A SMART INFORMATION INTERACTION IN THE SUPPLY CHAIN BASED ON THE INTERNET OF THINGS AND DATA ANALYTICS

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Abstract - The Supply Chain Data Collaboration relates to a partnership between supply chain members in which materials, business operations, and organizations are integrated, coordinated, and developed naturally to reach a common objective. The objective is to establish and work cooperatively in all elements of the supply chain. The total supply value of the distribution network is higher than the sum of each link's quality, which improves the profitability of the whole supply chain. Effective communication has always been subject to misinterpretation, data loss, and information delaying in supply chain integration. Effective information collaboration in supply chain organizations became a problematic point. A smart information interaction in the supply chain management (SII-SCM) model is proposed. This research largely employs the Internet of Things and big data analytics to provide a simulator of the bullwhip impact of distribution network, series of mathematical models of the bullwhip effect. The simulated findings prove the importance of information exchange in the supply chain.
Keywords: Supply chain, Internet of things, Big data, Collaboration model

1 INTRODUCTION TO SUPPLY CHAIN MANAGEMENT

Competition between companies has risen with the emergence of economic globalization, integration, and the information economy's age [1]. The new market situation is no longer suitable for old company and operational management models. Companies increasingly understand the application of supply chain planning techniques to produce synergies and the micro and macro environment [2]. It will promote customer loyalty with the firm, allowing the firm to improve its fundamental competence [3].

Suitable information cooperation should be conducted between supply chain components in the extremely competitive changing marketplace of the century to remove hidden information inside the supply chain [4]. Cooperation with supply chain statistics enables organizations to grasp information about upstream finished goods and downstream knowledge about the production of raw materials [5]. Every supply chain node can only manage manufacturing, distribution, and sales by completely gaining this knowledge. Informative collaboration may resolve the bullwhip effect, minimize total supply chain costs and provide asset profit [6].

In supply chain planning, domestic and international researchers have also conducted much fieldwork on the influence of the Internet of Things (IoT) [7]. The research examined using the IoT in cases and research methodologies to overcome the bumping effect. The benefits of the RFID system and the data network may be claimed, allow real-time information transfer, guarantee supply chain participants readily and accurately understand information, and eliminate the bullwhip effect [8].

The research into coordinated data chain distribution concentrates mostly on collaboration's material and value [9]. The research will be grouped into three types: collaboration of administration, collaboration with innovation, and cooperation between people and machinery [10]. The distinctions in value exchange between data transfer are explored, and the internal links between the coordination of the supply chain and the exchange of data are examined. The article assumes the supply chain management has many synergistic impacts, thoroughly analyses and communication risk management strategies in informational cooperation, and the vital function of data synthesis in decision-making [12].

The objective study of the level of synergy can give specific approaches and the foundation for a further enhancement of the synchronization of data in the supply chain for detecting the weak points in the distribution chains [13]. Thus it is a highly useful study to analyze the extent of information cooperation amongst firms. Some research utilized an information cooperation numeric assessment technique and assessed the co-operative effect of data supply chain data based on several performance measures to assess company information exchange and collaborative status in each supply chain connection [14].

The most comprehensive and reliable research connects the supply chain to measure the degree of synchronicity in the material on the supply chain by Raman et al. [15]. Carter et al. theoretical model was developed as an appropriate performance measurement for information technology in the supply chain administration [16]. The particular fuzzy technique of assessment was employed to evaluate the cooperation of information systems. The research shows cooperation in the supply chain partners. A two-dimensional indicator examines the scope and quality of the exchange of data and use of the supply chain, e.g., market, production capabilities, inventories, and production scheduling [17].

Most companies in the supply chain reflect the concerns of their own companies, judging by the conventional application of operations management [18]. It is difficult to create collaboration due to a lack of relationships between management. Furthermore, ineffective monitoring of goods, the absence of data management in the company's operations, actual data on the request for the goods of each node cannot be sent or received in the period, and the companies often commit an error in acquiring knowledge.

This article discusses the supply chain informational feature vector on a supply chain susceptibility viewpoint based on the IoT and Data Analysis theory. It evaluates the present bullwhip effect issue and supplies the chain information cooperation concept anchored on the current theory. The simulation checks for a decrease of the bullwhip affect the efficiency of the data cooperation paradigm. The method's contribution aims to enhance information-sharing effectiveness, lower the risk of interruptions to the supply chain and enhance the findings for studying the data coordinating body. A concept for coordinating the supply chain is proposed to enhance the bullwhip impact and resolve the specific bullwhip problem to find a new way of fixing this issue.

The rest of the research work as follows. Section 2 deals with the background of supply chain management. The proposed smart information interaction in supply chain management (SII-SCM) model is designed and implemented in section 4. The conclusion and future scope are illustrated in section 5.

2 BACKGROUND TO THE SUPPLY CHAIN MANAGEMENT

2.1 Green Supply Chain Management (GSCM)

In balancing overall production and consumption in an economical and timely manner, supply chain operations attempt to provide information from external and internal processes [19]. Through cost, service, productivity, organizations and corporations in their supply chain organization and operations seek to preserve their competition. Companies were looking for a strategy to create and operate the green idea in their supply chains to address issues and difficulties with supply chains. Some self-supporting problems with supply chain management (SCM) environmental sustainability, such as green logistics or green procurement, exist. It is important to remember that the green badge only relates to a certain area of durability [20].

The European Union has encouraged sustained cooperation during the World Summit of the International Community and the Global Environmental and Social Council to solve the demands of the present generations without an understanding of how the generations to come might meet their needs [21]. This problem demonstrates how ecological, economic, and social characteristics produce and preserve equilibrium.

The conception of Wang et al. in the existing literature was defined by describing the sustainable supply chain management (SSCM) as "the clear coherence, strategy, and attainment of the financial, ecological and social goals of an enterprise in connection to the primary inter-organizational operation of the organization and the long-term economic growth of its production process [22]." This study concentrated on the idea of GSCM as an organizational strategy that helps businesses participate by reducing environmental issues and impacts while enhancing energy sustainability to gain business income and meet the market shared objectives [23].

2.2 The Competitive Market Effects of GSCM

The financial advantages of greening are not evident. The study estimated that the adoption of environmental practices increases costs and speeds up corporate transactions. Marshall et al. have suggested that the link between economic achievement and green practices is compared to the apparent direct relationship [24]. Hong et al. mentioned that determining the societal and ecological methods is sometimes useful and not always crucial for dealing with this situation [25]. To adopt environmental and sustainability principles that are helpful, companies need to acknowledge this straightforward problem.

It should not be assessed on the price, reliability, availability, or flexibilities of conventional supply chain management (SCM). Because of the current environmental problems faced by suppliers, several organizations have lost their image [26]. Zhong et al. considered the implementation of green practices to have a major effect on the performance of companies [27]. It provides competitive benefits for organizations that use a defined way of greening principles combined with the correct internal supply chain by reducing or eliminating image or risk losses.

Green practices thus have a significant influence on internal business to assist in determining external economic resources. A large capacity of the GSCM may be used as a foundation for distinguishing and showing an advantage that is greater than the competing product. Castillo et al. argue that small and medium-sized suppliers have restrained sources from increasing energy sustainability [28]. Furthermore, organizations need to strive to take public environmental actions, but lesser supplier firms are not encouraged to incorporate environmental performance through laws in their control measures [29].

It still has a gap in achieving economic advantages by applying its vendors to green practices based on research. Furthermore, there is another key worry about the poor understanding of how organizations may develop, organize and coordinate efforts to attain green supplier practices [30]. The conclusion was reached that the influence of the factors on the provider's involvement in the GSCM activities must be assessed and investigated.

The research provides a mathematical framework to understand how businesses may develop the optimum supply chain purchasing plan using IoT. The authors point out that even the IoT technology innovation reduces inventorial costs, reduces transporting costs, minimizes the lack of commodities, and improves operational efficiency. The research investigates the influence of the Internet of Things (IoT) on all the components of supply chain administration. It utilizes the company logistics modules as the study object to investigate the use in the practice of firms in the context of the IoT.

3 PROPOSED SMART INFORMATION INTERACTION IN SUPPLY CHAIN MANAGEMENT (SII-SCM) MODEL

3.1 Supply Chain with the Internet of Things

In the evolutionary background of the Internet of Things, the technologies and meaning for the Internet of Things are continually increasing from basic object identification to sensing purposes to integrating radio frequencies, nanotechnical technology, and smart coordinated cyber. It is essential that the objects of the network naturally convey information. Through networks, individuals are informed of the things and instructed about the objects, and the objects may be controlled wisely, behave smartly to achieve a smart materials and people conversation.

The Internet of Things is developed based on electronic encoding computer technology and the network. It is a novel approach from merging two different techniques, one of the research findings in all areas. The Internet of things acts as a conduit in its capacity, using wireless technologies and electromagnetic technologies to create anything linked and autonomous.

In other words, the Internet of Things has two points: (1) the IoT devices may use every one of the goods which can be handled autonomously as customers, and the IoT has timely interaction between these customers. (2) in the core of the network, IoT has a particular kind of Internet. It is inside the purview of the growth of the Internet. It can be observed that the network is not only the fundamental requirement for the advent of a network of objects but its current firm growth.

Since all linkages within the distribution network change in real-time, it influences the supply chain statement's accessibility in near real-time. The cooperation in the distribution network information on the IoT has successfully resolved the challenges mentioned, and many authors have proved their viability, efficiency, and other benefits. So the Internet of Things is incorporated in the proposed smart information integration in the supply chain management (SII-SCM) model.

3.2 Artificial Intelligence in Supply Chain

Artificial intelligence and its use in the production process will be briefly described in this paper. The efficiency is improved by the proposed smart information integration in the supply chain management (SII-SCM) model, and the following techniques are inherited.

(1) The utilization of EPC/RFID technology

RFID recognition is an automatic non-contact recognition device that instantly recognizes target items and obtains necessary data via a radio transmitter. The EPC is a unique number for each object in the entity. EPC utilizes RFID to provide a universal, open labeling standard for every item that allows international identification and control.

EPC labels are applied in the supply chain to single pieces, boxes, palettes, transporters, and the supply chain system. The label numbers of these things are associated, which fully record the readmissions for the items. Each portion of the network is connected with the relevant middleware and online server to provide the received material in real speed to the inner data system by installing a scanning with a built-in RFID tag or a vast array of manual knowledge read from the portable device. The network system to gather, transmit and share data at the paths.

The use of technologies EPC/RFID increases the production chain's visibility. Users may check the instructions for the EPC to comprehend the product circulation data and buy the goods with trust. The logistics service provider can realize the benefits of the active entry and exit commodity, the automated product stock, and reference model status monitoring. The supply chain partners are also able to get dynamic data and get a high amount of knowledge.

(2) Networking and implementation of wireless sensor technologies

The sensor senses the material environment. Many sensors in the sensing field are spread to detect the most original data, such as temperatures, moisture, intensity, tension, vibrations, and contamination. Medical and healthcare, remotely theft, network maintenance, pollution management, and other industries are subject to the Internet of Things depends on sensing technologies. The placement of numerous sensor nodes throughout the manufacturing facility allows the manufacturing atmosphere to be monitored and the equipment to be controlled in live time. During the transport chain, present information like temperatures, moisture, atmospheric pressure, and vibrations are gathered frequently or sporadically and delivered to the intrusion detection center through a communications network to perform complete process surveillance. The data is gathered during the communicating.

In case of a harmful or overwhelming signal, take appropriate emergency steps to prevent big losses based on the success. In the supply chain knowledge sharing, sensing technologies may effectively perform game controller, collect information on administration in-depth, master all of the elements impacting the production process, coordinate and manage thoroughly, and improve supply chain activities.

3.3 Cloud Computing in Supply Chain

The proposed smart information integration in the supply chain management (SII-SCM) model uses the advantages of cloud computing technology. Cloud services technologies in big data are used to resolve the resource question of complex data in the IoT environment. The cloud services concept combines processing power with a vast quantity of information saved on portable apps, personal devices, and other interfaces. Cloud services information cooperation can overcome the weaknesses in the conventional platform for data cooperation.

Cloud computing equals a common resource of computer resources that may be configured. This common pool contains resources like computer servers, storage arrays, and server farms for programs. The user may use support and information to access collections and invest the lowest through internet connectivity. A cloud model has superior time service.

3.4 Collaborative Communication Model of the Intelligent Supply Chain

The article looks at the connection between the bullwhip-effect issue and supply chain information, cooperation concept based on the IoT and Big Data concept. It builds a distribution network, bullwhip effect cooperation model to enhance resources and minimize supply chain risks.

3.4.1 Bullwhip Effect - Theoretical Representation

This work creates a model of supply chain collaborative data bullwhip effect utilizing a bullwhip impact on the Internet of Things. Technologies and cloud computing systems enhance information cooperation effectiveness, minimize risks of interruptions in the supply chain, and enhance the findings from the investigation on data coordinating mechanisms building.

It is not just one manufacturer and store is involved in building a basic supply chain. It may also be a three-tier distribution network with distributors, manufacturers, distributors, and consumers. In the t-period, the producer must forecast the retailer t+1 order amount based on the past data of the store's inventory level. Wholesalers exclusively sell to stores in this supply chain and assume that only one business operates. Since it is nearest to the marketplace, the merchant influences the end consumer's transaction data and can forecast the information. Assume that D_t the parameter is the final consumer's requirements, and this requirement is accurate: The demand at a time t is expressed in Equation (1)

$$D_t = \propto + \beta D_{t-1} + \theta_t \quad (1)$$

β refers to request the factor variations, independently for each time t, $\theta_t \sim N(0, \sigma^2)$; providing that $\propto$ it is far lower than β, ensured that request parameter $D_t > 0$. In Equation (1), σ is continuous and higher than zero, β is the degree of the connection between request factors within adjacent cells time frames, known to as synchronization coefficients, and fulfilled $-1 < \beta < 1$. The request parameter $D_t \sim N(\propto, \sigma^2)$ is needed when β =0 in Equation (1). It may be known that constant modifications are required throughout time. The mean and variance are expressed in Equations (2) and (3) when t→∞,

$$E(D_t) = \frac{\propto}{1-\beta} \quad (2)$$

$$var(D_t) = \frac{\sigma^2}{1-\beta^2} \quad (3)$$

$E(D_t)$ floated up and down to the same level $\frac{\propto}{1-\beta}$, although it may not have been the same with $(D_t)$and $E(D_{t-1})$. The cloud computing variables are denoted as $\propto and\, \beta$. Many researchers that examine knowledge sharing in supply chain administration have taken the demand mentioned above variability strategy.

Assume that a time-limit L exists when a merchant commands the downstream provider in the supply chain. After the t interval each moment throughout the t+L interval, the seller gets the orders made from the provider. Assume that the merchant employs an inventories (s, S) approach to assure a particular degree of product maintenance. Set the factual point y_t, the next operation at all times t is expressed in Equation (4)

$$y_t = L\overline{D}_t + \varphi\sqrt{LS_t} \quad (4)$$

L is a consistent time of order, and the default variance estimation is S_t; φ defined as the degree of service supply. The expected demand is denoted as $\overline{D}_t$.

The purchase decision in L is 83 percent and 97 percent according to the confidence interval function. The simple moving approach predicts the retailer's market opportunity and confidence interval. D_t is utilized throughout the i time to indicate the consumer request and the accompanying formula exists. The expected demand and the variance estimated is denoted in Equations (5) and (6)

$$\overline{D}_t = \frac{\sum_{i=t-n}^{t-1} D_i}{n} \quad (5)$$

$$S_t^2 = \frac{\sum_{i=t-n}^{t-1}(D_i - \overline{D}_t)^2}{n} \quad (6)$$

The n is the monitoring period used by the average moving technique. The higher the n quantity, the more the previous data are examined, and the finer the output of treatment. The actual demand is represented as D_i. The expected demand is denoted as $\overline{D}_t$. Suppose that the parameter Q_t shall be the number of items the seller has ordered from the manufacturer of the company that complies. The quality ordered is expressed in Equation (7)

$$Q_t = y_t - y_{t-1} + D_{t-1} \quad (7)$$

The current output and the next output is denoted as y_{t-1} and y_t. The current demand is denoted as D_{t-1}. It allows the provider to refund excess inventory level at no cost if the quantity supplied Q_t has a negative value. The outcomes of the quality ordered is expressed in Equation (8)

$$Q_t = \left(1 + \frac{L}{n}\right) D_{t-1} - \left(\frac{L}{n}\right) D_{t-n-1} + \varphi\sqrt{L(S_t + S_{t-1})} \quad (8)$$

The standard variance is denoted as S_t, the previous standard variance is denoted as S_{t-1}. The demand at a time t is denoted D_t. The monitoring period is denoted as n, the limit is marked as L, and the weight of the network is represented as φ. It was utilized as the bullwhip effect quantized. The standard error is expressed in Equation (9)

$$BE = \frac{var\,(Q_t)}{var\,(D_t)} \geq 1 + 2(1 - \beta^{"}) \frac{L(L+n)}{n^2} \quad (9)$$

The quality ordered, the demand of the product are denoted as Q_t and D_t. The monitoring period is denoted as n; the limit is designated as L. The scaling factor is represented as β. It will become evident that the knowledge on request is increased following the transmission of the retailing into the chain management manufacturer, i.e., the modeling of the bullwhip informational synergistic.

3.4.2 Diminishing the Bullwhip Impact Based on the Iot Cooperation Model

As one of the main challenges in synchronizing the supply chain partners, the Bullwhip impact significantly impacts inventory management. Its influence comprises mainly poor responsiveness and haphazard planning for manufacturing.

Fig.1 shows the demand and the supply architecture of the proposed model. The bullwhip effect is categorized into two groups, as generating factor and magnification factor. It is further divided into the demand and supply process of uncertainty. Others are classified into demand forecasts, end market fluctuation, batch order and price fluctuation, order demand, and insufficient production. The magnification factor is again organized into the supply chain, complex structure, and further sub-divided into time delay and logistics delay.

(1) Reduce responding requirement and quality of service

Due to too much data on need, the provider cannot truthfully estimate the state of terminal requests on the marketplace and respond appropriately to the consumption for the upstream purchase. In many items, suppliers normally cannot adapt their manufacturing capabilities on time but rather manufacture items that are not required, rendering the whole supply chain less reactive to their client demands and a poorer support standard.

(2) Uncertainty in the planning of manufacturing and the increased expense of manufacturing

In typical cases, the producer anticipates sales volume based on the order from the next client, develops the manufacturing capacity, monitors stock quantities, and schedules the time to produce. Due to the bullwhip effect, the request for an order from manufactures is extremely volatile, much above the immediate needs of end customers. It presents significant challenges for companies to production schedule a poor construction consistency. And often this results in manufacturing stands motionless.

In parallel, the poor construction will lead to increased production coordinators' burden and raise model starts expenses due to an increase in overall supplier's prices.

(3) The impression of increased consumption and the increased risks in the distribution chain

As downstream companies in the distribution chain do not comprehend the true situation because of the continual expansion of data, it is an impression that genuine request has risen. Because of changing demands in the supply chain, wholesalers continued to order many producers, which contributed to increased production among manufacturing companies.

By researching and analyzing inventory management, it understands to accomplish successful supply chain planning, strategic alliances between supply chain participants are established effectively, and supply chain members are strengthened. Information coordinating promotes the seamless transmission of knowledge, effective utilization of resources, enhances coordination and communication generally, decreases supply chain timing differences, decreases information-distortion bullwhip effects, and decreases total supply chain operating costs. The introduction of the IoT developmental perspective enhanced the effectiveness of the running of operations.

Goods can be traced and tracked as they are transported across the supply chain in real-time. Each member may also know in due course the appropriate information about the product. With the IoT technology, all distribution network members and goods linked to the strategic supplier data will be coordinated with the end-users as much as possible. The supply chain is constructed using modern information technology to enable effective data coordination between supply chain partners, reducing bullwhip influence. In the production process, a supply chain cooperation model is developed.

Fig. 2 shows the proposed smart information interaction architecture in the supply chain management (SII-SCM) model. The proposed model receives information from the retailer, supplier, wholesaler, etc. With the help of the Internet of things, the proposed model gets a signal from the different users and product location information. The middleware makes the users access the features of the proposed model easily. It uses a combination of the Internet of Things with the characteristics of cloud computing, known as the Internet of major browsers, and the cloud services atmosphere. By developing an information configuration that enables the bullwhip impact of the distribution chain, the effectiveness of the cooperation on the knowledge may be enhanced and reduced. The danger of interrupting the supply chain boosts the process performance. Simulation results then check the effectiveness of the process.

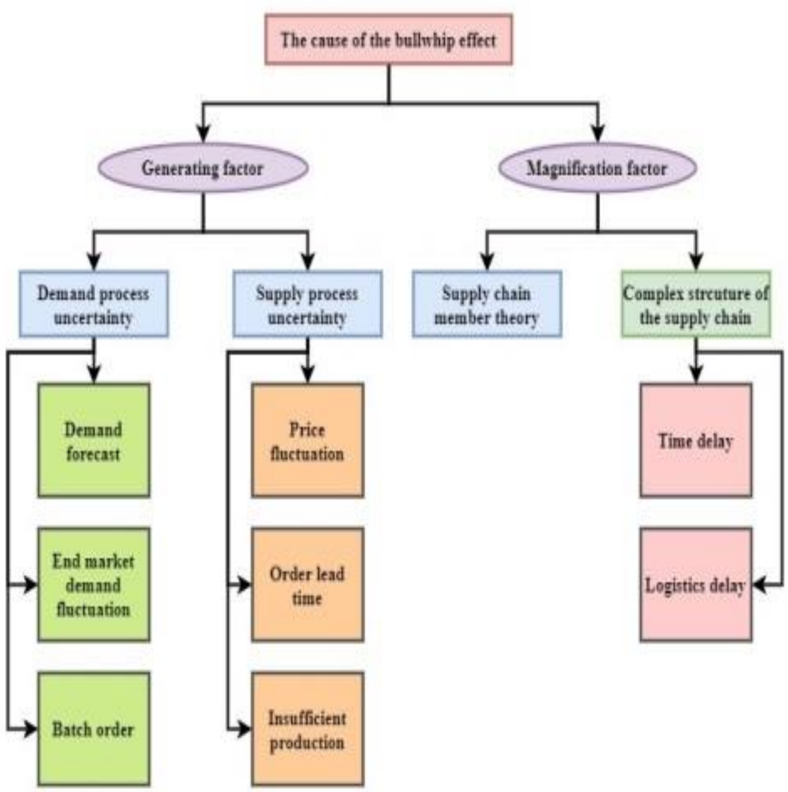

Figure 1 The demand and supply architecture of the proposed model

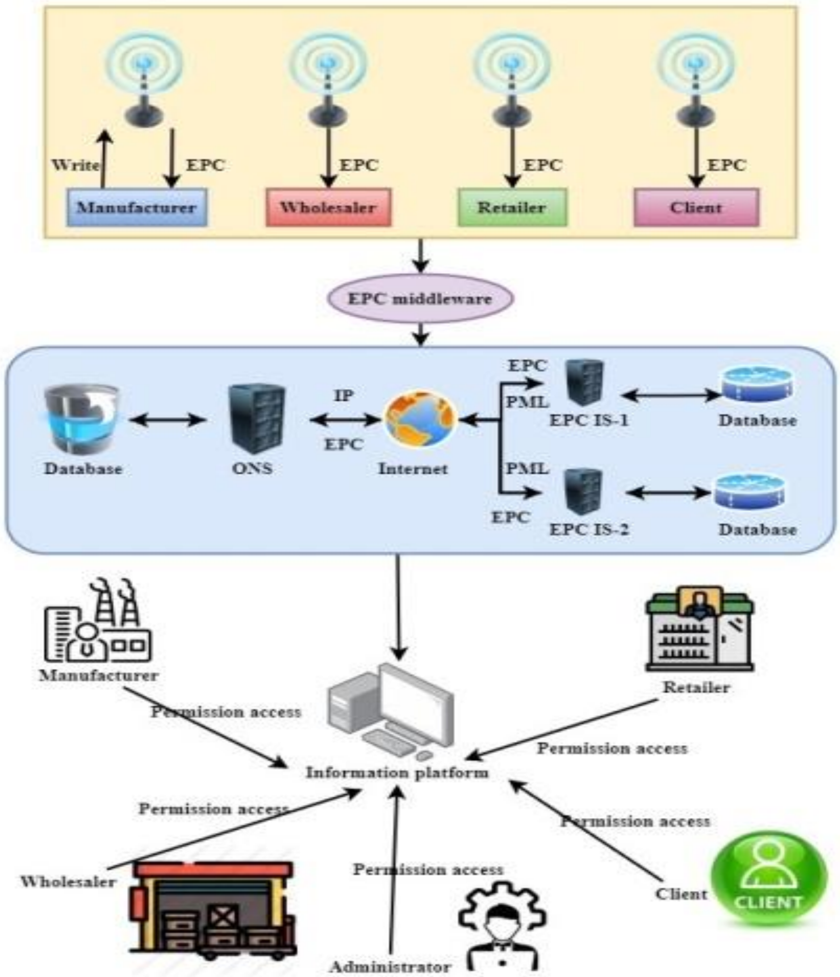

Figure 2 The architecture of the proposed smart information integration in supply chain management (SII-SCM) model

4 SIMULATION ANALYSIS

As the modern age has arrived, simulation software and the development of computer technology have been substantially improved. Different modeling software is available on the present market. It is faced with numerous businesses such as industrial, retail, and logistic sectors, and offers a tool for every aspect of life, and delivers a substantial economic advantage to any company. This package includes Auto Modification, Any Reasoning, Testimony, and e-M-Plant. Numerical simulation offers distinctive properties that may be selected based on various client requirements.

The proposed model is analyzed with the help of Matlab software. There are 50 products, 100 users, 20 retailers,four wholesalers, and 20 producers are considered for the analysis. The simulation area is 1000 x 1000m, where the users have placed a minimum of 200 m apart from each other. All the users are assumed as identical.

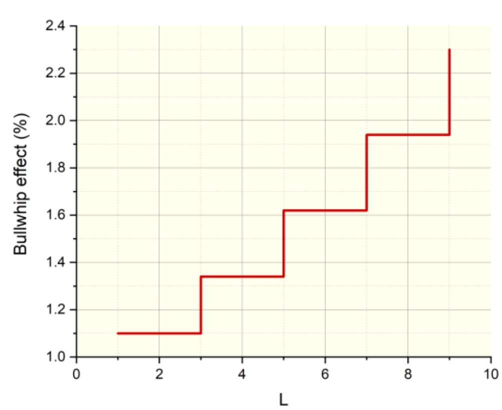

Figure 3 Bullwhip effect vs. L analysis

Fig. 3 shows the Bullwhip effect vs. L analysis of the proposed smart information interaction in the supply chain management (SII-SCM) model. The simulation is carried out by varying the value of the L variable from 1, 3, 5, 7, and 9, and the respective bullwhip effect is analyzed and plotted. The results show that the proposed smart information interaction in the supply chain management (SII-SCM) model reduces the bullwhip effect as the variable L decreases.

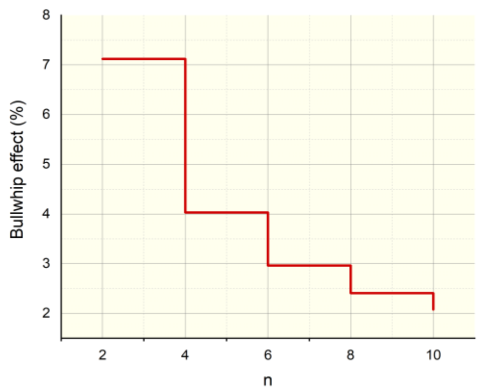

Figure 4 Bullwhip effect vs. n analysis

Fig. 4 shows the bullwhip effect vs. n analysis of the proposed smart information interaction in the supply chain management (SII-SCM) model. The n value is varied for the simulation analysis; as the n increases from 2, 4, 6, 8, and 10, the respective bullwhip effect is analyzed and plotted. The result indicates that the bullwhip effect decreases as the n value increases.

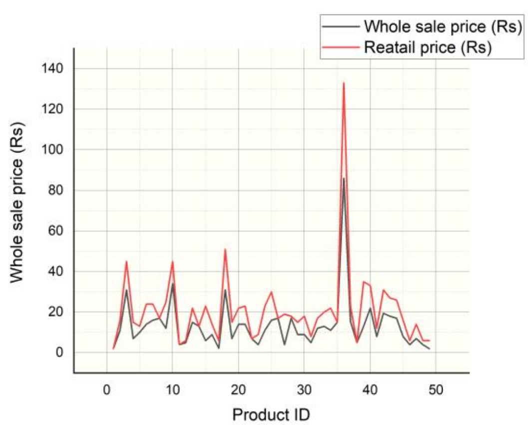

Figure 5 Price analysis of the proposed model

Fig. 5 shows the proposed intelligent information interaction price analysis in the supply chain management (SII-SCM) model. The wholesale price and the retail price of the 50 sample products from the dataset are analyzed and plotted in the above figure. The results show the deviation from the retail and the wholesale price of the goods.

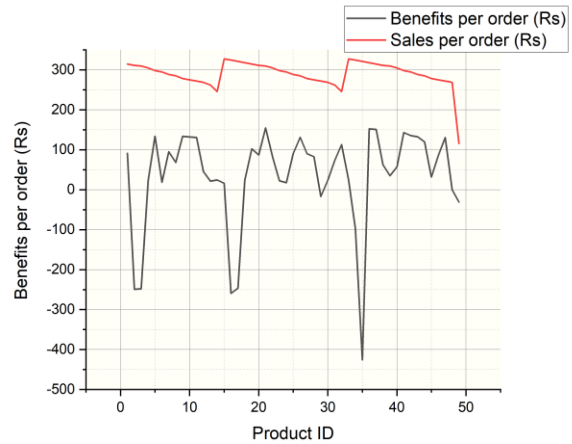

Figure 6 Benefits per order analysis of the proposed model

Fig. 6 shows the benefits per order analysis of the proposed smart information interaction in the supply chain management (SII-SCM) model. The individual sales per order cost the benefits per order cost of 50 sample products are analyzed and plotted in the above figure. The findings indicate that the proposed smart information interaction in the supply chain management (SII-SCM) model has the highest accuracy in predicting the samples.

The proposed smart information interaction in the supply chain management (SII-SCM) model is designed and implemented. The simulation outcomes such as bullwhip effect, sales cost, retailer cost, benefits per order cost are analyzed and plotted. The results indicate that the proposed smart information interaction in the supply chain management (SII-SCM) model has the highest performance.

5 CONCLUSION AND FINDINGS

The proposed smart information interaction in supply chain management (SII-SCM) model is designed and implemented in this research. The supply chain management model is developed via IoT technology and supply chain management, based on studies into the IoT technology distribution network administration and big data analytics. This research posits the phenomena of the bullwhip effect in the production process based on the challenges in operations management. In consideration of the bullwhip effect, the reasons and techniques of repression are examined thoroughly. Based on the previous study, the IT framework is developed with the development of the IoT and intelligent technologies, with knowledge in the production process being integrated.

Synergy to inhibit the bullwhip impact build a simulation environment of the bullwhip impact on the distribution network, and employ the simulation technique to model and analyze key aspects of the model and utilize the findings of graphic simulations to explain the value of the distribution network implementing synergy data realistically. The proposed model exhibits higher performance in all situations.

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