procurement and production processes benefit from the information provided by our customers.				1 2 3 4 5
5	Our customers actively participate in our product development processes.				1 2 3 4 5
Supplier integration(Seo, 2014)					Degree of Agreement
**	By applying IoT Adoption in our Supplier integration				
1	We utilize information technologies to share data with our primary suppliers.				1 2 3 4 5
2	We maintain strong strategic partnerships with our suppliers.				1 2 3 4 5
3	We engage in extensive joint planning to facilitate rapid response ordering processes (inbound) with our suppliers.				1 2 3 4 5
4	Our suppliers provide us with valuable information regarding production and procurement processes.				1 2 3 4 5

5	Our suppliers actively participate in our product development processes.	1	2	3	4	5
Internal integration (Seo, 2014)		Degree of Agreement				
** By applying IoT Adoption in our Internal integration						
1	We demonstrate a high level of responsiveness within our plant to fulfil the needs of other departments.	1	2	3	4	5
2	An integrated system has been implemented that encompasses all functional areas of plant control.	1	2	3	4	5
3	The exchange of information between purchasing, inventory management, sales, and distribution departments is given priority within our plant.	1	2	3	4	5
4	Within our plant, we prioritize the physical flow between production, packing, warehousing, and transportation departments.	1	2	3	4	5

SECTION 5: Supply chain performance.

The researcher's goal in this section is to evaluate the different facets of supply chain performance. Please select the appropriate number on the provided scale for each question to indicate how much you agree with the statements provided.:

Supply chain performance refers to Assessing the effectiveness of each stage of the e-commerce supply chain involves evaluating how well it optimizes costs, reduces inefficiencies, enhances speed, and meets customer expectations.

1	2	3	4	5
Extremely poor	poor	average	good	Excellent

Supply chain performance (De Vass et al., 2018)

** IoT Adoption in our Supply chain performance helps us to		Degree of Agreement				
1	Enhance product quality	1	2	3	4	5
2	Enhance the reliability of supply chain deliveries	1	2	3	4	5
3	Enhance perfect order fulfillment (error-free deliveries)	1	2	3	4	5
4	Enhance fill rates	1	2	3	4	5

5	Enhance supply chain flexibility (ability to respond to changes in product, volume, and mix)	1	2	3	4	5
6	Decrease cash-to-cash cycle time	1	2	3	4	5
7	Decrease total supply chain management cost	1	2	3	4	5
8	Decrease cost of goods sold	1	2	3	4	5
9	Enhance value-added productivity (sales per employee)	1	2	3	4	5



Appendix 2 (Anket)

BÖLÜM 1: GENEL BİLGİLER (Boirwais M.H .2013).

Bu bölümde araştırmacı, şirketiniz hakkında genel olarak bilgi edinmek ister.

1. Şirket Sektörü: Özel Kamu

2. İş ünvanınız: _____

3. Mevcut işinizdeki deneyim süreniz :

10 yıldan az 10 – 15 yıl

16 – 20 yıl 20 yıldan fazla

4. Eğitimsel yeterliliğiniz: _____

5. Lütfen şirketinizin türünü belirtiniz:

- Üretim.
- Hizmetler.
- İkisi burden.

6. Lütfen şirketinizin büyüklüğünü çalışanlar açısından belirtiniz:

- 1000'den az çalışan
- 1000 – 1500 çalışan
- 1501 – 2000 çalışan
- 2000'den fazla çalışan

7. Lütfen şirketinizin operasyonlarının coğrafi kapsamını belirtiniz:

- Yerel (örneğin; Tübrek, Alzewetina, Albrika, rasalanof, Al Zawia)
- Dünya çapında (örneğin; Çin, İngiltere, Avustralya, İtalya ve Japonya)
- İkisi birden.

8. Lütfen aşağıdakileri belirtiniz:

iii. Toplam müşteri sayısı:

- 100'den az 151 – 200
- 100 – 150 200'den fazla

iv. Toplam tedarikçi sayısı:

- 15'ten az 15 – 20 20'den fazla

9. Şirketinizde bilgi teknolojilerini kullanmaya ne zaman başladınız?

- 10 yıldan daha az 10 – 15 yıl
- 16 – 20 yıl 21 – 25 yıl
- 25 yıldan daha fazla

BÖLÜM 2: IoT Benimseme

Bu bölümde, araştırmacı şirketinizde IoT Benimsemesini ölçmeye çalışmaktadır. Lütfen aşağıdaki ölçeği kullanıp her soru için uygun sayıyı daire içine alarak aşağıdaki ifadelere katılma derecenizi belirtiniz.

Nesnelerin interneti veya IoT, benzersiz tanımlayıcılar ve insandan insana veya insandan bilgisayara etkileşim gerektirmeden bir ağ üzerinden veri aktarma yeteneği ile sağlanan, birbiriyle ilişkili bilgi işlem cihazları, mekanik ve dijital makineler, nesnelere, hayvanlar veya insanlardan oluşan bir sistemdir.

1	2	3	4	5
Kesinlikle Katılmıyorum	Katılmıyorum	Ne Katılmıyorum Ne Katılıyorum	Katılıyorum	Kesinlikle Katılıyorum

IoT Benimseme(Lee, Romzi, Hanaysha, & Alzoubi, 2022)

		Katılma Derecesi				
** IoT Benimseme, şirketimin						
1	Bireysel öge düzeyinde tanımlama sağlamasına yardımcı olur.	1	2	3	4	5
2	Birim seviyesinde (örn. konteyner/kutu/palet) tanımlama sağlamasına yardımcı olur.	1	2	3	4	5
3	Tedarik zinciri varlıklarını ve insanları otomatik olarak yakalanan veriler aracılığıyla görüntülemesine, izlemesine ve takip etmesine yardımcı olur.	1	2	3	4	5
4	Tedarik zinciri faaliyetlerini, süreçlerini ve çevre koşullarını ölçmesine yardımcı olur.	1	2	3	4	5
5	Tedarik zinciri süreçlerini uzaktan kontrol etmesine yardımcı olur.	1	2	3	4	5
6	Otonom tedarik zinciri kararları vermesine yardımcı olur.	1	2	3	4	5
7	Tedarik zinciri faaliyetlerini optimize etmek için gerçek zamanlı bilgi sağlamasına yardımcı olur.	1	2	3	4	5

8	Tedarik zinciri operasyonlarının gerçek zamanlı istihbaratını sağlmasına yardımcı olur.	1	2	3	4	5
9	Taktik ve stratejik karar verme için veri analitiğini uygulamak üzere büyük hacimlerde ve çeşitli veri sağlmasına yardımcı olur.	1	2	3	4	5
10	Tedarik zinciri içinde kurum içi ve kurumlar arası organizasyonel bilgi paylaşımını güçlendirmesine yardımcı olur.	1	2	3	4	5
11	Tedarik zinciri içinde kurum içi ve kurumlar arası organizasyonel karar vermeyi kolaylaştırmaya yardımcı olur.	1	2	3	4	5
12	Operatörler arasındaki iletişimi ve koordinasyonu güçlendirmeye yardımcı olur.	1	2	3	4	5

BÖLÜM 3: Tedarik Zinciri Çevikliği

Bu bölümde, araştırmacı şirketinizde Tedarik Zinciri Çevikliğini ölçmeye çalışmaktadır. Lütfen aşağıdaki ölçeği kullanıp her soru için uygun sayıyı daire içine alarak aşağıdaki ifadelere katılma derecenizi belirtiniz.

Tedarik zinciri çevikliği, bir şirketin hızla değişen tedarik zinciri gereksinimlerini karşılamak için özellikle satın alma, envanter yönetimi ve teslimattaki stratejisini hızla ayarlama becerisini ifade eder.

1	2	3	4	5
Kesinlikle Katılmıyorum	Katılmıyorum	Ne Katılmıyorum Ne Katılıyorum	Katılıyorum	Kesinlikle Katılıyorum

Tedarik Zinciri Çevikliği(Macclever & Annan and Seth, 2017)

		Katılma Derecesi				
** Tedarik Zinciri Çevikliğinde IoT Benimseme uygulayarak						
1	Şirketim her zaman teslimat güvenilirliğini artırmaya çalışır	1	2	3	4	5
2	Şirketim, ortamındaki tehditleri hızlı bir şekilde tespit eder.	1	2	3	4	5
3	Ürünleri ve müşteri hizmet seviyelerini düzenli olarak iyileştiriyoruz	1	2	3	4	5
4	Farklı gereksinimleri karşılamak için kaynakları seferber edebiliyoruz	1	2	3	4	5
5	Genellikle karar vermek için ihtiyaç duyduğumuz verilere hızlı bir şekilde erişebiliriz.	1	2	3	4	5
6	Gelecekteki değişen pazar ihtiyaçlarına uyum sağlamaya hazır ve yetenekliyiz	1	2	3	4	5
7	Müşterilerimiz ve tedarikçilerimiz ilgili bilgileri bizimle paylaşmakta hızlıdır.	1	2	3	4	5

BÖLÜM 4: Tedarik zinciri entegrasyonu

Bu bölümde, araştırmacı şirketinizde Tedarik Zinciri Entegrasyonunu ölçmeye çalışmaktadır. Lütfen aşağıdaki ölçeği kullanıp her soru için uygun sayıyı daire içine alarak aşağıdaki ifadelere katılma derecenizi belirtiniz.

Tedarik zinciri entegrasyonu, bir ürünün yerine getirilmesine dahil olan tüm tarafların tek bir sisteme entegre edildiği bir süreçtir.

1	2	3	4	5
Kesinlikle Katılmıyorum	Katılmıyorum	Ne Katılmıyorum Ne Katılıyorum	Katılıyorum	Kesinlikle Katılıyorum

Müşteri entegrasyonu(Seo, 2014)

Müşteri entegrasyonumuzda IoT Benimseme uygulayarak		Katılma Derecesi				
1	Pazar bilgileri hakkında büyük müşterilerle yüksek düzeyde bilgi paylaşımına sahibiz.	1	2	3	4	5
2	Bilgi teknolojileri aracılığıyla büyük müşterilerle bilgi paylaşıyoruz.	1	2	3	4	5
3	Talep görünürlüğünü tahmin etmek için büyük müşterilerle yüksek derecede ortak planlama ve tahminlerimiz var.	1	2	3	4	5
4	Müşterilerimiz, satın alma ve üretim süreçlerinde bize bilgi vermektedir.	1	2	3	4	5
5	Müşterilerimiz ürün geliştirme süreçlerimize dahil olmaktadır.	1	2	3	4	5

Tedarikçi entegrasyonu(Seo, 2014)

Tedarikçi entegrasyonumuzda IoT Benimseme uygulayarak		Katılma Derecesi				
1	Başlıca tedarikçilerimizle bilgi teknolojileri aracılığıyla bilgi paylaşıyoruz.	1	2	3	4	5
2	Tedarikçilerle yüksek derecede stratejik ortaklığa sahibiz.	1	2	3	4	5
3	Tedarikçilerle hızlı yanıt sipariş süreçleri (inbound) elde etmek için yüksek derecede ortak planlamaya sahibiz.	1	2	3	4	5

4	Tedarikçilerimiz, üretim ve satın alma süreçleri hakkında bize bilgi vermektedir.	1	2	3	4	5
5	Tedarikçilerimiz ürün geliştirme süreçlerimize dahil olmaktadır.	1	2	3	4	5

İç entegrasyon (Seo, 2014)

İç entegrasyonumuzda IoT Benimseme uygulayarak		Katılma Derecesi				
1	Diğer departmanların ihtiyaçlarını karşılamak için fabrikamızda yüksek düzeyde yanıt verme yeteneğine sahibiz.	1	2	3	4	5
2	Tesis kontrolünün işlevsel alanlarında entegre bir sisteme sahibiz.	1	2	3	4	5
3	Fabrikamızda satın alma, envanter yönetimi, satış ve dağıtım departmanları arasındaki bilgi akışlarına önem veriyoruz.	1	2	3	4	5
4	Fabrikamızda üretim, paketlenme, depolama ve nakliye departmanları arasındaki fiziksel akışlara önem veriyoruz.	1	2	3	4	5

BÖLÜM 5: Tedarik zinciri performansı

Bu bölümde, araştırmacı şirketinizde Tedarik Zinciri Performansının boyutlarını ölçmeye çalışmaktadır. Lütfen aşağıdaki ölçeği kullanıp her soru için uygun sayıyı daire içine alarak aşağıdaki ifadelere katılma derecenizi belirtiniz.

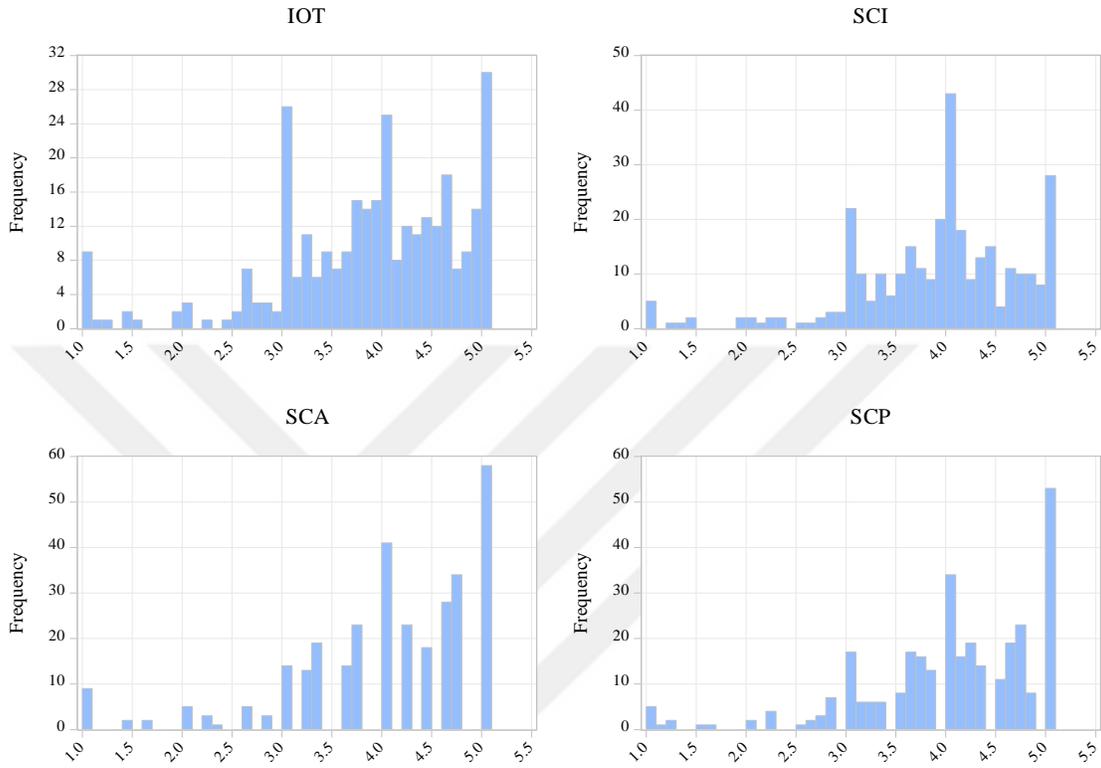
Tedarik zinciri performansı, e-ticaret tedarik zincirinin her aşamasının maliyetleri optimize etmede, verimsizlikleri azaltmada, hızı geliştirmede ve müşteri beklentilerini karşılamada ne kadar etkili olduğunu ifade eder.

1	2	3	4	5
Çok Zayıf	Zayıf	Orta	İyi	Mükemmel

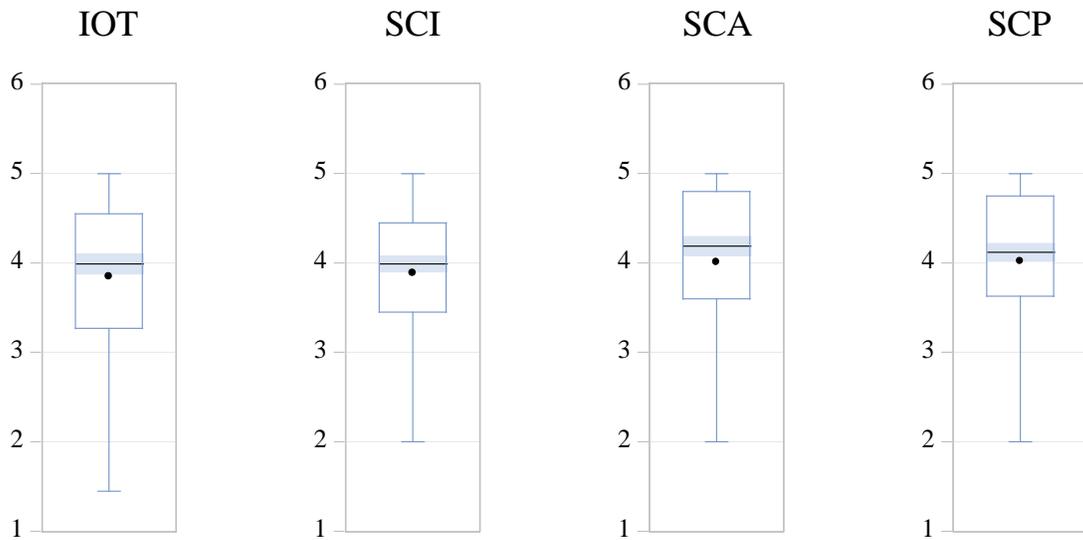
Tedarik zinciri performansı (De Vass et al., 2018)

** Tedarik zinciri performansımızda IoT Benimseme, bize		Katılma Derecesi				
1	Ürün kalitesini iyileştirmekte yardımcı olur.	1	2	3	4	5
2	Tedarik zinciri teslimat güvenilirliğini iyileştirmekte yardımcı olur.	1	2	3	4	5
3	Kusursuz sipariş gerçekleştirmeyi (hatasız teslimatlar) iyileştirmekte yardımcı olur.	1	2	3	4	5
4	Doluluk oranlarını iyileştirmekte yardımcı olur.	1	2	3	4	5
5	Tedarik zinciri esnekliğini (ürün değişikliklerine, hacmine, karışımına tepki verme) iyileştirmekte yardımcı olur.	1	2	3	4	5
6	Nakitten nakite döngü süresini azaltmakta yardımcı olur.	1	2	3	4	5
7	Toplam tedarik zinciri yönetimi maliyetini azaltmakta yardımcı olur.	1	2	3	4	5
8	Satılan malların maliyetini azaltmakta yardımcı olur.	1	2	3	4	5
9	Katma değerli üretkenliği (çalışan başına satış) arttırmakta yardımcı olur.	1	2	3	4	5

APPENDIX 3: Variable Histogram Charts



APPENDIX 4: Variable Box-Plot Plots



APPENDIX 5: Permission of the scales used in the Questioner

 **Dr. Anas Abd-Alhadi** • 8:11 AM

Hi, Dr Tharaka de Vass, my name is Anas Abdelhadi and I'm writing my PhD thesis. I've read your article "The effect of "Internet of Things" on supply chain integration and performance: An organisational capability perspective " and I want your Authuraizaition to use part of your quastinair

 **Tharaka de Vass** • 8:12 AM

Hi Anas,
No problem. I'm all for sharing knowledge.
Use it as you wish, please.
Regards,
Tharaka

 **ANAS ABDELHADI** Yesterday
to boirwaismaree ▾

Hello Dr MAREE. H. BOIRWAIS BOIRWAIS
I hope this email finds you well

My name is Anas Abdelhadi From Yeditepe University in Istanbul. Turkey and I'm writing my Phd thesis and I need your authorization to use some parts of your questionnaire that have been used in the following research paper ?
THE IMPACT OF USING INFORMATION TECHNOLOGIES ON SUPPLY CHAIN INTEGRATION AND SUPPLY CHAIN PERFORMANCE MANAGEMENT IN LIBYAN OIL COMPANIES

thanks in advance

 **Maree Boirwais** 5:41 pm
to me ▾

How it is going , Mr. Anas? With my pleasure you can use my phd thesis questionnaire in your doctoral thesis. Best Regards .you can contact by e-mail

 **Dr. Anas Abd-Alhadi** • 10:39 PM

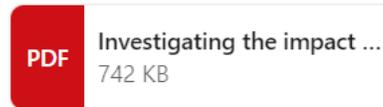
Hi, Dr Haitham M. Alzoubi, my name is Anas Abdelhadi and I'm writing my PhD thesis. I've read your article " Investigating the impact of benefits and challenges of IoT adoption on supply chain performance and organizational performance:" and I want your Authuraizaition to use part of your quastinair

 **Prof. Dr. Haitham M. Alzoubi** • 10:47 PM

Hello
I will check with my co-author

 **Prof. Dr. Haitham M. Alzoubi** • 8:50 AM

Dear Anas, the measurement items are available in Appendix A of the paper



 **Dr. Anas Abd-Alhadi** • 5:43 PM

Okay
Thanks for your response

 **Prof. Dr. Haitham M. Alzoubi** • 7:00 PM

It's my pleasure

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