**SRI VENKATESWARA INTERNSHIP PROGRAM FOR RESEARCH IN ACADEMICS (SRI-VIPRA)**

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# Project Report of 2024: SVP-2428

"GREEN SUPPLY CHAIN SYSTEMS UNDER CERTAIN CONDITIONS"

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# SRIVIPRA PROJECT 2024

**Title :** GREEN SUPPLY CHAIN SYSTEMS UNDER CERTAIN CONDITIONS


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**Certificate of Originality**

This is to certify that the aforementioned student from Sri Venkateswara College has participated in the summer project SVP-2428 titled “GREEN SUPPLY CHAIN SYSTEMS UNDER CERTAIN CONDITIONS”. The participant has carried out the research project work under my guidance and supervision from 1st July, 2024 to 30th September 2024. The work carried out is original and carried out in an online/offline/hybrid mode.

Amij Kumar

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## Acknowledgements

I would like to extend my heartfelt thanks to my teacher, Mr Anuj Kumar, for his invaluable guidance and support throughout the preparation of this research review report. His insights and encouragement have been instrumental in shaping this work. Thank you for your dedication and commitment to my learning.

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## INTRODUCTION

A supply chain is a system that connects various businesses and facilities—like suppliers, manufacturers, distributors, and retailers—that work together to get raw materials, turn them into products, and deliver those products to customers. Typically, materials move forward through the chain, while information moves backward. Recently, companies have become more interested in managing their supply chains efficiently because of rising costs for manufacturing and transportation, the global nature of markets, and the need to meet customer demands for a wide range of quickly changing products. Effective supply chain management can reduce production, inventory, and transportation costs and improve customer service at every step. [1]
The rise of the global economy and increased competition have made it crucial for companies to manage their supply chains effectively to quickly introduce new products and services. Many companies now use supply chain management (SCM) to boost their performance and achieve goals like providing better customer value, using resources more efficiently, and increasing profits. According to Porter (1985), understanding customer value and costs is essential for gaining a competitive edge. SCM helps with this by ensuring that goods and services reach customers on time, in the right place, in the right amounts, and at the lowest costs.
Measuring SCM performance involves looking at both internal processes and the expectations of other businesses in the supply chain, from suppliers to customers. Effective coordination among all parties in the supply chain is crucial for successful SCM. Since SCM deals with managing processes across different organizations, it is important to measure performance to manage the supply chain effectively. [2]
With the rapid rise in technologies, the basic core supply chain structures have developed more into complex networks between multiple entities involved from the very initial steps of procuring raw materials to shipment of finished products. These networks involve multiple linkages between organisations which can be in the form of transferring information and materials, even services whose outsourcing could add efficiency because of the specialisation of work associated with these agencies providing the same. This makes the supply chain networks more complex to understand for it involves five key areas: inbound logistics (suppliers), internal logistics (production), outbound logistics (distributors), demand sectors, and shipment assets. The inbound logistics basically deals with the procurement and storage of raw materials. Internal logistics focuses on the movement of supplies and materials within the company through a series of strategies. That includes warehouses, stock management, automation of product and supply, and storage systems. It also incorporates information technology, necessary equipment, and all material handling. Outbound logistics involves the processes of transporting, storing, and delivering products to customers or other businesses. It focuses on the movement of goods from the company to the final user, encompassing the sales and distribution activities that take place after production.
The pharmaceutical industry comprises a complex network of processes, operations, and organizations involved in drug discovery, development, and manufacturing. According to the World Health Organization (WHO), a drug or pharmaceutical preparation is any substance or mixture used for diagnosing, treating, mitigating, or preventing disease, or modifying organic functions in humans or animals. Drug development involves a lengthy process, including discovery, testing, and process development, before moving to manufacturing and distribution. This process is distinct from other industries due to its complexity.
Specifically, balancing future capacity due to uncertain demands because of clinical trials and increased competitor's activity is one of the challenges associated to the sector. The industry is also under obligation to multiple regulations which shrink its margins so, efficient capacity utilization and strategic infrastructure investments become crucial. Additionally, managing the pipeline and testing of new products involves carefully assessing risks and rewards before capacity planning. [3]

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## METHODOLOGY

This study employs a comprehensive literature review to examine the key challenges and strategies in the supply chain management of the pharmaceutical industry. The methodology synthesises relevant academic sources to better understand current supply chain practices. The data for this review was collected from multiple academic databases, including scholars' papers, ScienceDirect, and industry-specific journals and articles. The gathered literature was categorised thematically under major topics such as challenges, challenges and associated long-term sustainability strategies, analysing the issue from the perspectives of both businesses and end consumers, the pillars in the supply chain management of this particular industry along with the major challenges faced and the possible solutions to cope with these challenges. Each theme was further analysed for recurring patterns, innovative solutions, and their impact on supply chain efficiency. Additionally, the study utilises a case of Iran's pharmaceutical industry to extrapolate the findings.

## LITERATURE REVIEW

Pharmaceutical companies face a myriad of complex challenges that encompass a wide array of factors, including political, economic, social, technological, and legal aspects. This industry consists of a network of organizations, processes, and activities focused on the discovery and development of new drugs. Additionally, the pharmaceutical supply chain comprises various companies responsible for the production and distribution of medications, which play a crucial role in influencing customer satisfaction. [4]

The pharmaceutical industry grapples with several significant challenges that impact its complexity and operations. Among these challenges are the diminishing rates of discovery, approval, and commercialization of new chemical entities (NCEs), which has resulted in a decreasing number of blockbuster drugs reaching the market. Additionally, companies are facing intense competition from generic medications, increasing regulatory pressures, and sluggish growth in the United States, which is the industry's largest market. As a consequence, there is a pressing need for pharmaceutical companies to explore and penetrate new markets to sustain their growth and innovation. [3,4]

Challenges in the Pharmaceutical Industry and Strategies for Ensuring Long-Term Sustainability:

A study reveals that numerous pharmaceutical companies need to improve several key areas within their supply chains. These areas include enhancing customer satisfaction, increasing forecasting accuracy, optimizing inventory levels, and reducing overall supply chain costs. It is the intricate nature of pharmaceutical products and processes that amplify the challenges. These complexities can arise from various factors, such as having an extensive portfolio of finished goods, a diverse range of required materials, complicated distribution networks, significant investment costs, lengthy product development timelines, capacity limitations, and strict regulatory constraints. Addressing these issues is essential for pharmaceutical companies to maintain efficiency and competitiveness in the market. [5]

There can be end number of variables that can be utilised to assess the working of a supply chain that may not be viable enough but considering Supply Chain Operations Reference Model (SCOR) lists down the necessary variables. Basically, SCOR is a widely recognized approach to evaluating supply chain performance is the SCOR method, which was established by the Supply Chain Council (SCC). This model serves as a comprehensive framework for measuring supply chain effectiveness across various industries. Developed by the SCC in Pittsburgh, Pennsylvania, the SCOR model categorizes supply chain operations into five distinct processes. These processes are: **Plan**: This involves the planning activities necessary for balancing supply and demand. **Source**: This refers to the procurement processes involved in acquiring the goods and services needed. **Make**: This encompasses the production activities where raw materials are

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transformed into finished products. **Deliver**: This process includes the logistics and distribution activities required to transport products to customers. **Return**: This pertains to the processes involved in handling returns or exchanges of products.

The first three attributes focus on customer-oriented metrics, which assess the effectiveness of a company's operations in relation to customer satisfaction, such as delivery performance. These metrics are crucial for understanding how well a company meets the needs and expectations of its clients. In contrast, the remaining two attributes pertain to internal efficiency indicators that evaluate the company's operational performance from within. For instance, one such measure is the cash-to-cash cycle time, which assesses the duration it takes for a company to convert its investments in inventory back into cash flow. By analysing both customer-centric and internal efficiency metrics, organizations can gain a comprehensive view of their performance and identify areas for improvement. By breaking down supply chain operations into these five key areas, the SCOR model provides a structured way for organizations to assess and improve their supply chain performance, ultimately enhancing overall efficiency and effectiveness. [6]

## CUSTOMER-CENTRIC APPROACH TO SUPPLY CHAINS

Customer-focused supply chains prioritize the needs and experiences of their customers in every aspect of their operations. This means manufacturers not only aim for efficiency but also consider how they showcase their products and services in a changing market. They need to quickly gather and analyse customer demand to make informed decisions about planning, routing, and scheduling within the supply chain. This approach helps increase customer satisfaction, loyalty, and profits while minimizing customer loss.

Transitioning to a customer-centric organization can be challenging and take time. However, doing so enables companies to better focus on their customers and adapt swiftly to their evolving needs, which enhances their flexibility and resilience. Companies must be adaptable because both demand and supply can fluctuate greatly. To achieve this, they need to gain insights into their supply chains, allowing them to respond effectively and continue meeting customer expectations. [7]

Reliability is related to delivery performance when the right product with the right quantity, packaging, and documents is delivered to the right place and customer, at the right time. Responsiveness is the supply chain's ability to react effectively and promptly to customer requests or changes in the market, often referred to as agility.

This agility paradigm is particularly important in the pharmaceutical industry for several reasons. Firstly, the rapid pace of innovation has led to shorter product life cycles. New drugs and treatments are developed quickly, requiring companies to adapt their strategies and processes to stay relevant. This means that pharmaceutical companies must be able to swiftly move from research and development to market introduction, responding to the latest scientific advancements and regulatory requirements. Secondly, the increasing trend of mergers and acquisitions in the industry creates a need for agility. When companies merge, they must integrate operations, cultures, and product lines efficiently. An agile approach enables these companies to streamline processes and adapt quickly to new market dynamics, ensuring they can capitalize on their combined strengths. Additionally, changing customer behaviours—such as patients demanding more personalized treatment options and greater transparency—require pharmaceutical companies to be responsive. Companies need to quickly adapt their marketing strategies and product offerings to meet these evolving expectations, ensuring that they maintain customer satisfaction and loyalty. Finally, competitive actions in the pharmaceutical sector are often swift and aggressive. Companies must keep a close eye on their competitors and be prepared to respond rapidly to new product launches, pricing strategies, or marketing campaigns. An agile supply chain allows firms to pivot quickly, whether that means adjusting production schedules, reallocating resources, or modifying distribution strategies.

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## UNDERSTANDING SUPPLY CHAINS FROM AN INTERNAL PERSPECTIVE OF A BUSINESS

The supply chain includes all activities that convert raw materials into finished products and deliver them to customers. In recent years, globalization has prompted many companies to operate across various countries and continents. This makes it crucial for multinational firms to create a global supply chain network that balances lower costs, enhanced responsiveness, and better customer service. Cost is a vital performance metric in supply chains, directly affecting a company's profits. Emphasizing cost is essential, as it serves as a key indicator of operational efficiency. However, in a fast-changing market, responsiveness is equally important. A responsive supply chain can quickly meet market demands and adapt to customer needs. This agility often comes at the expense of cost efficiency, as more flexible supply chains may have higher operational costs. Customer service level is another important performance measure, indicating the percentage of customer demand fulfilled on time. A low customer service level can lead to lost sales and customers, ultimately impacting profitability. The interplay between these three metrics—cost, responsiveness, and customer service level—is crucial for effective supply chain design and planning. [8]
Cost reduction is a strategy that top companies use to foster more efficient relationships with partners and other businesses. This approach aims to lower product costs, minimise internal lead times and work-in-process inventories, enhance forecast accuracy and consistency, and implement just-in-time delivery strategies for expensive raw materials. As a result of these efforts, indirect costs have been significantly reduced.

## HOW DO PHARMACEUTICAL SUPPLY CHAINS WORK?

In simple terms, the supply chain processes in this industry begin with product development and marketing, which are key strategic functions. The sales and marketing teams work to identify market needs and turn them into customer demands. They do this by communicating with doctors who can prescribe pharmaceutical products to patients. At the same time, the sales and marketing teams collaborate with distribution companies and pharmacies to sell their products. This interaction helps them keep an eye on the market and predict future demand. The marketing department then shares forecast information with the planning department. This helps the planning team schedule various internal processes, such as purchasing materials, producing finished products, and managing distribution to meet market demand. For companies that produce branded and generic pharmaceuticals, there are also upstream suppliers, which can be local or international. These suppliers provide active pharmaceutical ingredients and other necessary materials. As a result, selecting suppliers and managing those relationships are crucial tasks for manufacturing companies. They need to evaluate potential suppliers based on both qualitative and quantitative factors. This includes assessing the quality of materials, delivery performance, the supplier's reputation, their industry standing, bargaining power, production facilities and capacity, technical capabilities, location, order fulfilment lead times, pricing, and total logistics costs. [9]

## CRITICAL SYNTHESIS

### PROBLEMS ASSOCIATED TO PHARMACEUTICAL SUPPLY CHAINS

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1. **Inaccuracy in Forecasting**

Challenges: Accurate forecasting is critical in the pharmaceutical industry due to the fluctuating nature of demand influenced by factors such as market trends, regulatory changes, and seasonal variations. Inaccuracies can arise from:

- Data Limitations: Incomplete or outdated data can lead to poor predictions about market demand. For instance, relying solely on historical sales data without considering current market dynamics can result in inaccuracies.
- Complexity of Demand: The demand for pharmaceutical products can be unpredictable due to factors like new drug launches, changes in treatment protocols, and shifts in patient populations.
- Market Access Variability: Differences in market access across regions can affect how quickly and widely a drug is adopted, making it difficult to forecast sales accurately.

Consequences: These forecasting inaccuracies can lead to either surplus inventory (leading to increased holding costs) or stockouts (resulting in lost sales and dissatisfied customers). Both scenarios can significantly impact a company's financial performance and reputation.

2. **Long Lead Times**

Challenges: Lead time refers to the time taken from placing an order until the product is received. In the pharmaceutical supply chain, long lead times can stem from:

- Regulatory Requirements: Strict regulations governing the production and distribution of pharmaceuticals can lead to extended approval and shipping times.
- Complex Manufacturing Processes: The production of pharmaceuticals often involves intricate processes that can be time-consuming, especially for new or specialized products.
- Global Sourcing: Many pharmaceutical companies source ingredients from various global suppliers, which can complicate logistics and extend lead times due to transportation delays and customs clearance.

Consequences: Long lead times can hinder a company's ability to respond swiftly to changes in demand. This can result in delayed product availability, reduced customer satisfaction, and lost revenue opportunities.

3. **Lack of Optimum Target Inventory**

Challenges: Maintaining the right level of inventory is crucial, but many pharmaceutical companies struggle with this due to:

- Variability in Demand: Fluctuating demand makes it challenging to determine the optimal inventory level, leading to either excess stock or shortages.
- Shelf-Life Considerations: Many pharmaceutical products have limited shelf lives, necessitating careful inventory management to avoid waste while ensuring sufficient supply.
- Regulatory Compliance: Compliance with regulations often requires maintaining specific inventory levels, which can complicate efforts to optimize inventory.

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Consequences: A lack of optimum target inventory can lead to increased costs associated with holding excess stock, including storage and potential write-offs for expired products. Conversely, insufficient inventory can lead to missed sales and lost market share.

4. **High Supply Chain Costs**

Challenges: The pharmaceutical supply chain can be expensive to manage due to various factors:

- Transportation Costs: Shipping pharmaceutical products, especially those that require temperature control, can be costly. The need for specialised packaging and handling adds to these expenses.
- Regulatory Compliance Costs: Complying with regulatory requirements can incur significant costs, including investments in quality control, documentation, and audits.
- Inventory Holding Costs: Maintaining large inventories increase costs related to warehousing, insurance, and potential losses from unsold or expired products.

Consequences: High supply chain costs can erode profit margins, making it challenging for companies to remain competitive. Additionally, inefficient supply chain operations can lead to higher costs overall, further impacting financial performance. [9,10]

## POSSIBLE SOLUTIONS

### A. COLLABORATIONS

Collaboration in the supply chain has been extensively studied, with numerous concepts available. Notable large-scale initiatives, such as Efficient Consumer Response (ECR) in the fast-moving consumer goods sector, as well as Vendor Managed Inventory (VMI) and Collaborative Planning, Forecasting, and Replenishment (CPFR) initiatives, offer a variety of strategies for fostering collaboration among supply chain partners. [11]

Collaborations in the pharmaceutical supply chain play a critical role in ensuring efficiency, innovation, and resilience. The pharmaceutical industry is highly regulated and complex, requiring seamless coordination between various stakeholders, including manufacturers, suppliers, distributors, and healthcare providers. Effective collaboration enhances transparency, allowing for better visibility and traceability across the supply chain, which is essential for ensuring drug safety and quality. One of the key benefits of collaboration is risk mitigation. By working together, companies can share vital information regarding potential disruptions, such as raw material shortages or regulatory changes, and proactively manage these risks. Moreover, partnerships foster innovation by facilitating research and development collaborations, which can accelerate drug discovery and improve supply chain technologies, such as blockchain for tracking and artificial intelligence for demand forecasting. Collaborations also drive cost efficiency. By forming strategic alliances, companies can pool resources, streamline operations, and reduce redundancies. This is particularly important in global pharmaceutical supply chains, where the need for timely delivery of drugs, vaccines, and other medical products across borders is essential. Shared logistics and joint distribution strategies can help lower transportation and storage costs, improving overall supply chain performance. Furthermore, the COVID-19 pandemic highlighted the importance of strong collaborations in rapidly scaling up production and distribution of critical medical supplies and vaccines. Cross-industry partnerships and public-private collaborations were crucial in responding to this global health crisis.

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### B. INVESTMENT IN RESEARCH AND DEVELOPMENT (AND TECHNOLOGY)

R&D in the pharmaceutical supply chain is essential for solving challenges related to drug shortages, production inefficiencies, and regulatory compliance. By driving innovation in drug development, optimizing manufacturing processes, improving sustainability, and integrating advanced technologies like AI, R&D ensures that the supply chain is resilient, efficient, and capable of meeting the growing global demand for medicines.

By investing in new technology, the innovation with respect to products that are complex and have a quite fluctuating demand could be increased which could bring a solution to the problem of longer lead times, adapting to dynamic needs, etc.

Investing in new and advanced technologies within pharmaceutical companies significantly enhances operational flexibility, product quality, and overall customer satisfaction. Advanced technologies allow companies to adapt more easily to changing market demands, ensuring that they can meet customer expectations with greater precision and reliability. Additionally, by shortening production lead times, companies can improve their responsiveness to fluctuations in demand, ensuring that products reach the market more quickly. This enhanced responsiveness, combined with better quality and flexibility, drives an increase in actual sales and expands the company's market share. Studies have shown that the growing uncertainties in the global environment, such as regulatory shifts and supply chain disruptions, underscore the need for faster adoption of innovative technologies. By integrating these technologies, pharmaceutical companies become more agile, able to adapt swiftly to challenges, and maintain continuity in their supply chains. Furthermore, logistics executives consistently rank technology as the most critical factor in enhancing supply chain capabilities, recognizing its role in optimizing efficiency, minimizing risks, and ensuring smooth operations throughout the supply chain. [12]

## CONCLUSION

The pharmaceutical industry faces several significant challenges within its supply chains, including inaccurate forecasting, long lead times, lack of optimal inventory, and high supply chain costs. Each of these issues is interconnected and can severely impact a company's ability to meet market demands effectively. Inaccurate forecasting arises from various factors, such as data limitations, unpredictable demand patterns, and regional market access variability. When companies rely on incomplete or outdated data, they risk making poor predictions, which can lead to either surplus inventory—resulting in increased holding costs—or stockouts, which cause lost sales and dissatisfied customers. Long lead times present another substantial challenge. These delays can be attributed to stringent regulatory requirements, complex manufacturing processes, and the intricacies of global sourcing. As a result, companies may find it difficult to respond swiftly to changes in market demand, leading to delayed product availability and ultimately affecting customer satisfaction and revenue opportunities. Furthermore, many pharmaceutical companies struggle to maintain an optimal level of inventory. Fluctuating demand, shelf life considerations, and compliance with regulatory standards complicate inventory management. Companies may end up with excess stock, incurring costs related to warehousing and potential write-offs for expired products. Conversely, insufficient inventory can lead to missed sales opportunities and a loss of market share, both of which can jeopardize a company's competitive standing. High supply chain costs are another pressing concern. The expenses associated with transportation, regulatory compliance, and inventory holding can erode profit margins, making it increasingly difficult for companies to remain competitive. Inefficiencies in supply chain operations can exacerbate these costs, leading to further financial strain. To tackle these multifaceted challenges, collaboration among supply chain partners is essential. By fostering strong partnerships, companies can improve efficiency, enhance transparency, and share vital information

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regarding potential disruptions, such as raw material shortages or regulatory changes. Effective collaboration not only mitigates risks but also promotes innovation, which is crucial for adapting to the rapidly evolving pharmaceutical landscape. Strategic alliances can lead to shared logistics, joint distribution strategies, and overall cost efficiencies, enabling companies to respond more effectively to global health needs. Investment in research and development (R&D) and advanced technologies is equally important. R&D initiatives drive innovation in drug development and optimize manufacturing processes, while new technologies enhance operational flexibility, product quality, and customer satisfaction. By integrating technologies like artificial intelligence for demand forecasting and blockchain for supply chain tracking, companies can significantly shorten production lead times and improve their responsiveness to fluctuating market demands. This not only boosts sales potential but also expands a company's market share.

Therefore, addressing the challenges in pharmaceutical supply chains requires a comprehensive approach that combines collaboration and technological investment. By embracing these strategies, companies can enhance their resilience and efficiency, ensuring they are well-positioned to navigate the complexities of the industry. Ultimately, these efforts will lead to better service for healthcare providers and patients alike, reinforcing the pharmaceutical sector's crucial role in global health.

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