"Role of Internet of Things (IoT) in Supply Chain Management Effectiveness: An Empirical Study"

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Abstract:
The Internet of Things (IoT) is a network of interconnected hardware, sensors, and software programs that gather and share data collected. IoT devices can be installed in manufacturing facilities, warehouses, distribution centers, transportation equipment, and retail establishments, as well as throughout the entire ecosystem. The supply chain's numerous elements, such as inventory levels, product conditions, equipment performance, and transportation routes, may be tracked, monitored, and analyzed with the ease of these IoT devices. Supply chain managers can achieve a level of visibility and management over the operations never before possible by utilizing IoT capabilities. Real-time data gathering and analysis support proactive decision-making, enabling quicker reaction times to anticipated interruptions, inventory level optimization, and enhanced demand forecasting precision. IoT-enabled supply chain management also improves traceability and transparency, giving businesses the capacity to comply with regulations, reduce risks, and guarantee the quality and safety of the products. Additionally, IoT-driven supply chain management encourages coordination and integration among a range of stakeholders, including suppliers, manufacturers, logistics service providers, and clients. Enhanced coordination, shorter lead times, and better customer service are all made possible by the supply chain's smooth data and information flow. IoT devices can help automate repetitive processes so that staff members can concentrate on more value-added activities.

Introduction:
The emergence of the 'Internet of Things' (IoT) has fundamentally changed many facets of our lives, including how organizations run. Supply chain management is one industry where IoT has made a big difference. IoT technology has made it possible for supply chain managers to monitor and regulate operations more efficiently, which has increased productivity, reduced costs, and raised customer satisfaction. The term "Internet of Things" describes a network of physical objects, including machinery, automobiles, home appliances, and other things, which are equipped with electronics, software, sensors, and connectivity. This technology allows these objects to gather and share data. IoT technology makes it possible to track, monitor, and control devices in real time, offering insightful data that can be utilized to streamline procedures and increase productivity. By enabling real-time visibility into every step of the supply chain, IoT technology has completely changed how supply chain management is done. Commodities in transit can be tracked using IoT sensors implanted in goods, cars, and warehouses. Additionally, they can keep tabs on how the logistics partners are doing and spot any possible supply chain bottlenecks or delays **(Lee, I., & Lee, K. 2015).**
Numerous logistical procedures, including inventory management and warehouse operations, have been automated. Businesses may streamline processes, lower costs, and increase efficiency with the help of IoT sensors

and automation systems. IoT-enabled robots, for instance, can be used to automate the transportation of items in warehouses, lowering the need for manual labor and enhancing accuracy. Inventory management has been enhanced, which is a major advantage of IoT in supply chain management. Companies may trace the passage from production line to client with the help from IoT sensors installed in products. This real-time visibility enables businesses to enhance inventory accuracy, lower the risk of stockouts, and optimize inventory levels. Businesses can reduce downtime and maximize asset utilization thanks to IoT technology, which makes predictive maintenance possible. Companies may track the performance and health of the machinery in real-time using IoT sensors integrated into the devices, spotting possible problems before they become serious. This gives businesses the option to plan maintenance in advance, cutting downtime and increasing equipment reliability **(Whitmore et al. 2015).**

Data management is a problem when using IoT in supply chain management. Companies need to have the proper systems in place to gather, analyze, and act on the massive volumes of data that IoT sensors are producing. Additionally, they must guarantee that the data is trustworthy, accurate, and secure. Integration presents another difficulty. For IoT solutions to be effective, they must be integrated with current systems and procedures. Businesses must make sure that the IoT solutions can effortlessly interact with the systems of the logistics partners and work with the current systems **(Tadejko, P. 2015).** Despite these difficulties, the advantages of IoT for supply chain management are obvious. With the use of IoT technology, businesses can optimize the performance of the whole supply chain, boost supply chain visibility, and improve logistical operations.

Literature Review:

The Internet of Things (IoT) idea has drawn a lot of attention recently as a crucial enabler for supply chain management's digital transformation. An overview of the Internet of Things and how it relates to supply chain management is the major area to understand. It has some of the possible advantages of IoT technology, like real-time visibility, process automation, and better decision-making.

IoT and Supply Chain Management and Logistics: By supplying real-time data, expanding visibility, and enhancing decision-making, IoT technology has revolutionized conventional supply chain management procedures. Position, state, and status of cargo in transit can be gathered via IoT-enabled devices including sensors, RFID tags, and GPS systems. Real-time data contributes to improved inventory accuracy, shorter lead times, and fewer stockouts. Because early warning systems, predictive maintenance, and improved risk management are now available, supply chain resilience is also increased. Supply chain managers may spot possible dangers with the use of IoT technology and take appropriate measures to reduce them. By increasing productivity, lowering costs, and raising customer happiness, IoT technology has also significantly contributed to the transformation of logistics operations. State, status for cargo in transit can be provided via IoT-enabled devices including smart sensors, RFID tags, and GPS systems. Real-time data contributes to improved inventory accuracy, shorter lead times, and fewer stockouts. State, and status of products in transit, the integration of IoT with logistics operations has further increased supply chain visibility. Logistics managers may track items moving in at exact time, spot any delays, and take appropriate action to assure on-time delivery **(Li et al. 2015).**

The Role of the Internet of Things (IoT) in Supply Chain Management Effectiveness: Enhancing visibility and real-time tracking are two of the main benefits of IoT in supply chain management. Inefficiencies and delays result

from supply chain managers' poor visibility into the movement of commodities. However, it is now possible to manage and monitor shipments, inventory levels, and production procedures in real-time thanks to IoT-enabled sensors and devices. In order to optimize the supply chain, managers may now identify bottlenecks, reduce processes, and make data-driven decisions. A key component of supply chain management is inventory management, and IoT is important in streamlining this procedure. Companies can obtain precise and up-to-date information on inventory quantities, locations, and conditions by adding IoT sensors to products, pallets, or containers. The use of this information enhances inventory replenishment, decreases stockouts, reduces overstocking, and improves demand forecasts. Supply chain managers can use IoT to execute just-in-time strategies, lower carrying costs, and boost inventory management effectiveness as a whole. Asset tracking and predictive maintenance are two important areas where IoT has a big impact on supply chain management. Companies are able to remotely monitor the functionality and condition of the machines, vehicles, and other assets by utilizing IoT sensors and connections. To anticipate maintenance requirements, avoid failures, and maximize asset utilization, real-time data on characteristics such as temperature, vibration, or working hours can be analyzed. This proactive approach to maintenance decreases downtime, increases asset longevity, and boosts operational effectiveness. For supply chain management to be successful, stakeholders must work together effectively. Between suppliers, manufacturers, distributors, and customers, IoT promotes seamless communication and collaboration. Stakeholders can communicate in real-time, plan activities, and move rapidly in the event of supply chain changes or interruptions thanks to IoT-enabled devices and platforms. With better decision-making, increased responsiveness, and shorter lead times, there will be an increase in customer satisfaction. Assuring product

traceability and quality control is crucial in sectors like food, medicine, and consumer products. The tracking of goods along the whole supply chain, from the point of origin to the final consumer, is possible because of IoT technology. IoT sensors enable businesses to keep an eye on environmental factors like humidity, temperature, and other factors that could affect the quality of their products. With the use of this information, regulations are always followed, recalls are better managed, and quick action may be taken to stop product damage or spoiling **(Gnimpieba et al. 2015)**.

Challenges and Consideration: Along with the significant advantages that IOT brings in the field of Supply chain, also come a few barriers or factors that negatively impact the use of these technologies in the economy. Data Security: Because there are so many devices online, there are serious concerns about data security with IoT. IoT devices produce a tremendous quantity of data, including sensitive data about goods, shipments, and customers that need to be secured from unauthorized access, cyberattacks, and data breaches. Interoperability: Internet of Things (IoT) systems and devices is something that multiple suppliers create and may utilize various platforms and protocols. It might be difficult to make sure that these systems and devices communicate and work together seamlessly. To deal with this issue, standardization efforts, and open protocols are required. Scalability: Supply chains can be lengthy and intricate, including a large number of parties, locations, and procedures. In terms of infrastructure needs, connectivity, and managing a large number of devices and data streams, scaling IoT installations to encompass large-scale supply chain networks can be difficult. IoT devices depend on the network for connectivity and network reliability in order to transfer data in real time. Supply networks, however, frequently connect distant or dispersed places with patchy network coverage. The success of IoT-enabled supply chain management depends on ensuring dependable connectivity

throughout the whole chain, particularly in locations with subpar network infrastructure. Data management and analytics: IoT creates a significant amount of data from a variety of sources, including sensors, RFID tags, and linked devices. It might be difficult to manage, analyze, and derive useful insights from this data in an efficient manner. To extract useful information from IoT-generated data, organizations must spend money on reliable data management systems, analytics software, and data scientists. Cost and Return on Investment: Putting the Internet of Things (IoT) into supply chain management needs a large investment in IoT hardware, connectivity, infrastructure, and data management tools. To ensure the viability and sustainability of IoT deployments in their supply chains, organizations must carefully examine the costs and possible return on investment (ROI). Workforce Skills and Change Management:

The introduction of IoT modifies the supply chain's current procedures, workflows, and roles. To guarantee that staff has the knowledge and abilities to operate and make efficient use of IoT devices, workforce training, and change management activities are essential **(Haddud et al. 2017).**

Objective of the Study
To find out the role of internet of things (IoT) in supply chain management effectiveness

Methodology
This study utilized a structured questionnaire to conduct a survey, and statistical methods such as mean & t-test were used to analyze the responses from 171 participants. The sampling method used in this research was convenience sampling, where individuals were selected based on their accessibility & willingness to participate.

Table 1 Role of Internet of Things (IoT) in Supply Chain Management Effectiveness

Serial No.	Statement of Survey	Mean Value	t-value	p-value
1	By attaching sensors to products, containers, and vehicles, businesses can gather valuable data on location, temperature, humidity, and other relevant parameters.	4.27	9.911	0.000
2	IoT devices may collect data on equipment performance, allowing businesses to implement predictive maintenance practices.	3.73	2.784	0.003
3	By implementing RFID tags and sensors, businesses can track inventory levels, identify slow-moving or obsolete items, and improve demand forecasting.	4.48	11.570	0.000
4	Through the use of sensors and blockchain technology, businesses can track and authenticate products from the source to the destination.	4.29	7.966	0.000
5	IoT devices, such as smart shelves, RFID tags, and automated picking systems, can improve warehouse operations.	4.18	7.196	0.000
6	By analyzing real-time traffic data, weather conditions, and vehicle performance, businesses can optimize delivery routes, reduce fuel consumption, and enhance on-time delivery rates.	4.44	11.218	0.000
7	Data captured through IoT devices enables businesses to adapt their supply chain processes in real-time,	3.91	5.084	0.000

	aligning production, inventory, and distribution with changing customer demand.			
8	Temperature and humidity sensors can monitor the conditions of sensitive products during transportation, ensuring compliance with quality and safety standards.	4.33	11.383	0.000
9	IoT enables improved collaboration and visibility across supply chain partners.	4.39	11.615	0.000
10	By analyzing the collected data, businesses can identify bottlenecks, inefficiencies, and areas for improvement.	4.24	9.719	0.000

Table1 demonstrates the mean values for each of the statement of the study done on the "role of internet of things (IoT) in supply chain management effectiveness", examining the average scores, the statement that obtains the highest mean score can be described as "By implementing RFID tags and sensors, businesses can track inventory levels, identify slow-moving or obsolete items, and improve demand forecasting", which has the mean score of 4.48, Looking at the next statement which is "By analyzing real-time traffic data, weather conditions, and vehicle performance, businesses can optimize delivery routes, reduce fuel consumption, and enhance on-time delivery rates" the mean score is found to be 4.44. Looking at the mean value of 4.39 for the statement "IoT enables improved collaboration and visibility across supply chain partners" shows that supplier collaboration is also responsible for the internet of things (IoT) in supply chain management. Looking at the other aspect of internet of things (IoT) in supply chain management is, "Temperature and humidity sensors can monitor the conditions of sensitive products during transportation, ensuring compliance with quality and safety standards" which displays the mean score of 4.33, and the statement "Through the use of sensors and blockchain technology, businesses can track and authenticate products from the source to the destination" showcase the mean value of 4.29. Then the statement "By attaching sensors to products, containers, and vehicles, businesses can gather valuable data on location, temperature, humidity, and other relevant parameters" obtains mean value of 4.27 and the

statement "By analyzing the collected data, businesses can identify bottlenecks, inefficiencies, and areas for improvement" has 4.24. The statement "IoT devices, such as smart shelves, RFID tags, and automated picking systems, can improve warehouse operations" showcase the mean value of 4.18. Therefore, the last two statements fall within the lowest category or level, "Data captured through IoT devices enables businesses to adapt their supply chain processes in real-time, aligning production, inventory, and distribution with changing customer demand" mean value of 3.91, the statement "IoT devices may collect data on equipment performance, allowing businesses to implement predictive maintenance practices" has 3.73. The significance of the t-value for each statement in the investigation on the role of internet of things (IoT) in supply chain management effectiveness is significant. The t-value statements were positive, and their significance value was less than 0.05, indicating a significant relationship between the two variables.

Conclusion:
In summary, It is crucial to improve the efficiency of supply chain management. IoT makes it possible to track, monitor, and analyze critical data points in real time across the supply chain network by integrating physical devices and systems. Because of this interconnection, there are fewer bottlenecks, delays, and expenses thanks to greater visibility, efficiency, and reactivity. Optimum routing and logistics are possible because of IoT-powered sensors,

RFID tags, and smart devices. These technologies also enable accurate inventory management. Stakeholders obtain useful insights via IoT, enabling proactive decision-making and efficient operations. At the end of the day, the incorporation of IoT in supply chain management fosters improved collaboration, transparency, and agility, enabling businesses to better satisfy customer demands in today's dynamic marketplace. Not only in the field of supply chain and logistics but also in various others, IOT has proved to be a significant game changer. It has more capability to evolve which might take place in the near future.

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