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Revolutionizing Retail: Examining the Influence of Blockchain-Enabled IoT Capabilities on Sustainable Firm Performance

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Abstract: Blockchain has revolutionized the field of supply chain management, allowing firms to optimize their operations and achieve enhanced levels of efficiency and environmental responsibility. This study investigates the relationships between the functionalities of the blockchain-enabled Internet of Things (IoT) and many aspects of the supply chain, namely, supplier integration, internal integration, customer integration, and sustainable logistic capabilities. It also analyses the impact of these correlations on the supply chain performance and sustainability of firms. This study is grounded in an empirical inquiry carried out using a questionnaire survey of the retail industry in Pakistan. Partial Least Squares Structural Equation Modelling (PLS-SEM) was employed to analyze the data. The findings indicate a direct correlation between the use of BC-enabled Internet of Things (IoT) capabilities and the integration of the supply chain, as well as logistic capabilities. Furthermore, there is a strong and meaningful correlation between blockchain-enabled supply chain integration and sustainable logistic capabilities and firm performance. The research findings indicate that the combined impact of digital innovations results in higher levels of corporate performance and sustainability. By embracing digitization through blockchain technology, business organizations can attain supply chain excellence. This integration enhances the adoption of environmentally beneficial actions, minimizes waste, and decreases carbon emissions across supply chains, thus reinforcing the connection between sustainable firm performance and environmental sustainability. As a result, the enterprises may execute sustainably through improved logistical capabilities and effective integration. The results hold great theoretical and practical significance for improving supply chain management efficacy and accomplishing multiple SDGs, including SDG-8, SDG-9, SDG-11, and SDG-12.

Keywords: blockchain; internet of things; supply chain management; supply chain integration; supplier integration; internal integration; customer integration; sustainable logistic capabilities; sustainable firm performance; waste reduction; carbon emission; environmental sustainability

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1. Introduction

Effective retail supply chains that run smoothly assist in avoiding shortages, price rises, and delays in delivering key commodities. Retail supply chains also contribute to economic growth and job creation. They connect numerous industries, including manufacturing, food, and agriculture, creating a significant amount of revenue, supporting small businesses, and boosting economic growth. The supply chain adapts to changing customer demands via market and consumer feedback, making it easier to introduce new products. The retail supply chain aids the agricultural business by fostering innovation. Supply chain management systems enable better resource planning, coordination, and optimization, resulting in increased output while reducing waste and improving resource management [1,2].

Every company needs supply chain management (SCM) to be successful because it increases customer satisfaction, lowers operating costs, and boosts operational efficiency at the lowest possible cost while maximizing output. For accurate and timely information flow

overseeing the SCM network, it is crucial for all SC activities to be integrated [3] Cooperation and coordination across all SC departments and participants are seen as essential elements of SC integration. An effective way to address these issues is the implementation of digital supply chain operations. This enables enhanced collaboration and coordination, facilitates the seamless exchange of information, and ensures efficient management of the diverse stakeholders involved [4].

Pakistan's retail industry is distinct and ranks third in size after manufacturing and agriculture while being largely unorganized. Over the previous ten years, wholesale and retail trade's percentage of GDP has averaged a stable 17.5% (Punjab Board of Investment and Trade). Every citizen is probably impacted by the retail industry every day, at least more than once. This clarifies the importance of the retail industry and supports the importance of this study for Pakistan.

There are inherent restrictions, such as a lack of efficiencies resulting from small-scale operations, a lower degree of functional competence, and a lack of financial strength. Such limits have a negative influence on the unorganized sector's capacity to demonstrate its potential. It can only be overcome by a thorough integration of technology to improve sustainable competence. There is a need for proper sustainable supply chain infrastructure in Pakistan's retail sector, which is a system that integrates technology with suppliers, enterprises, and customers at the same time. Implementing current technologies can only help to increase coordination among supply chain players and help in making more sustainable supply chains. SCM's systems provide more effective resource planning, coordination, and optimization, resulting in increased productivity, less waste, and improved resource management [1].

Transferring information and fostering engagement between separate and disconnected systems is a challenging task. Consequently, meeting client requests becomes challenging, leading to inventory management challenges. Additionally, it hinders the capacity to effectively handle quality control concerns due to the absence of real-time tracking and traceability [5,6].

Nevertheless, enlisted SC activities encounter numerous challenges, including the potential for data loss, fraudulent activities, errors, inadequate shipment monitoring, insufficient data sharing via a protected network, incapability to manage substantial volumes of logistics records, and inefficient information flow [7]. There are sustainability issues in Pakistan's retail sector as well. A number of factors affect the accessibility and sustainability of the supply chain as a whole, including carbon emissions, inefficient transportation and infrastructure, wasted food, ineffective processing and manufacturing, water scarcity, and so on [8].

In order to surmount these challenges, it is recommended that the retail industry adopt digital technologies to improve the effectiveness and precision of sustainable supply chain management (SCM) operations. To avoid complications and uncertainties, establishing a digital SC and incorporating new technologies into SCM operations are necessary for the development of an efficient SC [9]. Digitally advanced SC systems can reduce risk, improve inventory management, track logistics activities in real-time, and facilitate real-time information sharing. Despite all these, the unchecked integration of digital technology applications in business poses inherent risks of data breaches and cyber threats.

Blockchain is regarded as one of the more relevant emerging technologies that are ideal for supply chain management in the retail sector because of its cutting-edge features, which include dissemination of information in real time to all concerned partners, cybersecurity for sensitive and financial data, traceability, credible tracking ability, transparency, safer transaction ecosystem, visibility in real time, and dependability [10]. Because of the complicated network of relationships between multiple industries, the retail industry highly values these assets for contemporary supply chain management.

Produção et al [11] have described that the integration of the supply chain (SC) can be improved by leveraging the unique capabilities of blockchain technology to increase the information exchange platform for both internal and external SC members. In order to

address these limitations, it is necessary to utilize advanced technologies like blockchain, which can enhance logistics operations by facilitating the rapid exchange of information and by allowing effective and efficient traceability [12]. Blockchain can enhance stock management and demand forecasting accuracy while also promoting faith in suppliers and contractors for payment purposes [13–16]

The purpose of this study is to provide supply chain managers and decision-makers with a comprehensive understanding of the significance of blockchain technology in addressing retail supply chain issues. The implementation of blockchain technology in the retail industry is now in the early stages, and leaders in the field are seeking additional literature or proof that outlines the benefits and provides a roadmap for adoption to address supply chain issues. The intention of this research is to propose an in-depth summary of blockchain technology in the retail industry and to make supply chain professionals more aware of its distinct advantages and potential to enhance businesses' overall performance and sustainability. To address the issues faced by the retail sector, it is necessary to improve the characteristics of supply chain integration, including customer integration, internal integration, and supplier integration. Blockchain is a technology that enhances supply chain performance by facilitating IoT capabilities, supplier integration, customer integration, and internal integration via its unique properties. Furthermore, the integration of BC technology offers improved logistical capabilities for more efficient and sustainable management of the logistic function.

Researchers have mostly overlooked the retail industry, resulting in a scarcity of studies on the application of blockchain technology as a solution for sustainable supply chain management (SSCM). This paper is a preliminary attempt to propose a framework that identifies the issues and difficulties faced by the retail sector's supply chain (SC) in all of its phases (upstream, midstream, and downstream). It also explores how blockchain (BC) properties might be used as a solution to address these problems in supply chain management (SCM). Furthermore, this research observes the influence of Internet of Things (IOT) capabilities, supply chain integration (SCI), and sustainable logistics capabilities (LCs) on the sustainable firm performance (SFP) of a business that is operating in a blockchain environment. It also considers the role of SLC as a mediator to analyze the impact of SCI on SFP. In order to comprehend the possible chances, the retail sector of Pakistan was selected. This sector holds significant importance in the economy and is crucial for the uninterrupted movement of products in many industries. In addition, Pakistan's retail business attempts to embrace innovative technology for sustainable supply chain management (SSCM) operations. This technology assists decision-makers in understanding the significance of blockchain in SSCM, its implementation methods, and the solutions it offers for their challenges.

These research questions are aimed in a direction to understanding blockchain (BC) presence and its influence in the retail SC ecosystem.

1. Does retail blockchain- enabled IOT(BIOT) significantly affect SCI, SLC, and SFP?
2. Does retail blockchain-enabled SCI significantly affect SFP and SLC?
3. Do SLC and SCI as mediators influence the relationship between BIOT and SFP?
4. Does SLC have a mediating role in impacting SCI's effect on SFP?

2. Literature Review

The digital transformation phenomena encompass the continuous utilization of digital technologies to significantly change the operations, customer service, and competitive strategies of firms in the marketplace [17–19]. Digital transformation entails leveraging digital technology to optimize company operations, streamline workflows, and elevate consumer satisfaction [20–23]. Blockchain is a technological advancement that can facilitate digital transformation in SC solutions. BC technology is based on a system of a distributed ledger which eliminates the presence of middlemen and enables safe and transparent dealings between participants of a single supply chain. This technology is so versatile in its uses that it can be utilized in any of the supply chain functions, ranging from sourcing

to distribution and retailing. Because its solutions offer a safe and decentralized way to manage data and transactions, they are relevant to the phenomenon of digital transformation [24]. This can assist companies in streamlining their processes, cutting expenses, and increasing productivity [25]. Blockchain technology, for instance, can make it possible to track materials and commodities in an SC in a transparent and safe manner, lowering the possibility of scams or forging which eventually increases traceability. Moreover, an effective transaction system between stakeholders and the development of new digital solutions is made possible by blockchain technology, which can open up new business prospects. This can stimulate growth and innovation in sectors of the economy which have historically been categorized as having high entry barriers and little to no competition sectors. There are four main ideas that underpin the use of blockchain in SC.

The resource-based view (RBV) in the context of retail sector SCs proposes that companies should take into account their distinct resources and competencies while planning how to use blockchain. Retail companies, for instance, might have access to critical data and knowledge about sourcing, distribution, and selling; these could be used to create blockchain solutions that increase the effectiveness of SC and save costs. Furthermore, RBV advises businesses to concentrate on developing and obtaining the assets and competencies required to successfully apply blockchain, such as IT integration solutions, data analytics solutions, and experienced staff for the development and implementation of BC [26]. There is another relevant theory to retail SC which is the principal-agent theory, which emphasizes how crucial it is to create incentive programs and oversight systems that reflect the interests of all parties involved in the blockchain network [27].

Retail sector SC stresses the importance of networking because this aids in the innovation process, building trust, which results in efficient collaboration among SC members. The theory that is most relevant to this is network theory (NT) [28]. Retailers, for example, may need to collaborate with suppliers, logistics support, distributors, and other stakeholders to create a BC system that ensures complete SC transparency while lowering costs.

Finally, transaction-cost analysis (TCA) can support companies in defining the most productive governance method, either centralized or decentralized, by considering issues such as information imbalances, asset uniqueness, and uncertainty [29]. The application of transaction-cost theory (TCA) can assist retail companies in finding the finest governance framework for the BC ecosystem that proposes companies should take into account the expenses related to the implementation and use of blockchain technology, and should carefully evaluate these costs in comparison to the potential advantages of enhanced efficiency, transparency, and security [30].

3. Retail Industry IOT, Supply Chain Integration, Sustainable Logistic Capabilities, and Blockchain

Retail SCI is categorized into three segments: (1) Supplier integration, (2) Internal integration, and (3) Customer Integration [31]. Each retail sector encompasses distinct activities and processes with unique challenges. Figure 1, describe how supplier integration involves managing production, processing, and sourcing. Hence, challenges of equipment tracking and data management arise due to the presence of numerous and diverse devices, which leads to poor equipment health and potential production delays. From a data management perspective, there are differences between each location's data generation and storage which is difficult to trace in real time. This can lead to misunderstandings and inaccurate data, ultimately resulting in erroneous policymaking [32]. As a result, supplier integration necessitates a highly secure platform and a real-time information system, as these data are critical to the decision-maker, and cyberattacks are more likely to occur. Blockchain technology possesses the capacity to address this matter with enhanced efficiency and efficacy. Internal integration relies heavily on third-party logistics (3PLs), an extensive network of logistics support providers, to facilitate the transportation of products. This division manages tens of thousands of contractors and logistics companies and generates vast quantities of sensitive data, which is extremely challenging, given that

it must also maintain all financial records. Inaccurate transactions, increased transportation costs, and transition delays are all consequences of this phase's issue. Blockchain technology is well suited to manage the solution due to its data processing capabilities and transparency in the realm of cyber security. Furthermore, this phase highlights the transport sector and its critical need for traceability, visibility, and trackability, which are all strengths of blockchain.

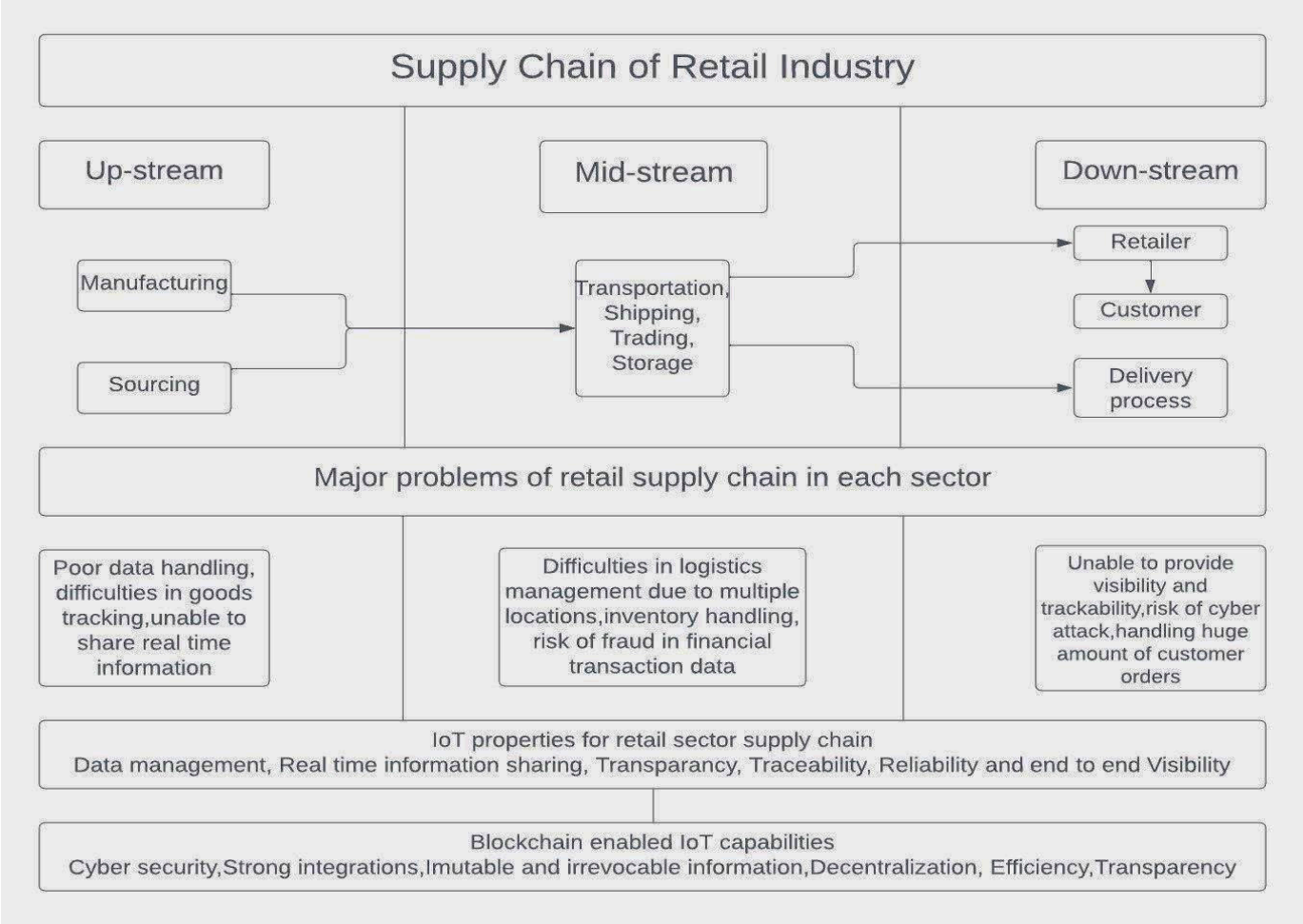

Figure 1. Problems in Retail sector. Source Figure by author.

Lastly, customer integration handles the final items' marketing, sales, and distribution. Because it manages the final product's delivery and transportation to clients, customer integration is crucial. To prevent customer dissatisfaction, it is imperative to successfully manage supply and demand activities. Customers must follow shipments with delivery information in the current digital era, and retail businesses must offer a platform that provides complete visibility. Blockchain technology is most suited to meet these needs [30].

A crucial and quickly expanding topic of supply chain management research is the influence of technology-enabled supply chain integration on sustainable logistics capability, which has a considerable impact on company performance. De Vass et al [31], investigated the influence of the Internet of Things (IoT) on the integration and performance of firms. It analyzed this impact from the perspective of organizational capabilities. The results showed that IoT-enabled capabilities have positively affected supply chain integration, establishing a mutually advantageous relationship that enhances overall performance. This suggests that the integration of technology can greatly facilitate the ability of supply chain partners to efficiently exchange data, work together, and enhance their logistic capabilities.

Moreover, sustainable logistics capability refers to the effectiveness, responsiveness, and flexibility of sustainable logistical operations [33]. The incorporation of IoT into supply

chain management enhances logistics by providing exceptional visibility throughout the whole supply chain ecosystem. Pundir et al [34] argued that, within the supply chain, sensors, RFID tags, and smart devices are combined to provide businesses with immediate information regarding inventory levels, shipment statuses, and potential disruptions. This enhanced visibility enhances the flexibility of logistics by enabling prompt responses to changing circumstances and optimizing the utilization of existing resources. Additionally, Arumugam et al. [35] claimed that IoT-enabled SCI improves the traceability and transparency of logistical systems. Keeping an eye on the movement of goods at every stage of the supply chain reduces the likelihood of errors and delays and sets the foundation for building stakeholder confidence. From a logistical standpoint, the degree of openness is advantageous since it lowers uncertainty, streamlines procedures, and encourages data-driven decision-making. Aslam et al. [30] argued that logistics capability is impacted by IoT-enabled SCI in a number of areas, including predictive analytics. By leveraging the data produced by IoT devices, organizations may utilize advanced analytics to estimate demand, identify potential bottlenecks, and optimize routing.

The implementation of sustainable supply chain methods is facilitated by the process of digitalization, which promotes the adoption of environmental and social responsibility. Companies can utilize data analytics to identify and address inefficiencies, resulting in optimized routes that reduce both fuel consumption and carbon emissions [36].

4. Hypotheses Development

It is necessary to adopt BC if a firm is planning to re-design its SC as it needs to deal with more modern SC issues. Figure 2 shows problems, solutions, and the conceptual framework that is adopted to develop these hypotheses. To cope with these challenges, firms require blockchain-enabled IoT, strong supply chain integration, and reliable logistic capabilities.

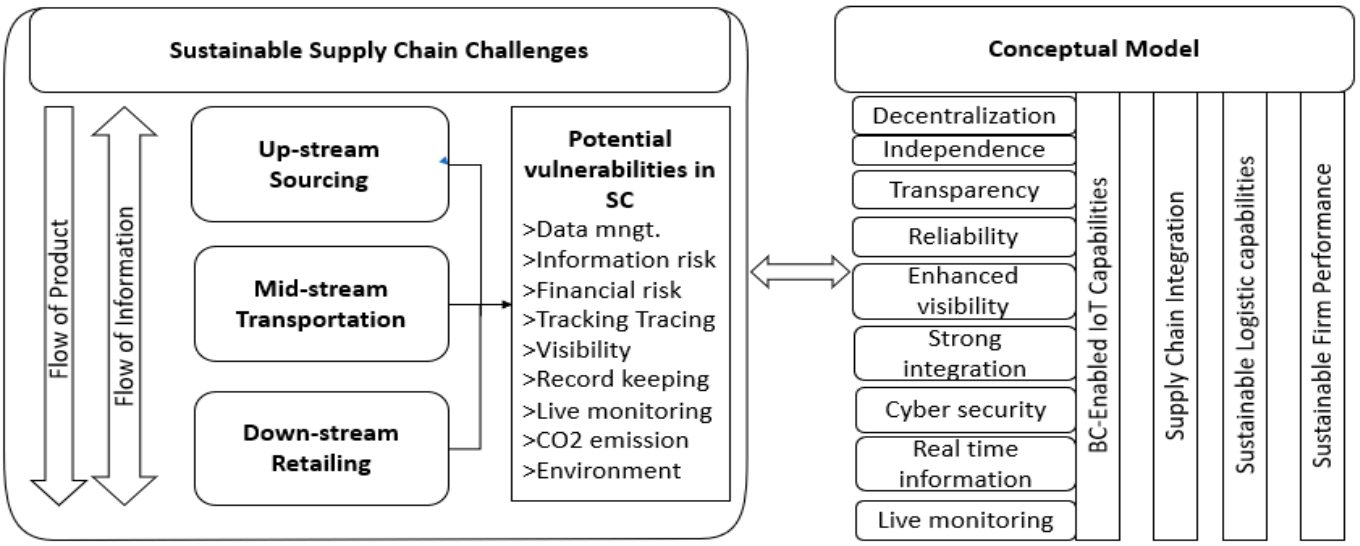

Figure 2. Overview of the problems and conceptual solutions. Figure by author.

4.1. Blockchain-Enabled IOT (BIOT), BC-Enabled SC Integration (SCI), and Sustainable Firm Performance (SFP)

Supply chain integration (SCI) is a large-scale strategy that proposes a close interaction with all SC members and is the coordination and information-sharing mechanism among all SC partners [37]. Building an SCI will speed up response times and cut expenses. A number of operations, including transportation, purchasing, manufacturing, warehousing, inventory management, third-party logistics providers, raw material suppliers, retailers, and customers, form the foundation of the retail SC. Consequently, cooperation and coordination across SC operations are essential to SFP. Blockchain technology facilitates the

integration of customers and supplier supply chain activities by offering a shared record of information that is exceptionally trustworthy, secure, and precise [38]. SCI (internal integration refers to the coordination and cooperation across different divisions inside an organization, whereas external integration refers to the collaboration and partnership between suppliers and customers) helps in the resolution of issues among SC members, and that may enhance the efficiency and effectiveness of firms, thus significantly contributing to the improvement of overall SC performance [39].

H1. *Blockchain-enabled IOT capabilities have a positive impact on SCI.*

H1a. *Blockchain-enabled IOT capabilities have a positive impact on SCSI.*

H1b. *Blockchain-enabled IOT capabilities have a positive impact on SCII.*

H1c. *Blockchain-enabled IOT capabilities have a positive impact on SCCI.*

Similarly, Argyropoulou et al. [40] conducted an empirical study to examine how the Internet of Things (IoT) capacity affects the integration of supply chains and the performance of businesses in the retail industry in the United Kingdom. Their results resemble those of De Vass et al. [31]; there is evidence showing that the capabilities of the Internet of Things (IoT) greatly enhance the integration of supply chains and, consequently, lead to an improvement in the overall performance of companies. The convergence of evidence emphasizes the vital role of IoT-enabled supply chain intelligence in strengthening logistical capabilities and, as a result, enhancing the overall performance of the supply chain. Hence, we consider it crucial to examine the influence of blockchain-enabled supply chain integration on sustainable firm performance (SFP). In the majority of cases, the Internet of Things (IoT) is primarily backed by blockchain technology.

4.2. BC-Enabled SCI as a Mediator between BIOT and SFP

H2. *SCSI mediate the relationship between BIOT capabilities and SFP.*

H3. *SCII mediate the relationship between BIOT capabilities and SFP.*

H4. *SCCI mediate the relationship between BIOT capabilities and SFP.*

4.2.1. Sustainable Logistic Capabilities, Blockchain-Enabled IOT Capabilities, and Sustainable Firm Performance

Blockchain technology offers contemporary methods to enhance the efficiency of supply chain management and reduce the associated risks [41], Ref. [42] TECH-driven supply chains enhance the old supply chain operations and introduce innovative methodologies which aid in risk reduction [43]. BC empowers supply chain management to effectively manage anticipated and unanticipated fluctuations in demand and supply by utilizing up-to-the-minute data, comprehensive visibility, and transparent processes. This results in improved performance for the organization [44]. Implementation of blockchain SC helps the firm obtain several benefits such as (1) an effective process capability, (2) strengthening the information sharing capability, (3) accurate inventory management, (4) optimizing warehousing and delivery process, and (5) optimizing the route. All these benefits combined guarantee enhanced LC.

Logistics and supply chain processes are radically altered by the incorporation of Internet of Things (IoT) technologies into blockchain-enabled logistics capabilities, which reshape the transportation, tracking, and management of products. The emergence of the Internet of Things (IoT) has revolutionized the logistics industry by enhancing visibility, efficiency, and data-driven decision-making. Dasaklis et al. [45] argued that the essence of IoT-enabled logistics is the integration of intelligent sensors and devices throughout

the entire logistics network. By integrating these devices into various components such as vehicles, shipping containers, warehouses, and even individual cargo, a vast and interconnected ecosystem can be established. These sensors facilitate an uninterrupted flow of data throughout the supply chain by collecting up-to-the-minute information regarding location, temperature, humidity, and other relevant variables [46]. Visibility enhancement is among the most significant benefits of IoT-enabled logistics. Ben-Daya et al. [47] argued that logistics managers can acquire exceptional visibility into the entirety of the supply chain procedure through the utilization of IoT sensors, which enable real-time monitoring of shipment locations and conditions. This visibility facilitates proactive decision-making by allowing for timely responses to disruptions, as well as route optimization and delay minimization [48]. In addition, the alignment of petroleum consumption and route simplification facilitated by IoT-enabled logistics contributes to the fulfilment of sustainability objectives.

Nyulásziová & Paľová, 2020 [49] argued that logistics managers possess current data regarding traffic conditions, weather patterns, and the status of vehicles, which aids them in making decisions that minimize adverse environmental effects. It increases overall operating efficiency and is in line with corporate social responsibility objectives [48]. There are several drawbacks associated with IoT-enabled logistics, including concerns regarding data security, standardization, and the financial investment required to implement the technology. Ensuring the secure transmission and storage of sensitive logistics data is of utmost importance. To ensure seamless integration among different elements of the logistics network, it is imperative to standardize IoT protocols and communication formats. By integrating blockchain technology into the systems, these obstacles can be surmounted.

To study the effect of blockchain-enabled IOT capabilities on blockchain-enabled logistic capabilities, it is important to study the direct relations.

H5a. *Blockchain-enabled IOT capabilities have a positive impact on sustainable logistic capabilities.*

H5b. *Blockchain-enabled IOT capabilities have a positive impact on sustainable firm performance.*

H5c. *Sustainable logistic capabilities have a positive impact in sustainable supply firm performance.*

SLC mediates the relationship between BIOT (BC-enabled IOT capabilities) and SFP (sustainable firm performance).

H6. *SLC as a mediator between the relationship of BIOT and SFP.*

4.2.2. Blockchain-Enabled Supply Chain Integration, Sustainable Logistic Capabilities, and Sustainable Firm Performance

An area of supply chain management research that is both significant and rapidly growing is the influence of tech-enabled supply chain integration on logistics capability. This influence has a substantial impact on the performance of organizations.

A study was conducted on how IOT influences SCI and SFP, and the results demonstrated the positive effects of IoT capabilities on supply chain integration, thereby elucidating a symbiotic relationship that culminates in enhanced performance [31]. Enhancing this IoT integration is possible through the utilization of blockchain properties. This suggests that the incorporation of blockchain technology could significantly facilitate the ability of supply chain stakeholders to collaborate, exchange information efficiently, and enhance logistics capabilities.

The following hypotheses are put forward to study the effect of BC-enabled SCI on SLC and SFP:

H7a. *SCSI significantly affects SLC.*

H7b. *SCSI significantly affects SFP.*

H8a. *SCII significantly affects SLC.*

H8b. *SCII significantly affects SFP.*

H9a. *SCCI significantly affects SLC.*

H9b. *SCCI significantly affects SFP.*

The blockchain facilitates robust integration among all the members of an SC, enhances logistical capabilities through the provision of a platform for information exchange, and fortifies financial transactions through cyber security [50]. The term "logistic capabilities" pertains to the enhancement of an organization's capacity and capabilities to react promptly and efficiently in the face of (un)certain logistic demands [48]. In light of this, this research puts up the following hypothesis, which uses LC as a mediator between BC-enabled SCI parameters.

H10. *SLC mediate the relationship between BC-enabled SCSI and SFP.*

H11. *SLC mediate the relationship between BC-enabled SCII and SFP.*

H12. *SLC mediate the relationship between BC-enabled SCCI and SFP.*

Regarding the conceptual model in Figure 2, this study focuses on finding the most effective SC solution, as a result of the problems that are encountered by the retail sector, and uses three IVs that are enabled by blockchain (IOT capabilities, SC integration (SCI), and sustainable logistic capabilities (SLCs) and one DV, that is, sustainable firm performance (SFP). SLC and SCI are considered mediator variables in this study. Figure 2 depicts the conceptual model of this investigation, including the directions of the hypotheses.

5. Methodology

The primary purpose of this research is to investigate the implications that were brought about by blockchain technology on IOT, supply chain integration, and sustainable logistics capabilities and the impact of this blockchain-enabled IOT on firm performance with the mediating role of supply chain integration and sustainable logistics capability. As it is explained in Figure 3, the conceptual framework for this research. The choice of the retail industry in Pakistan is consistent with the resource-based view (RBV) hypothesis, which asserts that a company's resources and competencies have a substantial impact on its performance. The retail industry in Pakistan has distinct resources and capabilities, including its unorganized structure and significant opportunities for international investment, skilled workforce, and extensive supply chain networks. Furthermore, the decision to focus on the retail industry for this research is supported by theoretical justifications based on the distinct characteristics of this industry. Among these are the tremendous complexity and uncertainty that are present in the supply chain, the critical role that supply chain management plays in both operational and financial success, and the potential of blockchain technology to address the specific difficulties that are faced by the industry.

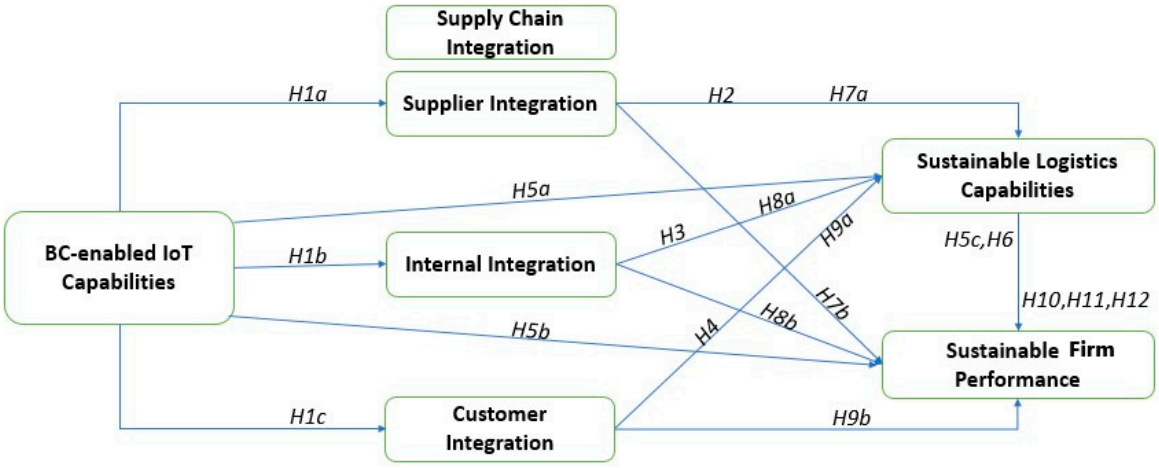

Figure 3. Conceptual model and hypotheses directions. Figure by author.

Sampling Techniques and Measures

The retail industry in Pakistan is often regarded as the fundamental support of the economy, with numerous sectors relying on a seamless flow of goods and raw materials. The retail sector in Pakistan is classified as part of the private sector. Based on the figures provided by "The Economist Intelligence Unit", there are over 2 million retail establishments, with 800,000 of them being FMCGs. The market valuation of this product spans a broad range, from 42 billion to 105 billion dollars. It holds the position of being the third most significant contributor to the economy of Pakistan, accounting for 18–20% of the Gross Domestic Product (GDP).

We collected the list of retail firms that were registered in the small and medium business index of Pakistan. We selected firms who had two or more retail outlets. They should have been present in at least two or more regional provinces of Pakistan. At least half of them should have had an online presence and dealt in online retailing. The number of firms that we were able to point out according to our needs was around 500. Additionally, to oversee supply chain operations, this sector is divided into four primary segments: manufacturers, traders, distributors, and retailers. This study employed non-probability convenience and judgement sampling strategies to gather data, according to the researcher's proficient understanding of the retail business.

In the context of this particular research project, the survey questionnaire was aimed specifically at SC managers as its target audience. That being the case, it was presumed that a single SC manager is representative of a retail organization. A total of 500 questionnaires were delivered to the retail organizations in their supply chain and logistics divisions. Questionnaires were distributed to supply chain managers for them to respond. After conducting a follow-up, it was determined that a total of four hundred individuals had successfully finished the survey. However, it was determined that 15 of the responses were unfinished and were therefore excluded from the data analysis. As a result, the final sample size consisted of 385 supply chain managers and retailers. The response rate for the survey was calculated to be 70%. In order to gain insight into the knowledge and background of supply chain (SC) managers and retailers, we conducted a survey that included demographic inquiries on age, gender, level of education, overall experience in the field of supply chain management, total experience in the retail sector, and the type of firm they work for. These questions provided a comprehensive profile of the respondents.

This study utilized a survey questionnaire that has been previously employed in research, but we made revisions to ensure its relevance to the blockchain application and to enhance our understanding of Pakistan's retail sector.

The item scales for different aspects of blockchain-enabled supply chain (SC) are as follows: BC-enabled IOT consists of 9 items. BC-enabled SCSI consists of 4 items. BC-enabled SCII is formed of 4 items. BC-enabled SCCI includes 4 items. SFP has 8 items. SLC

consists of 8 items. A Likert scale of five points (1, strongly disagree; 5, strongly agree) was used to assess the SC manager's impression of blockchain technology for IoT, supply chain integration, sustainable logistic capabilities, and sustainable firm performance.

6. Data Analysis Procedure

This study utilized PLS-SEM due to its significant prominence in the field of business research. Partial Least Squares Structural Equation Modelling (PLS-SEM) is becoming more prevalent in many domains to analyze non-normal data and small sample sizes, particularly in the realm of supply chain management. SEM has been utilized by several studies and is widely recognized and effective because of its capacity to assess latent variables (LVs) and the associations between LVs [51]. In order to evaluate the proposed conceptual model using PLS-SEM, a multistage procedure was contemplated, encompassing both inner and external model analysis.

In the process of analyzing data using PLS-SEM, the assessment of the measurement model was prioritized before assessing the structural model [52].

6.1. Demographic Analysis

In order to comprehend the respondent profile in Table 1, this study inquired for demographic information like gender, age, qualifications, overall experience in supply chain management, total experience in retail supply chain, and the type of organization. This study found that 90.3% of the respondents were male, while just 9.6% were female. This indicates that the retail business in Pakistan is predominantly male-dominated, particularly in the SC department. Regarding the age category of supply chain (SC) managers, 51.1% of managers were within the 30–35 years' age range. Furthermore, the combined percentage of individuals aged 25–30 and over 50 was 48.9%. The analysis of the respondent profile revealed that 90% of participants in this study belonged to the age category from 31 to above 50. This indicates that supply chain managers are typically senior-level employees with significant professional experience. Regarding the qualification category, 53.8% of respondents possessed a master's degree, indicating a commendable level of literacy in the retail industry's SC sector. Regarding the total experience in supply chain management (SCM), 40% of supply chain managers had fewer than 5 years of work experience in the SCM department. Conversely, 60% of managers possessed over 5 years of experience, indicating that the managers are highly experienced in SCM operations. Regarding overall experience in retail supply chain management (SCM), 40% of supply chain professionals had more than 5 years of expertise in managing the retail supply chain. These professionals are well acquainted with the potential issues that may arise in the current supply chain network. In the retail sector, there are six primary types of firms: general or departmental stores, specialized stores (such as those selling fruits or medication), textile or clothes and footwear stores, beverages and tobacco stores, gasoline retailers, and sellers of lubricants and spare parts. This survey encompassed all categories of firms.

Table 1. Respondent's profile.

Demographic	Details	No. of Appearance	Percentage	Total
Age	25–30	129	33.5	385
	30–35	197	51.1	
	35 and above	59	15.4	
Gender	Female	37	9.6	385
	Male	348	90.3	
Qualification	Undergraduate	178	46.2	385
	Masters	207	53.8	
	PhD	0	0	
Working Experience	<5 years	153	39.7	385
	>5 years	232	60.3	

Table 1. *Cont.*

Demographic	Details	No. of Appearance	Percentage	Total
Employment Level	Supervisor	53	13.7	385
	Assistant Manager	85	22	
	Manager	165	42.8	
	Above Manager	82	21.2	
Number of employees	Less than 50	194	50.3	385
	More than 50	142	36.8	
	Above 100	49	12.7	
Retail company type	Non specialized stores (General)	45	11.6	385
	Specialized stores (Fruits, medicine, etc.)	41	10.6	
	Drinks, Beverages and Tobacco stores	85	22	
	Textile, Clothing and Footwear	119	31	
	Fuel and Auto Lubricants	65	17	
	Household stores (Furniture, Hardware, Sanitary equipment and gardening)	30	7.8	

Source: Table by author. Note: Represents the respondent's profile and demographic factors, items, frequency, and percentage.

6.2. Measurement Model Assessment

Convergent validity was tested using composite reliability, factor loading, and average variance (AVE). According to the literature, the factor loading values should be more than 0.7, and the AVE should not be less than 0.5. Figure 4 and Table 2 demonstrate that the AVE value was not less than 0.5, and the factor loading was greater than 0.7. This clarifies the notion of convergent validity in our study. In this research, except for BIOT1 (0.603), BIOT2 (0.620), and BIOT9 (0.695) all constructs had loadings greater than 0.7. Even though the suggested threshold values must be ($\geq$0.7), removing constructs with a value lower than 0.7 caused a discriminant validity problem, so every construct with a value greater than 0.7 and rounding up (BIOT9) was kept back, and constructs with a value lower than 0.66 (BIOT1 and BIOT2) were removed; consequently, our proposed model contained 35 items, as seen in Table 2 and Figure 4.

Table 2. Measurement properties for reflective constructs.

Variables	Construct	Factor Loading	α	CR	AVE
Blockchain-enabled IOT Capability	BIOT 3	0.714	0.859	0.860	0.542
	BIOT 4	0.750			
	BIOT 5	0.740			
	BIOT 6	0.759			
	BIOT 7	0.748			
	BIOT 8	0.743			
	BIOT 9	0.695			
SC Supplier integration	SCSI 1	0.876	0.893	0.902	0.757
	SCSI 2	0.898			
	SCSI 3	0.908			
	SCSI 4	0.793			
SC Internal Integration	SCII 1	0.884	0.933	0.937	0.834
	SCII 2	0.937			
	SCII 3	0.921			
	SCII 4	0.909			

Table 2. *Cont.*

Variables	Construct	Factor Loading	α	CR	AVE
SC Customer Integration	SCCI 1	0.755	0.775	0.777	0.598
	SCCI 2	0.736			
	SCCI 3	0.812			
	SCCI 4	0.787			
Sustainable Logistic capabilities	LC 1	0.805	0.925	0.925	0.656
	LC 2	0.802			
	LC 3	0.828			
	LC 4	0.835			
	LC 5	0.782			
	LC 6	0.801			
	LC 7	0.805			
	LC 8	0.818			
Sustainable Firm performance	FP 1	0.850	0.949	0.95	0.736
	FP 2	0.883			
	FP 3	0.821			
	FP 4	0.874			
	FP 5	0.840			
	FP 6	0.871			
	FP 7	0.867			
	FP 8	0.854			

Source Table by author.

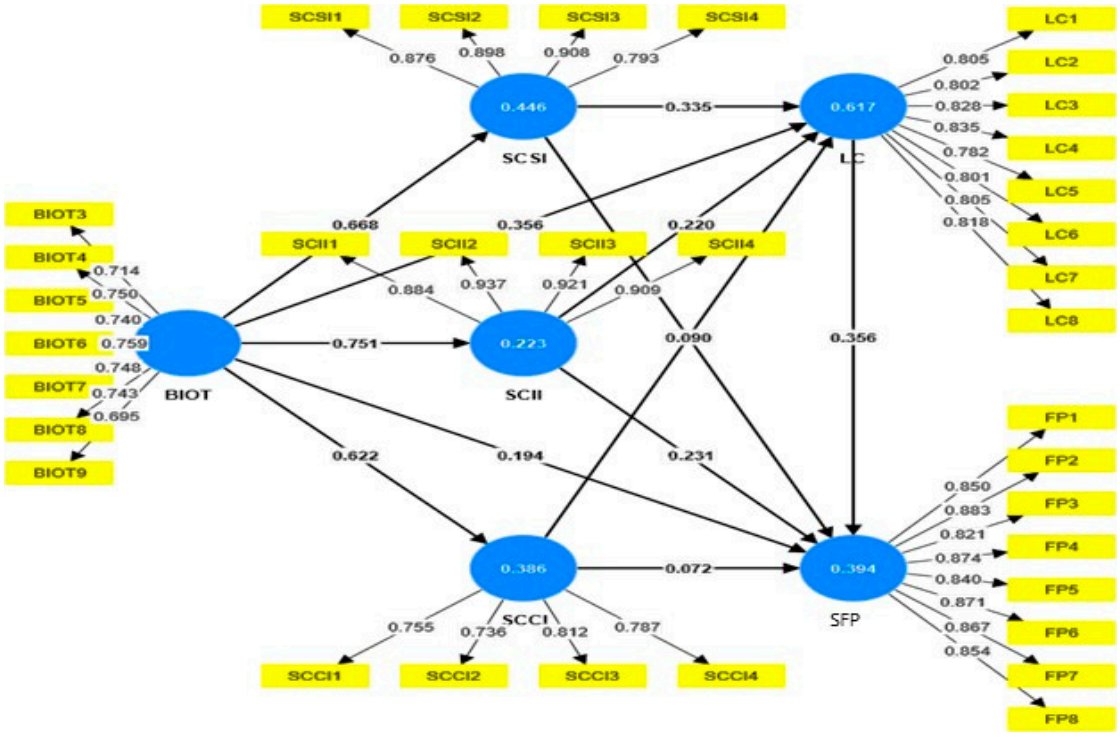

Figure 4. Model from PLS.

Discriminant validity is demonstrated by Table 3, where it is assessed using the square root of the average variance extracted (AVE). The concept of discriminant validity was proposed by [53]. The square root, which is expressed in bold form, is higher than all other numbers. The HTMT matrix provides researchers with the values for Table 4, which are used to examine the discriminant validity of their model in Structural Equation Modelling (SEM).

Table 3. Fornell–Larcker Criterion (The bold and diagonal are the square root of AVE values).

Fornell–Larcker Criterion	BIOT	SFP	SLC	SCCI	SCII	SCSI
BIOT	**0.736**					
SFP	0.547	**0.858**				
SLC	0.710	0.597	**0.810**			
SCCI	0.622	0.463	0.627	**0.773**		
SCII	0.151	0.074	0.134	0.133	**0.889**	
SCSI	0.668	0.501	0.693	0.578	0.213	**0.870**

Table 4. Heterotrait-monotrait ratio (HTMT)—Matrix.

HTMT—Matrix	BIOT	SFP	SLC	SCCI	SCII	SCSI
BIOT						
SFP	0.590					
SLC	0.794	0.634				
SCCI	0.766	0.537	0.739			
SCII	0.169	0.080	0.144	0.156		
SCSI	0.757	0.544	0.757	0.691	0.236	

6.3. Structural Model Assessment

The structural model was assessed using the following metrics: "the coefficient of determination (R2), the blindfolding-based cross-validated redundancy measure (Q2)", and the statistical significance and relevance of the path coefficients values of R-sq and Q-sq as given in Table 5. Once the reliability and validity were confirmed, Structural Equation Modelling (SEM) was employed to analyze the hypothesis, specifically focusing on examining the direct and indirect impacts. The examination of the indirect effect was conducted to assess mediation. The *p*-value was taken into account in this procedure. When analyzing the data, a minimal *p*-value of 0.05 was used to test the hypothesis.

Table 5. Value for R-square and Q^2 predict.

Variables	R-Square	R-Square Adjusted	Q^2 Predict
SFP	0.394	0.386	0.347
SLC	0.617	0.613	0.495
SCCI	0.386	0.385	0.382
SCII	0.223	0.220	0.210
SCSI	0.446	0.445	0.434

(Note: Acceptable range for R-sq is >0.25 and <0.75, for Q-sq value should be >0).

6.4. Direct Effect

The bootstrapping method was used to evaluate the structural model, which explains whether the path coefficients of the constructs are significant. *p*-value and T-value were the primary focus, where the value of acceptance for *p*-value < 0.05 and for T-value > zero. The

results of this bootstrapping resampling method with 5000 resamples determined that all the paths are statistically significant. The results are explained in Table 6. It explains that BIOT has a positive effect on SCSI, SCII, SCCI, SLC, and SFP. SLC has a positive significant impact on SFP as well. Therefore, H1a, H1b, H1c, H5a, H5b, and H5c are supported.

Table 6. Direct effect.

Hypothesis	Relationship	P-Coefficient	S.D (STDEV)	T Statistics (|O/STDEV|)	*p* Values	Decision
H1a	BIOT → SCSI	0.668	0.035	9.260	0.000	Supported
H1b	BIOT → SCII	0.751	0.048	3.150	0.002	Supported
H1c	BIOT → SCCI	0.622	0.039	6.052	0.000	Supported
H5a	BIOT → SLC	0.356	0.051	6.943	0.000	Supported
H5b	BIOT → SFP	0.194	0.091	2.134	0.033	Supported
H5c	SLC → SFP	0.356	0.080	4.449	0.000	Supported
H7a	SCSI → SLC	0.335	0.049	6.854	0.000	Supported
H7b	SCSI → SFP	0.090	0.068	2.136	0.018	Supported
H8a	SCII → SLC	0.220	0.031	0.646	0.002	Supported
H8b	SCII → SFP	0.231	0.042	0.755	0.004	Supported
H9a	SCCI → SLC	0.216	0.058	3.748	0.000	Supported
H9b	SCCI → SFP	0.072	0.080	2.902	0.036	Supported

Hypotheses H7(a,b), H8(a,b), and H9(a,b) explain the relationship between SCI, SLC, and SFP. As per the results of this study, the researcher found that SCSI significantly impacts SLC and SFP, and SCII has a significant positive impact on SLC and SFP. And finally, SCCI is also positively associated with SLC and SFP. Table 6 explains the results and directions of path analysis. Therefore, all of these hypotheses have been supported, as all of them had a *p*-value greater than 0.05.

6.5. Mediation Effect

The mediating analysis indicates a significant positive relationship between BIOT and sustainable firm performance when mediated by SCSI. This analysis also indicates SCCI's role in influencing the relationship between BIOT and SFP. The mediating analysis also revealed the positive association between BIOT and SFP using SCII as a mediator.

The results in Table 7 of the mediation analysis reveal a significant positive relationship between BIOT and sustainable firm performance when mediated by sustainable logistic capabilities. This statistically significant coefficient suggests that this relationship is not likely due to any random chance. These findings provide empirical support for H6 that SLC serves as a mediator in the relationship between BIOT and SFP and the role of SLC in understanding the association between BIOT and SFP.

Furthermore, mediation analysis reveals the positive association between SCSI and SFP using SLC as a mediator. There is a notable positive relationship between SCII and SFP when SLC is considered a mediator. Finally, this analysis indicates a positive relationship between SCCI and SFP when influenced by SLC. Therefore H10, H11, and H12 are supported.

Table 7. Mediation effect.

Hypothesis	Relationships	P-Coefficient	Sample Mean (M)	ST. DEV	T Stat	*p* Values	Decision
H2	BIOT → SCSI → SFP	0.139	0.137	0.047	2.826	0.041	Supported
H3	BIOT → SCII → SFP	0.106	0.106	0.037	2.859	0.004	Supported
H4	BIOT → SCCI → SFP	0.103	0.103	0.038	3.525	0.006	Supported
H6	BIOT → SLC → SFP	0.109	0.110	0.035	3.154	0.002	Supported
H10	SCSI → SLC → SFP	0.105	0.105	0.030	3.501	0.000	Supported
H11	SCII → SLC → SFP	0.058	0.058	0.018	2.728	0.017	Supported
H12	SCCI → SLC → SFP	0.067	0.065	0.022	2.964	0.003	Supported

7. Discussion and Conclusions

This study intended to understand the in-depth effect of blockchain-enabled IoT capabilities on SCI, SLC, and SFP. In this research, we conducted a preliminary assessment of the supply chain challenges that are particular to the retail industry and put up a solution that leverages the potential of blockchain technology. Moreover, this work presented a strategy for incorporating blockchain technology into the supply chain management of the retail sector, with a focus on the most essential elements, i.e., IoT on SC integration parameters such as supplier integration, internal integration, and customer integration, sustainable logistic capabilities, and sustainable firm performance. Secondly, we analyzed the impact of BIOT on SFP by considering SCI as a mediator. Thirdly, we examined the impact of SCI on SFP by using SLC as a mediator, with an understanding of the mediating role of logistics.

Q2: Does retail blockchain-enabled IOT significantly affect SCI, SLC, and SFP?

The results reveal that blockchain-enabled IOT capabilities have a positive impact on SCSI (β 0.668, t 9.26 and p 0.00 < 0.05), SCII (β 0.151, t 3.15, and p 0.002 < 0.05), and SCCI (β 0.622, t 6.05 and p 0.00 < 0.05), respectively. BIOT has a significant and positive impact on SLC (β 0.356, t 6.95, and p 0.00 < 0.05) and SFP (β 0.0.194, t 2.13, and p 0.033 < 0.05). This indicates that SC managers are of the opinion that blockchain technology will enhance supply chain integration, sustainable logistic capabilities, and ultimately, sustainable firm performance.

The Internet of Things (IoT) may greatly enhance SC integration. This aligns with other studies that have confirmed the mediation effect of SC integration in enhancing IOT impact on performance [54,55]. Results of this study are also similar to that study [56]. The researcher's findings about SCII and BIOT also seconds the findings of Ganbold et al. [57], who also emphasized that SC internal integration is more positively associated with BIOT as compared to SCSI or SCCI. Hence, it is essential to devise more streamlined and effective standard procedures for identifying SC requirements, conducting real-time analysis, disseminating information to all members of SC, and fostering bilateral involvement with supply chain counterparts.

Q3: Does retail blockchain-enabled SCI have a significant effect on SFP and SLC?

Different studies conducted on the same relationship based on different contexts by different researchers also show the same findings, with a significant impact of digitalized supply chain integration on firm performance [58]. Technology-enabled supply chain collaboration has a positive association with enhanced logistic capabilities [59].

Our results revealed that SCSI has a positive impact on sustainable logistics capabilities (β 0.335, t 6.85, and p 0.00 < 0.05) and sustainable firm performance (β 0.09, t 2.13, and p 0.018 < 0.05). SCII also shows a positive association with SLC (β 0.220, t 0.064, and p 0.002 < 0.05) and SFP (β 0.231, t 0.75, and p 0.004< 0.05). SCCI also has a positive significant impact on logistic capabilities (β 0.216, t 3.74, and p 0.000 < 0.05) and firm performance (β 0.072, t 2.9, and p 0.033 < 0.05). Supply chain integration is regarded as a

valuable characteristic of retail supply chain management (SCM) due to its involvement with various supply chain partners. These partners include suppliers, customers (including industrial, marketing companies, government and private organizations), logistics providers, third-party logistics, shipping agencies, and stakeholders from both domestic and international markets. Hence, the exchange of precise, reliable, and prompt information is a crucial component.

Q4. Does retail blockchain-enabled SLC have a significant effect on SFP?

The research confirms that BC-enabled SLC positively impacts SFP; therefore, the results are consistent with Aslam et al. [30]. This research is intended to confirm that the capabilities of a BC-enabled supply chain can improve its efficacy and efficiency, which can be understood as a decrease in the overall expenses of the retail supply chain, a reduction in inventory, and promised deliveries as an assessment of customer needs. Thus, the foundation of logistical capabilities is the ability to efficiently deploy supply chain resources to meet customer expectations by achieving a predetermined degree of customer satisfaction [60].

Blockchain-enabled LC has a positive and significant impact on firm performance (β 0.356, t 4.449, and p 0.000 < 0.05). This demonstrates how SC managers view blockchain technology as enhancing the company's agility, flexibility, and responsiveness, cutting lead times, and enhancing logistical operations [61–63]. In recent years, in Pakistan, the retail industry has experienced significant price volatility, occasionally leading to overnight price surges. Price volatility impacts the demand and supply of commodities. As the price increases, the demand for the good decreases, requiring the entire supply chain function to operate more intelligently and efficiently. On the other hand, because of its wide range of geographic locations, the retail industry has more protracted supply chain (SC) problems, and each delay lengthens the time it takes to acquire items. Therefore, the retail sector must enhance its level of responsiveness and adaptability.

Finally, we determine that in supply chain management (SCM), the most crucial factors for company performance are the capabilities of the Internet of Things (IoT), supply chain integration (SC integration), and logistic capabilities [64,65]. Supply chain managers assert that blockchain technology enhances the capabilities of the Internet of Things (IoT) by facilitating the real-time exchange of information and ensuring openness, visibility, and privacy.

Q5; Do supply chain integration (SCI) and sustainable logistics capability (SLC) have a mediating role in transmitting BIOT effect to SFP?

This study discovered that logistics capabilities, supplier integration, internal integration, and customer integration all play a positive and significant role in mediating the link between blockchain-enabled Internet of Things (IoT) capabilities and SFP performance. Using PLS-SEM bootstrapping, we analyzed the total and indirect effects of sustainable logistic capabilities and supply chain integration, referring to the results in Table 7, the SC manager's perception of sustainable logistic capabilities (β = 0.109, t = 3.154, p = 0.002), and enhanced blockchain enabled IOT capabilities, which resulted in better SFP. In addition, blockchain offers distinct characteristics, for example, transparency, tracing ability, and efficient communication for supply chains, enhancing their agility and resilience [66]. The results show in (Table 7) that SC managers believe that supplier integration (β 0.139, t 286, and p 0.041 < 0.05) significantly influences the relationship between blockchain-enabled IOT capabilities and SFP. Supply chain managers are of the opinion that implementing blockchain technology enhances both internal and external integration, leading to increased business resilience and improved overall performance [67]. Results from Table 7 explain that internal integration of the supply chain can enhance the relationship between BIOT and SFP (β 0.106, t 285, and p 0.004 < 0.05). Supply chain customer integration as a mediator enhanced the relationship between BIOT and SFP (β 0.103, t 3.525, and p 0.006 < 0.05).

Supply chain integration is based on three parameters, i.e., supplier integration, internal integration, and customer integration. In this study, the researcher evaluated the character of logistic capabilities as a mediator between supplier integration, internal integra-

tion, customer integration, and firm performance. Table 7 shows results for the mentioned relationships. Supplier integration has a positive and significant impact on SFP (β 0.105, t 3.501, and p 0.000 < 0.05), considering SLC as a mediator. There is a notable positive relationship between supply chain internal integration and SFP when SLC is considered as a mediator (β 0.058, t 2.78, and p 0.017 < 0.05), and results in Table 7 indicate a positive relationship between supply chain customer integration and SFP when influenced by LC ((β 0.067, t 2.96, and p 0.003 < 0.05. Logistic capabilities have four dimensions: "information sharing, coordination, integration of inter-firm activities, and supply chain responsiveness" [68]. Many researchers have developed an opinion that LC has the potential to enhance resilience and enhance sustainability and performance [69]. Our finding also supports the arguments of Argyropoulou et al. [40], which explain that LC can integrate various supply chain processes, including logistics, packaging, distribution, warehousing, return functions, order management, and monitoring. It also facilitates real-time information sharing among multiple members of a SC. This results in real-time visibility into supply chain operations, leading to improved overall firm performance [40].

8. Managerial Implications

The majority of retail businesses in our study (79%) are SMEs, and 31% of these businesses use blockchain-based data analytics based on the Internet of Things in their retail supply chains, according to the descriptive statistics of our sample. Furthermore, 72% of merchants have used two or more IoT technologies in their supply chains and logistical operations that are made possible by blockchain. In Pakistan's retail business, over 53% of traders use smartphones and mobile applications, 78% employ RFID/wireless communication technology, and the usage of robots and drone technology (4%), is still in its early phases of development.

This study offers significant insights and consequences for management in the field of SCI and LC. Managers and policymakers should be aware that incorporating internal process integration into the supply chain, facilitated by the BIOT (Blockchain Internet of Things), may enhance an organization's capacities to integrate externally and improve their efficiency and effectiveness. This will immediately empower them to efficiently oversee resource allocation, minimize expenses, and promptly address consumer needs, eventually enhancing corporate productivity. This paper proposes that retailers should include suitable blockchain technology and establish a BIOT-based platform to facilitate real-time information sharing among all stakeholders in the supply chain. This integration fosters an optimal environment for external integration with customers and suppliers, enhancing the efficiency and effectiveness of the supply chain and ultimately enhancing performance.

The findings recommend that managers allocate resources to implement blockchain technology in order to enhance supply chain processes and enhance profitability and sustainability. To ensure that staff members are capable of utilizing and overseeing technology, managers should prioritize the advancement and instruction of their employees. Digitalization facilitates tailored customer interactions, which managers can leverage to enhance consumer happiness through customized products and improved delivery. The paper provides managers with insights on how blockchain may enhance sustainability and offers guidance on the use of green technology and practices.

9. Regarding Theoretical Implication

This study identifies the most crucial components of supply chain (SC), which are essential for the overall expansion of supply chain management (SCM), such as business intelligence and optimization technology (BIOT). These factors include the integration of SC tasks, both internally and externally, and the use of logistic capabilities (LC). Furthermore, this paper examines the significance of blockchain technology regarding advancements in technology, integration, and LC, which are identified as key aspects of blockchain-enabled SC.

Furthermore, this study emphasizes the blockchain features associated with supply chain management (SCM), including the capacity to share real-time information, provide cyber security, promote transparency, provide end-to-end visibility, ensure dependability, and enable traceability. This study effectively clarifies the correlation between blockchain technology and supply chain characteristics. It also suggests further research to investigate the impact of other developing technologies, such as big data, artificial intelligence, and 3D printing, on the adoption of supply chain management in various sectors.

Blockchain-Enabled Supply Chain and Sustainable Development Goals (SDGs)

Supply chains that utilize blockchain technology exhibit enhanced flexibility, responsiveness, and sustainability. Their operations and distribution processes are designed to support the Sustainable Development Goals (SDGs) and minimize their environmental footprint through the use of sustainable supply chain practices [70,71]. Implementing energy-efficient transportation and sustainable sourcing methods are instances of sustainable business practices that can enhance a company's reputation, attract environmentally concerned clients, and augment revenues. The supply chain's digitization has a significant impact on businesses' long-term sustainability and financial prosperity [72].

Businesses may improve their operations and support the global effort towards a more sustainable future by accomplishing the Sustainable Development Goals. Enhancing supply chain integration, blockchain facilitates data exchange and communication among stakeholders in a streamlined fashion. This contributes to the attainment of SDG 9 as technology-enabled supply chains establish a dependable and efficient infrastructure that fosters innovation and sustainably advances the economy. SDG 8 pertains to the efficient exchange of information within supply chains facilitated by blockchain technology. Instantaneous communication and exchange of information result in improved decision-making, reduced operational inefficiencies, and heightened production. To accomplish SDG 12, supply chain operations were integrated with data-driven insights and technological automation. Businesses can encourage conscientious consumer behavior and sustainable manufacturing and production methods by reducing waste, resource consumption, and environmental impacts [73]. SDG 11 is aided by the digitalization of supply chain distribution, which reduces carbon emissions, streamlines transportation and logistics, and alleviates traffic congestion. Cities that implement sustainable distribution methods can become more habitable and cleaner [73].

10. Recommendations

The company's goals, and a flexible supply chain that includes the retail ecosystem, require a thorough digital transformation. Technology and tools for blockchain need investment, and these can aid data-driven decision-making, trend analysis, process optimization, and demand estimations. Monitoring communications and products requires digital platforms. Integrating all supply chains can maximize shareholder and partner benefits. BC technology optimizes demand, transportation, and inventory in supply chains to create a sustainable supply chain. Fast and flexible technological integration is needed. Staying current on industry news and technology can improve supply chain operations.

11. Limitations and Future Research Directions

This work has several limitations that have the potential to provide new opportunities for upcoming scholars. The primary constraint is that the study was confined to Pakistan. A potential avenue for future research is doing an international study to establish a more comprehensive foundation for cross-market evaluation of the efficacy of BIOT capabilities at SCI, LC, and FP. Furthermore, this survey was carried out with retailers. Hence, future investigations should explore a cross-sectional analysis encompassing supply chain collaborators to gain alternate viewpoints inside this particular framework.

The integration of blockchain technology into supply chain management (SCM) is now underway and is regarded as a significant field of study. Nevertheless, the use of

blockchain technology in supply chain management (SCM) remains uncertain due to the numerous studies completed through literature reviews [55], and empirical analysis is still limited [74,75]. According to our information, no empirical research has been conducted on retail sector SC networks in developing countries.

As far as we know, there have been no empirical studies undertaken on retail supply chain networks in developing nations. The research community has largely neglected the study of retail SCM, despite its significant importance in the global economy. It is crucial to enhance SCM practices in this sector.

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