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The Integration of The Internet of Things, Big Data, And Artificial Intelligence in Supply Chain Management.

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ABSTRACT
Supply Chain Management (SCM) is a critical area where businesses should focus with a clear vision. Traditional methods of handling SCM are complex, time-consuming, and prone to numerous difficulties and errors. Even the use of currently available software often fails to meet all the requirements of SCM. The traditional approach is challenging because it involves many manual activities, from collecting raw materials to using them in production, tracking production status, and transporting finished goods to vendors and customers. This lack of transparency and proper communication with customers further complicates the process.
Keywords — IoT, Big Data, Artificial Intelligence, Supply Chain Management, Sensor

I. INTRODUCTION

Supply chain management (SCM) is a vast and crucial field that encompasses the entire production process, from collecting raw materials to the final delivery of goods to sellers and customers. SCM involves coordination among various organizations and requires continuous, interrelated activities to achieve goals with minimal cost and maximum efficiency, ultimately leading to significant benefits and high customer satisfaction. This comprehensive process involves planning, organizing, leading, and controlling.

Effective management is vital in SCM, as it aims to produce high-quality, valuable, and customer-friendly products to increase demand and profitability. The adoption of the Internet of Things (IoT) and Artificial Intelligence (AI) has significantly transformed SCM, providing substantial benefits and improving efficiency.

In this paper, we propose a novel approach that integrates IoT, AI, and Big Data to revolutionize SCM. This combined use of advanced technologies offers numerous advantages, especially for organizations that adopted them promptly during the COVID-19 pandemic. While many SCM companies faced shutdowns due to lockdowns, those that implemented these technologies thrived and reaped substantial benefits

II MOTIVATION

We've observed significant benefits from the use of the Internet of Things (IoT) in Supply Chain Management (SCM). Similarly, the application of Artificial Intelligence (AI) in SCM has yielded remarkable results. Since AI relies heavily on data, the vast amounts of structured, semi-structured, and unstructured data generated by IoT devices are invaluable. These data are collected, organized, and processed using Big Data technologies, serving as training data for AI systems.

The idea of integrating these technologies stems from their individual successes in SCM. By combining IoT, AI, and Big Data, we can achieve even greater efficiency and effectiveness. Each technology offers unique and overlapping benefits, creating an opportunity for synergistic use to maximize advantages.

SCM often involves repetitive processes over long periods for the production of goods. Traditionally, this requires substantial human labor, which has limitations in terms of capacity, energy, decision-making, and execution. IoT simplifies tasks like tracking materials, identifying requirements, and communicating needs to IT teams. It also monitors the location, transportation, and delivery of goods, ensuring optimal routes and precise tracking.

AI reduces the need for human labor by performing tasks that humans find challenging. It can manage everything from raw material requirements to production timelines and logistics. AI operates continuously, leading to increased production and time savings. It can also predict security threats, detect defects, and automate billing and communication processes. By combining IoT, AI, and Big Data, SCM can be transformed like never before.

A. Internet of Things in SCM: IoT assists in real-time tracking of goods under production, monitoring production times, material consumption, manpower usage, and remaining production time without physical site visits. For effective use, the system must be network-connected, with production site devices also networked. IoT allows managers to continuously monitor production status, offering enhanced control and security. It simplifies life by enabling control of connected devices remotely via the internet, aiming to connect all significant items for easy operation from anywhere.

B. Artificial Intelligence in SCM: AI, a revolutionary human invention, allows machines to perform human-like tasks with high speed and accuracy. It reduces human stress and physical demands, taking on numerous responsibilities. In SCM, AI aids in raw material procurement, processing, and final product production, leading to long-term labor cost reductions and increased profits. AI machines can operate non-stop, significantly enhancing productivity and time efficiency. They also assist in predicting security threats, detecting defects, optimizing transportation routes, and automating billing.

C. Big Data in SCM: Big Data streamlines SCM, enhancing delivery speeds, communication between manufacturers and suppliers, business operations, customer service, marketing, and overall revenue. It enables faster, safer, and more beneficial decision-making through analytics reports, aiding in timely production and efficient process observation. Big Data helps companies understand customer preferences and needs, promoting the development of desired products. By analyzing past and present data, businesses can identify strengths and weaknesses in production, cost, sales, and profit. Big Data sources are diverse, including search engines, social media, customer care, billing, internet logs, online marketing, cab bookings, educational blogs, research publications, weather data, traffic information, and more.

III LITERATURE REVIEW

This research focuses on using multimodal transport systems to solve transport problems, which may subsequently be applied to AI neural network (NN) problems. Any simplex approach can be used to solve the multimodal transportation problem (MMTP), which is a linear programming issue[9]. The concept's applicability is tested through a comprehensive case study of automated truck driving logistics. The assumption that four distinct and ever more unacceptably high thresholds must be reached before human users and artificial intelligence systems may effectively and completely trust each other, according to the results. This idea is used in the design of many automated logistic systems, such as those that drive cars or aeroplanes. [10].
The ability of warehouse operations to perform in logistics, logistics management, and logistics coordination is enhanced by the application of artificial intelligence. The integration of artificial intelligence in warehousing has the potential to enhance the overall smart, dynamic, and advantageous warehousing environment. The study focuses on the automated storage and retrieval of inventory from the warehouse using cloud computing, artificial intelligence, and the internet of things to provide access to the stock at any time.[11]. What humans cannot accomplish is made feasil ` by artificial intelligence (AI). Artificial intelligence becoming a good substitute for humans in the logistics and retail industries, as it can perform tasks that humans cannot.[12]. The author of this paper provides a full explanation of how the SCM can use the internet, as well as what the Internet of Things (IoT) is, what magic it can do for the SCM, and how the SCM can benefit from SCM.[13].The author of this report discussed the potential applications of IoT in the transportation, logistics, and food production sectors. The author has provided detailed information on the IoT's limitations in the aforementioned domains and how to overcome them.14].The author has developed a supply chain information transmission model using IoT and RFID after identifying various weaknesses in current SCM systems. They have also designed a network diagram that illustrates how IoT may be applied in SCM in a different way than it can in other industries.We may use the pharmaceutical manufacturing industry as an example to see how IoT has helped it become a more profitable, productive, and rapidly expanding sector. By successfully creating a network of supply chain information transmission, the model employed here can assist in resolving issues with information asymmetry in the supply chain and aid in the creation of a worldwide supply chain management network.[15]. Sensors are used by IoT devices to collect data on a wide range of variables, including location, temperature, motion, equipment handling, humidity throughout the day, light levels, and movement speed. The Internet of Things (IoT) has been designed with devices such as RFID chips, sensors that are attached to other devices, and artificially intelligent devices in order to transfer data with high accuracy and to enable the use of the information generated by all of these devices to make major decisions [7].Goods will always be found where the stakeholders want them to be, whether at rest and when moving, thanks to the Internet of Things.IoT also monitors the precise location and pace of commodities movement. IoT keeps an eye on how raw resources and things are stored. IoT also facilitates the detection of defective items and automatically generates a receipt upon delivery of the good at a designated place.

IV METHODOLOGY USED

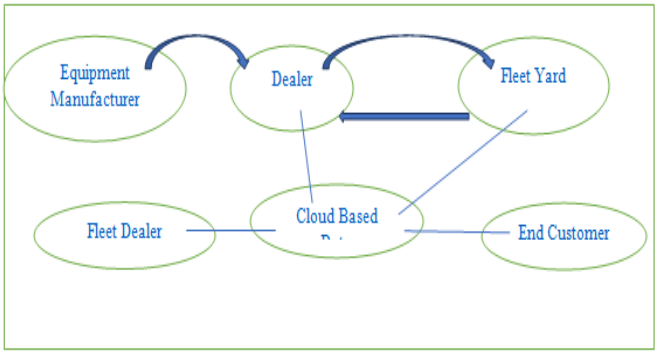

FIGURE1: IOT in SCM

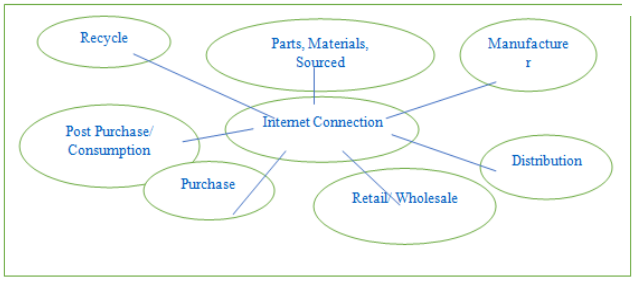

FIGURE2: IOT in SCM

The obstacles that IOT faces

• Skill Gap: Because IoT is a rapidly expanding technology with a constant stream of new hardware and software being introduced, highly skilled IT personnel are required to handle the IoT.
• Increasing Data Storage Challenges: As a result of the massive volume of data generated by the great number of connected equipment and devices, adequate data storage facilities must be set up so that any machine learning algorithm may use the data directly.
• Dangers to Security: One of the most crucial areas to concentrate on is security because, in the Internet of Things, security is paramount. Appropriate security measures must be taken, and the entire system must be continuously watched over and protected from threats. Extremely skilled network and security engineers are needed.
• Connectivity problems: The Internet of Things (IoT) requires that every gadget be able to connect to the internet, which is another difficult task.

A. *IOT architecture in SCM:*

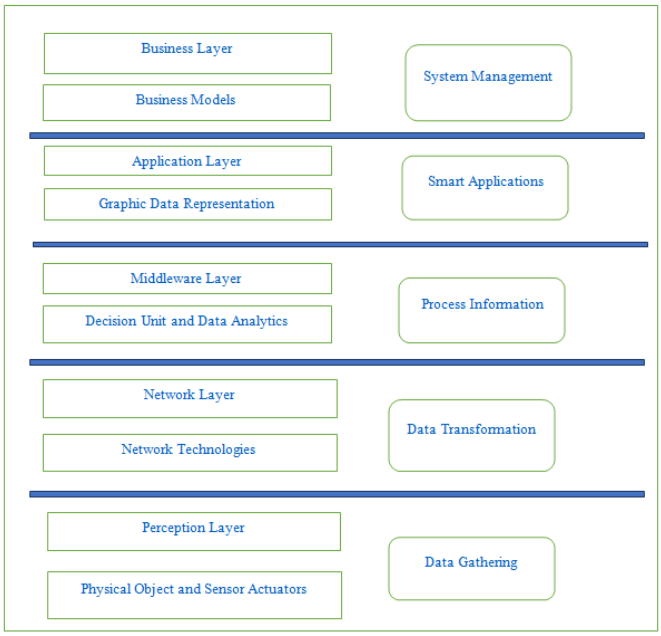

FIGURE3: IOT Architecture in SCM

B. *The wonder done by Artificial Intelligence in SCM:*

AI is helping SCM to deliver the strong operational capabilities which help in accurate dimensions planning, improved productivity, high quality, lessen costs, and increase output, all while stimulatingless risky working place. The SCM with AI isgoing to make the future of SCM better and better.

C. *Challenges of AI in SCM:*

- System Complexities:The Artificial Intelligence system is very complex and so expert IT professionals are required to design and develop and integrate it with the new technologies.
- The Scalability Factor:Maximum of the Artificial Intelligence systems are designed for specific task and here sometimes there may need to use the same machine for some other purpose and it is very difficult to design such system and it needs long research.
- The Cost of Training:The Artificial Intelligence systems are profitable in the long run but it needs expert professional to design, to develop, to use and to maintain and so initially the cost involved will be high.
- The operational cost involved:The operational cost involved is also high but we have to find ways to decrease all these so that it proof beneficial.

D. *Readying Supply Chain for Artificial Intelligence:*

- Set realistic expectations
- Know how the company uses technology
- Dive into your data

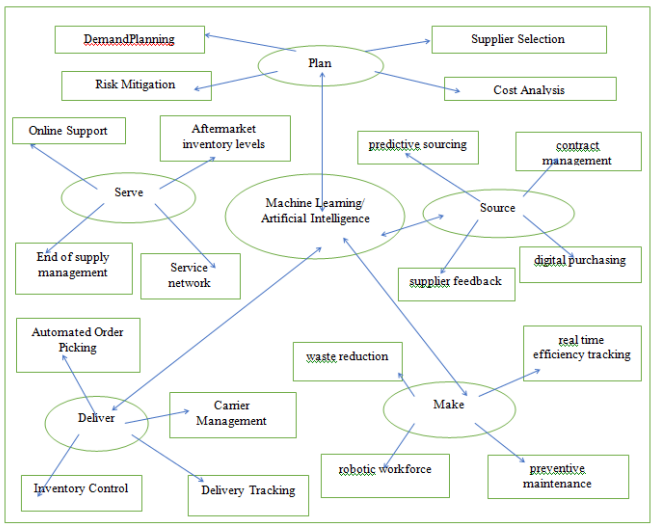

FIGURE4: Machine Learning& Artificial Intelligence in SCM

E. *Use of AI within supply chain management.*

Predictive analytics: demand analytics, network planning and best uses strategy, best uses of produced goods, transport route prediction, etc.; research on a specific area; restoration planning research; comprehensive analysis of investment; etc. Plan and strategy.

2. Investment and supply chain management: This has to do with the goods or materials that are sold to consumers in order to turn a profit. A few of the many facets of investment management are keeping track of and supervising purchases made from suppliers and consumers, preserving material availability, maximising the quantity of merchandise available for sale, and order fulfilment. Inventory management consists of three crucial steps:

• Purchasing Records: These document the purchases of components or raw materials and their delivery to the warehouse

Record-keeping for Storage: The warehouse houses the goods. After being transformed into a product at the production site, the raw materials are transferred back to the stock regions and shipped to the designated locations.

Making money off of the investment made.Completed goods are retrieved to fulfil client orders. Goods are shipped to the specific clients who place a purchase. Wearable: • Smart glasses: Employees who used Google smart glasses to run a specially created programme outperformed those who did not by 15%. Moreover, the mistake rate dropped to 12%. Voice headsets: Companies that build gear and software will soon incorporate audio-enabled interfaces to allow consumers to engage with their voice directly. • Smart watches: Used to monitor the actions required to transport an item from one place to another. It is also employed to forecast the actions required for the upcoming cargo journey. It can also monitor how long it takes to finish the cargo.

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F. Source of Big Data:

The following are some sources of Big Data:

1. From the electronics devices like sensors.
2. All the social media platforms.
3. All types of online or offline business deals and transactions made.
4. All types of file, audio, video, text, words, pdf etc.
5. Televisions channels and radio channels and other online platforms.
6. Social Data comes from social media and different search engines.

Machine data is the information which is generated by sensors that are installed in machinery , industrial equipment, and even web logs which track user behaviour.

Transactional data are the transactions happened online and offline which include order payments receipt, invoices Delivery receipts, payment orders, money transfers.

Unstructured data comes from information that is not organized or easily interpreted by traditional databases or data models. Examples can be Metadata, data from twitter and many other social media posts.

Multi-structured data are the variety of data formats and data types collected and generated from electronic devices, mechanical devices, and online and offline activities and multi structured data can be extracted from social media, search engine, electronics transactions, internet logs, and many other sources like email. Blogs, matrimonial sites and educational and medical and research websites etc.

Big Data can make a big change in business because nowadays data means everything and Big Data has enormous amount of data to make an organization many things.

G. Big Data is benefitting Supply Chain Businesses in the following ways:

FIGURE5: Benefits of using Big Data in SCM.

Big Data is the huge amount of data that is generated from many different sources which include the search in a search engine, the message shared in the social media, the likes and comments and dislikes in the social media, the sharing and disliking of videos, the phone calls made, the messages sent, the electronic bill generated for a purchase, the mail sent and the information shared on the internet for some specific use etc. The datacollectionin big data has been focused on the 6V's –volume (the huge amount of data gathered), velocity (the fast speed in growing the numbers of data) and variety (the data generated and gathered are from many different sources and many different types) variability(the number of data are increased in fast speed) and value (the data which are useful).

V . THE COMBINE APPROACH OF IOT, BIG DATA AND ARTIFICIAL INTELLIGENCE:

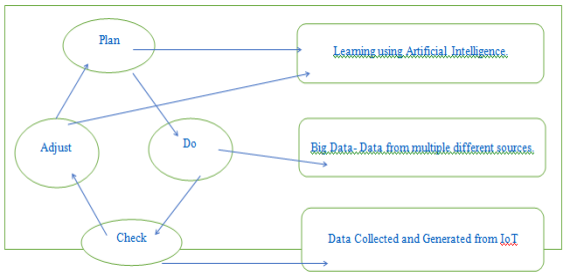

FIGURE6 : Combine approach of IOT, Big Data and A.I in SCM.

As we know that Big Data contains information generated from any device that has the capability to connect to the internet and that has data transfer and sharing capability. Big Data contains information generated from any existing devices from any field. Big Data contains information generated from machines, electronics devices and other informationlike structured or unstructured or semi structured. And the information that we get from social media is very useful in knowing the sentiment of the customer. From the social media information, it is easy for the business owners to predict the requirements of the users, the expectation of the users from the goods and the demand of particular goods at particular season and also it is easy to predict which products are bought together and also the benefits and loss of providing different offers.

Then we have the IoT, IoT is nothing but connecting all the devices together for easy and useful information sharing. In the next few years, according to the experts, maximum of the human usable stuffs will have internet connection capacity. To make anything compatible to IoT, the thing should have electronics circuits to be able to connect to the internet. In the supply chain system, IoT is very useful to track everything happening from collecting raw data to processing the raw data to produce the expected goods and also transporting the goods to the vendors and to the customers.

IoT can be used to track availability of raw materials at particular location and the distance to be covered to transport the raw materials to the company's production site. IoT will track the step by step processing of the goods and the amount of time taking and when the final product will be produced. IoT trace the location of the goods and the warehouse where the goods are stored and when the goods have to be transported to different warehouses and different vendors. IoT can also track the payment details and the overall documentation of the whole process automatically. IoT uses sensors and internet to keep on tracking the goods and the transportation etc. IoT can also predict the customers' needs and any risk and security lapse. As we know that every company will install camera and all those camera will be connected to the internet and so IoT can keep view of what is happening at the site. All these information associated with the IoT are gathered in the Big Data and can be used by the Artificial Intelligence machines.

And now Artificial Intelligence will increase the service to the supply chain management system. Artificial Intelligence in supply chains helps to deliver properplanning, good products, increase production, cost effective, and satisfying outcomes, all while motivating a safer working place. The Ai-Powered Supply Chain will give more values and profits to the stakeholders in the coming future.Accurate buy and sales, reduction in cost, less duplication and more production, faster delivery, proper risk management, proper storage in the warehouse with proper movement of the goods, high safety, less investment and more profits, better customer interaction and deliverying goods on demand, proper planning and proper action plan and more security, smart decision making and transparent in the process of production and delivery.

IoT and Big Data along with Artificial Intelligence can make an organization stay away from the blind spot problems. These technologies will help the organization to keep track of everything on a second to second basis.IoT along with Big Data and Artificial Intelligence can track any cargo with internet accessing capability.

All these advanced technologies are replacing the old aged manual process of calling, messaging, sending fax etc. Now everything is done automatically so that no delay, no waiting, no acknowledgement from any authority is required. Every decision is taken automatically by the machine and every bills calculation and bills generation and sending of bills to the specific person or team is totally taken care by the machine itself. All these are the benefits of collaborating all these technologies together.

The traditional supply chain visibility concept is out-dated because it can record the arrival of any goods only when the goods arrived at a particular predefined checkpoint and it can't accurately track the condition of the goods and the shipment when the transportation is on the way. There is also the lack of predicting temperature condition of the goods and the vehicles and also very hard to choose proper route so that the shipment does not delay. The solution to all these problems is the combined technology of IoT, Big Data and the Artificial Intelligence. These advanced technologies will automate everything from collecting raw materials to process of production to shipment to delivery to the warehouses and customers. It saves time, money, efforts, and number of workforce involved, and helps in in time delivery of the goods. These advanced technologies enable to connect all the parties involved easily and to know the status of everything second to second. These advanced technologies can connect the goods, the cargos, the ships and all the equipments and devices involved with enterprise IT systems via the use of sensors, GPS, mobile networks and a cloud-based platform.

The sensors can capture information about the condition, geographical location and environment where the goods is available and transmit signals and data to the servers through the network to provide a closer picture of the goods at the current location. These datas can then be used in the future for preparing artificial intelligence systems.

By using all these information's, proper steps are taken automatically by the Artificial Intelligence machines and share the information's through the IoT. So the collaboration of IoT, Big Data and Artificial Intelligence gives a supply chain management company huge benefits.

The combine approach of IoT, Big Data and Artificial Intelligence allows the stack holders to monitor the condition and the environment and the weather condition during the shipments in real time allows clients to verify the whole journey of a product, predict, correct, and even prevent problems with the help of faster response time. With the help of the advanced technologies, stakeholders can easily get information about any type of issues on the cargo carrying

their goods. The issues can be temperature; speed, poor network, heavy traffic etc and so proper steps can be taken to deliver the goods in time without any problems.

The sensors attached on the vehicle and the goods carrying allow to take necessary actions in time. Because of this, proper route can be chosen in time and also it leads to safely delivery of the goods without any disruptions.

IoT along with Big Data and Artificial Intelligence makes the supply chain management easy, trackable, secure, speed up, fast, safe and satisfaction to all the people involved. The organizations that use all these combined approach will definitely save money, increase efficiency and keep their customers happy.

There are various reasonsbehind the incorporation of big data,IoT and AI because these combine technologies bring tremendous positive changes in the supply chain management systems.

1. Providing more precise diagnostics information
2. Planning facilities as per precise demand forecast
3. Proactive maintenance and operation
4. Managing risk and contingencies beyond human control
5. Inventory sensors for warehouse management
6. Artificial intelligence for a smarter workforce

VI IOT, ARTIFICIAL INTELLIGENCE AND BIG DATA USES IN SCM

- Real Time Location Tracking: IoT along with Big Data and Artificial Intelligence can track the current status of any goods or materials under production. IoT uses the data of Big Data and Artificial Intelligence and Machine Learning together uses the data produces by IoT and available data from Big Data to automatically track the location of goods in the warehouse as well as during transportation.
- End to end visibility into supply chain: IoT along with Big Data can observe the SCM step by step from the start to the end. The sensors attached to the goods and tha transport vehicle helps the IoT devices to continuously track the current status. The data generated from this will be used by the artificial intelligence system for automation of all these activities.
- Better customer service: This combined technology provides real time interaction with the customers and so gives more satisfaction to the customer which lead to satisfaction and profit.
- More efficient waste management: These technologies help in reducing waste of the materials and also predict the exact number of material requirements for the production.
- Storage Condition Monitoring: These technologies monitor real time location of the goods both when in transportation and when the goods are delivered to any warehouse or customers.
- Forecast the movement and the arrival of the product: These technologies can predict the route to be taken to carry the goods and the time taken and also the time to be taken to arrive the goods at particular location.
- Locate goods in the warehouse: The sensors used can track the exact location of the goods in the warehouse and the number of goods available and which goods are in good condition and which are not.
- Check quality of goods: These combined technologies can check the quality of the goods on a regular basis and it will take decision to replace or repair a good.
- Monitor storage conditions: The goods are to be stored at the warehouses and these technologies will monitor the location of the goods from loss and damage.
- Helps in predicting maintenance: These technologies monitor the equipments regularly and it will give signals when any of the equipment or device is needed to do servicing for better performance.
- Helps in inventory management: These technologies help in selling the goods at a profitable price and these technologies also help in reading the sentiment of the customer and suggest for right offers to be given for more sales.
- Monitor location: These technologies locate the goods and the equipments involved. These technologies follow the location of the goods when in transportation also.
- Monitor goods condition: These technologies monitor the condition of the goods both in the warehouse as well as when in transportation so that no damaged occurs.
- Monitor lifetime of the product: These technologies monitor the validity of the product and replaced and redesigned and reproduce if any product is expired.
- Improve contingency planning: These technologies can predict in advance the possible outcomes of all the equipments , goods and materials involved. These technology can predict temperature, network, route, traffic, security, any possible damaged to be happened etc.
- Asset Management, Automation: It means automating all the process of supply chain management. Automation to find raw materials, automation to detect location, automation to trace route, automation to detect fire etc.
- Improve Resource Management: These technologies help in managing the resources well so that no materials go wasted and increase profits and quality.
- Transparency: These technologies make the whole process transparent so that trust and believe increases from all the corner.
- Sustainability: The right time prediction helps in sustaining customers and all the stakeholders involved.
- High Speed: These technologies lead to faster production, faster delivery, faster decision and faster transportation and tracking and prediction.
- Higher Accuracy: These technologies lead to more accurate in timing and sharing information about billing, delivery, production.

- Improved Flexibility: These technologies make everything flexible, may be changing of route, changing of delivery place, changing of order product, changing of replacement etc.
- Increased Efficiency: These technologies increase performance and decrease in wasting time of production, transportation, delivery etc.

VII CHALLENGES OF IOT, BIG DATA AND ARTIFICIAL INTELLIGENCE INCORPORATION.

Artificial Intelligence, Big Data, and the Internet of Things will all significantly alter supply chain management. However, there are obstacles to overcome, such as security, a stable and constant internet connection to all goods and devices, timely data filtering and utilisation from Big Data, training AI machines for precise prediction, and the ability to integrate all IoT items. Since there are so many advantages, it is critical for businesses to combine all of these technologies in order to reap the greatest benefits. In the long run, this will ensure that the firm can continue to create items and transport them to customers even in the event of a crisis such to the one that struck Corona.

Furthermore, integrating all of these technologies ought to have no impact on the current hardware and software; instead, they ought to seamlessly adjust to one another and function flawlessly.

VIII CONCLUSIONS

All of these technologies will integrate and cooperate extremely well, according to the final judgement. When combined, these technologies will provide a wide range of advantages. Timely production of goods, reduced wastage of raw materials, appropriate maintenance, increased security, early warning of potential hazards, accurate forecasting of demand and supply requirements, increased efficiency and reduced error, elimination of the need for manual data creation, improved customer and stakeholder relations, timely transportation and delivery of goods, appropriate route management during transportation, no delays, increased profits,

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