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Identify Opportunities of Sustainable Supply Chain Practices in Indian Pharmaceutical

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Abstract: ***The pharmaceutical supply chain management system varies between developed and developing countries in terms of structure, organization, financing, and the characteristics of successful supply chains. A well-established supply chain management (SCM) system within the pharmaceutical industry can significantly enhance a company's performance by maximizing resource efficiency and meeting customer demands. Clear sustainability indicators are crucial for success, as a weak SCM system can lead to significant organizational challenges. This study aims to identify the best practices and strategies in SCM that can help reduce costs.***

Keywords: sustainable supply chain, Issues, India Pharma industry, opportunities, practices, carbon emissions

1. Introduction

A successful SCM strategy in Pharma industry can reduce costs and increase sales. By following effective SCM practices, leading companies can refine their supply chains, applying specific strategies for supply and demand planning, forecasting, sourcing, procurement, and execution. Every part of the supply chain must work together to add value to the products being transported. If any part of the supply chain fails, it negatively impacts the overall effectiveness of the entire system.

Efficient supply chain processes are key to lowering costs, maintaining product quality, and ensuring that products are available when needed. To stay competitive, industries must prioritize effective SCM practices. Many healthcare companies in India spend significant amounts on SCM-related challenges due to a lack of knowledge about the best strategies and practices to reduce high costs. By adopting these best practices, companies can enhance their services and create more value through SCM.

Improved services, in turn, encourage ongoing investments to strengthen the SCM system through cost-saving strategies, planning for uncertainties, and minimizing risks. Additionally, adopting best practices helps leaders implement more accurate forecasting models, expand into new markets, and allocate the necessary capital to modernize and improve the entire SCM system.

2. Literature Review

The pharmaceutical industry involves processes and organizations focused on the development, design, and production of drugs. describe the pharmaceutical supply chain as a system where drugs are made, transported, and consumed. Companies must manage their supply chain activities to remain competitive. notes that managing supply chains is challenging due to factors like product variety, short the stages of a product's life, hiring outside companies, and improvements in technology advances, And the worldwide integration of businesses. It also Entails significant expenses and lengthy clinical trials., and challenges like generic competition and unpredictable demand. The innovation has slowed because drug development takes 15-30 years. The WHO (2009) reports that drug prices in developing countries can be up to 650% higher than international standards, with limited access to affordable medicines. Issues such as poor funding, inaccurate forecasting, lack of stock incentives, inefficient distribution, and theft contribute to medicine shortages (WHO, 2009). identifies factors like pricing, demand uncertainty, government regulations, supplier power, and global economic conditions as key challenges.

To address these issues, companies must find new ways to be competitive and innovate continuously. The effect of digital transformation on business strategies and competitive edge. Perspectives on Technology and Society. points out risks in drug recovery, including timing, quality, returns, and costs in managing reverse supply chains suggests. The primary challenges will include product creation, design, optimizing the supply chain, and assessing the global life cycle. Pahlevan, (2021) stresses need for The pharmaceutical industry can draw lessons from others. sectors toward achieve Operational efficiency.

Throughout recent years, Industry technologies have remained introduced Within the pharmaceutical sector, with stringent regulations imposed by various stakeholders to ensure safety and protect public health. Successes and challenges of health systems governance towards universal health coverage and global health security: a narrative review and synthesis of the literature. Health research policy and systems despite these technological advancements, most pharmaceutical companies still rely on traditional batch-based production methods Instead of continuous production. The absence regarding reliable online Standards monitoring and flexible manufacturing processes has created challenges in maintaining a consistent drug supply, sometimes resulting in shortages during emergencies. Ensuring the ability to obtain medicines is a crucial Obligations of pharmaceutical

companies, as the availability and affordability of these products directly impact patient health.

Carbon Emissions within the Pharmaceutical industry has not been a major focus when it comes to carbon emissions, especially compared to industries like energy, mining, and automotive. However, as the global need for medicines grows due to increasing diseases, the industry's carbon emissions problem is also getting worse. While this is a big issue, there are clear opportunities to reduce emissions across the entire pharmaceutical sector.

Besides pharmaceutical manufacturers other participants Those involved in the pharmaceutical supply chain, such as distributors, healthcare providers, and pharmacies, must upgrade their services and technology to meet the demands of the pharmaceutical sector. Across entire pharmaceutical supply chain presents additional challenges, including the need for more human involvement, sustainability concerns, safety issues, and the potential for serious errors. Traditional Analysis of the pharmaceutical supply chain has primarily focused on economic factors like profitability, cost, and lead time but it is essential to develop a smart, sustainable, and comprehensive approach that aligns with the future direction of the industry.

Examples of Indian Pharma Companies Promoting Sustainability:-

- **Using Renewable Energy**: Cipla is taking steps to be more sustainable by buying a 32.49% stake in AMP Energy Green Eleven, a company that develops solar power plants to help support Cipla's operations.
- **Improving Operational Efficiency**: Piramal Pharma Solutions has made significant progress in climate action by improving its processes and energy efficiency. In FY2023, the company reduced its emission intensity by 15% compared to the previous year.
- **Adopting Smart Manufacturing**: Leading companies like Dr. Reddy's and Cipla are investing in advanced manufacturing technologies. Dr. Reddy's in Hyderabad, for example, is using six of the eight Technologies within the industry advanced information analysis, digital models, Machine-driven processes, and internet of things (IIoT).
- **Zero Liquid Discharge (ZLD):** Glenmark has adopted a Zero Liquid Discharge approach at its plants in Aurangabad and Sikkim. This process recycles water from wastewater for use in boilers, cooling towers, and gardening, helping meet 38% of the plant's annual freshwater needs.

Opportunities For Indian Pharma Companies to Drive Sustainability:

- **Power Purchase Agreements and More Renewable Energy**: Indian pharmaceutical companies can boost sustainability by signing agreements for renewable energy and using more green energy.
- **Working with Green Suppliers and Promoting Eco-Friendly Transportation**: Companies can make their supply chains more sustainable by working with suppliers that focus on the environment and adopting green transportation options.
- **Zero Waste and Better Water Management**: Companies can improve sustainability by implementing zero-waste strategies and using water responsibly across the supply chain.
- **Eco-Friendly R&D**: By designing research and development activities with sustainability in mind, pharmaceutical companies can create more eco-friendly products and processes.

3. Research Question

The central research question of this study was: What are the issues and opportunities do Indian pharmaceutical supply chain practices encounter to promote sustainability?

Objective:

The objective of the study was:-

1) To provide thoughtful and meaningful information on various SCP Issues and opportunities
2) To study the opportunities for Indian pharma companies in global markets
3) To understand the SWOT analysis of Indian pharma industry

4. Research Methodology

A literature review aims to integrate previous and present research discoveries in a particular field, offering thorough along with innovative insights while recognizing research gaps along with emerging trends for future exploration. For this research, a literature review grounded in content analysis was performed. following the steps outlined further down. We chose Bibliographic databases, which encompass. Science Direct, Scopus, EBSCO, Emerald, and Taylor & Francis, for Our exploration. Key phrases were divided into primary and secondary keyword categories based on articles that outlined frameworks related to pharmaceutical Industry, sustainable supply chain, supply chain, and pharmaceutical supply chain practice. The research design includes secondary data sources from various journals, books, newsletters, websites, observations the principal search terms used initially correspond to various stages of the pharmaceutical supply chain, while the secondary keywords focus on sustainability and pharmaceutical Industry dimensions. The specific keyword strings employed in the search are detailed in following table. The search was conducted by combining primary and secondary keyword strings and matching them with terms found in the titles, abstracts, or phrases from earlier studies. All research papers considered were in English, authored Written by researcher and published in available scholarly journals with peer review through digital repositories. The initial search yielded a broad spectrum Involving articles about quality and supply chain with a particular emphasis on operational performance. To refine the selection and align with the scope of the study the subsequent inclusion criteria were used:

1) Articles featured in reviewed academic journals or presented at academic conferences; 2015-25 and
2) Articles that address research questions pertaining to the issues and opportunities associated with sustainable supply chain practices with respect to Indian pharmaceutical sectors.

5. Discussion

A recent study showed that 91% of 75 publicly traded pharmaceutical companies did not have climate goals that align with a 1.5°C pathway by 2022. Additionally, only 4% were on track to meet the Paris climate targets for 2030. On a positive note, some companies have made progress, with 46% of the industry (by revenue) joining the United Nations' Race to Zero Campaign, aiming for net-zero emissions by 2050. To cut down on emissions, pharmaceutical companies can focus on switching to renewable energy, replacing fossil fuels, and reducing emissions from their supply chains (Scope 3 emissions). Working with global energy companies could speed up this process. Indian pharmaceutical companies can also learn from the actions of global companies in sectors like automotive and mining.

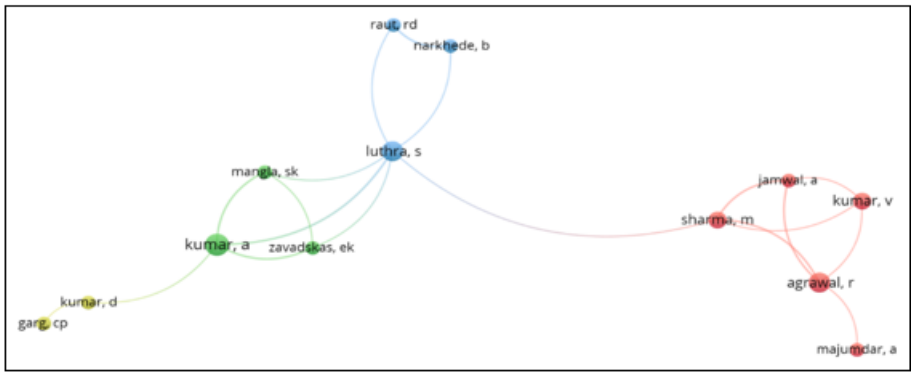
While some global pharmaceutical companies are making good progress, many are still in the early stages of planning. One of the challenges is that the pharmaceutical industry lacks low-carbon products and services compared to other industries. Research has shown that some obstacles to decarbonization include high costs, unmet expectations, and a Insufficient knowledge or comprehension of the available solutions

6. Implication

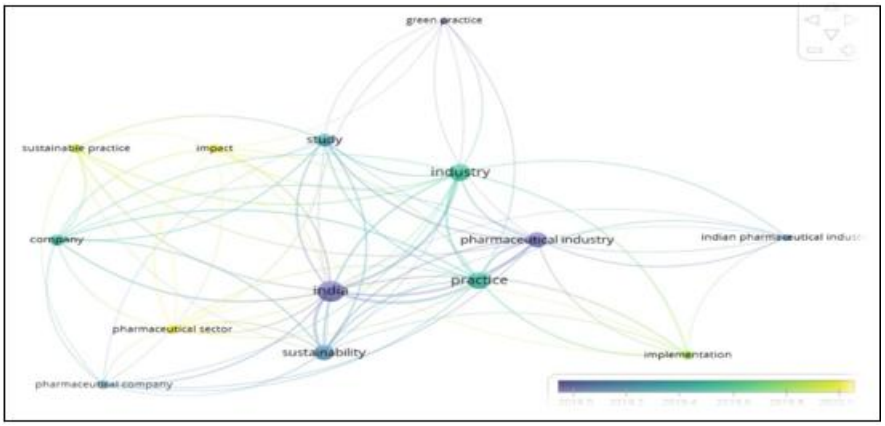
Pharmaceutical companies contribute to carbon emissions in many ways, such as through their supply chains, manufacturing processes, and on-site activities. In some cases, their emissions are as high as or even higher than those from the automotive industry. These emissions come from employee commuting, business travel, energy use in company facilities, waste, and making medicines. Additionally, because pharmaceutical supply chains often span different countries, transportation over long distances creates more emissions.

Given the many sources of emissions in the pharmaceutical industry, there are several areas where companies can reduce their carbon footprint. By targeting these areas and adopting sustainable practices, the pharmaceutical industry can make a big difference in fighting climate change

7. Results



Interpretation: The vosviewer author cooccurance shows the number, strength and links of cocitations between authors who are influential in this field of study



Key Issues in Pharmaceuticals Supply Chain Practices:

Issues	Considerations
Inventory Control	• How can inventory be managed optimally? • What factors contribute to inventory fluctuations, and what strategies can stabilize them?
Outsourcing and procurement strategies	• What are the key supply chain capabilities, and which are less critical? • How does product design affect outsourcing choices?
Supply contracts	• How volume discounts and revenue sharing affect business success. • Best pricing strategies to keep orders and shipments consistent.
Green logistics	• Introduce green technologies step by step to manage costs over time. • Study costs and benefits carefully to show long-term savings and environmental benefits.
Regulatory Requirements	• Continuously monitor regional and international regulatory frameworks. • Formulate and implement internal policies aligned with global sustainability benchmarks
Digitalization & Automation	• Implement advanced green computing methodologies to mitigate electronic waste generation. • Integrate renewable energy sources to ensure environmentally sustainable digital infrastructure.
Block chain & transparency	• Utilize blockchain to ensure secure and tamper-proof tracking of medicines from production to the customer. • Deploy smart contracts to automatically validate and approve each transaction within the supply chain

The pharmaceutical supply chain is complex and faces diverse challenges that may affect the timely along with efficient delivery of medications. Key issues include:

a) **Regulatory Compliance:** Pharmaceutical companies must navigate a wide array of local and international guidelines, including Good Manufacturing Practices (GMP), Good Distribution Practices (GDP), and Drug Enforcement Administration (DEA) standards. Failing to comply with these can result in delays, penalties, or loss of access into markets.

b) **Temperature Control and Storage**: Certain pharmaceutical products, like vaccines and biologics, require precise temperature control throughout the supply chain. Maintaining these conditions is challenging and costly, and any deviation from the required temperature can compromise the product's safety and effectiveness.

c) **Supply Chain Transparency**: Limited visibility in the supply chain makes it difficult to track products in real time, which can lead to issues like stockouts, inventory imbalances, or delays. Using advanced tracking technologies, such as blockchain, can improve transparency.

d) **Global Sourcing and Logistics:** Relying on international suppliers for raw materials and finished products creates vulnerabilities, such as dependence on specific regions or suppliers. Events like geopolitical instability, trade restrictions, or natural disasters can disrupt the movement of goods.

e) **Raw Material Shortages**: The pharmaceutical industry depends on a few key suppliers for raw materials. Any delays or shortages in these materials can disrupt production and cause medication shortages.

f) **Supply Chain Complexity:** The pharmaceutical supply chain is multi-layered, involving manufacturers, wholesalers, distributors, and retailers. This complexity can make it difficult to ensure timely deliveries and streamline operations, especially in remote or developing regions.

g) **Sustainability and Environmental Impact:** As customers and governments Seek greater sustainability in practices, pharmaceutical organizations must address issues like packaging waste, carbon emissions from logistics, and the responsible sourcing of materials.

8. Issues in Indian Pharmaceutical Supply Chains

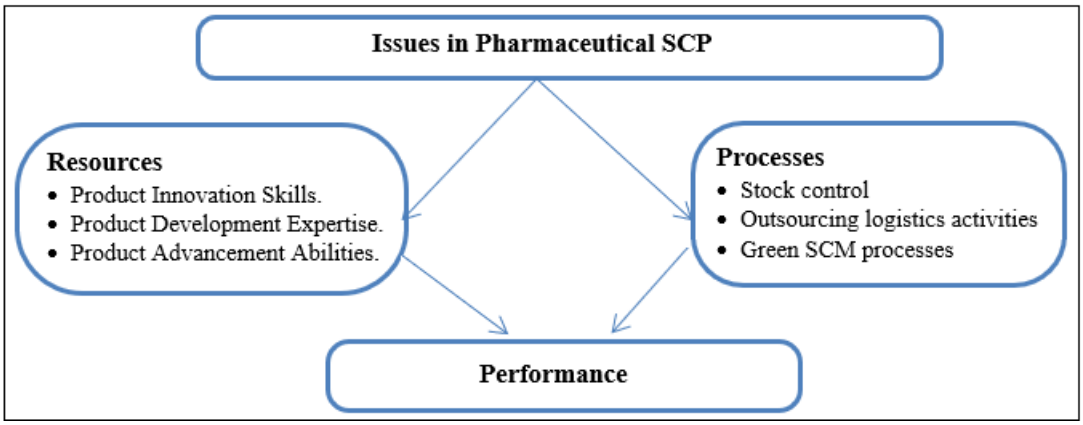
Pharmaceutical companies globally are facing challenges such as maintaining compliance with international quality standards, adapting to healthcare reforms, managing patent expirations, and meeting increasing service demands. These companies must focus on reducing costs, improving flexibility, and speeding up product launches. Effective strategic planning is essential for thriving in the rapidly market. Implementing effective decision-making strategies and systems is crucial for managing new product portfolios. These tools aid in evaluating potential risks and aligning decisions with organizational objectives, such as maximizing profitability or reducing time to market. By adopting structured portfolio management practices, pharmaceutical companies can prioritize projects, allocate resources efficiently, and navigate the complexities of product development within a highly regulated environment.

Health Action International and the WHO (2009) highlighted challenges such as insufficient funding, lack of incentives to maintain stock, inaccurate forecasting, poor distribution systems, and drug theft for resale, which have limited the availability of affordable generic drugs for primary healthcare. It has been suggested that stricter regulations be implemented to control new drug prices and encourage the use of generic alternatives.

The success of a strategy depends on several key factors:

- **Resources:** These include assets such as expertise in product and process development, capacity planning, network infrastructure, and e-business capabilities.
- **Processes**: These involve value-adding activities like inventory management, outsourcing logistics, and implementing environmentally friendly supply chain practices.

Both resources and processes are essential for developing and implementing effective strategies.



9. Framework Issues in Pharmaceutical SCP

Resources of Pharmaceutical Supply Chain

Resources are the assets that an organization has using these resources effectively to build different skills is key to keeping the supply chain competitive. The next section explains the different types of resources within an organization.

Product Advancement Abilities

Product Development Expertise. is influenced by multiple factors, including heightened competition, rapid technological advancements, escalating costs, and reduced product life emphasized that the diminishing effective patent life, coupled with the inevitable introduction of generic drugs into the market, poses a big risk to making a profit for newly developed products. Consequently, it is imperative firms that strategically plan capacity investments that ensure availability of adequate manufacturing materials for production of the forthcoming products. Achieving a sustainable competitive advantage necessitates the development of competencies that deliver lasting benefits that are difficult to diminish easily duplicated by competitors. Additional challenges, such as the rising cost of pharmaceuticals and the increasing demand for new product development, are shaping the operational dynamics of pharmaceutical supply chains.

New process development capability

Efficient process development is crucial for enhancing performance and maximizing the productivity of pharmaceutical products. By implementing optimized processes, manufacturers can reduce production costs and improve the quality of medicines. Research in any field typically follows a cyclical approach, starting with exploratory studies like interviews or surveys, followed by case studies and theoretical frameworks, highlighting the importance of process development. Furthermore, effective process planning and scheduling play a key role in new product development, driving improvements in product discovery, process optimization, and plant design in the pharmaceutical industry.

Capacity planning

Analyzing pharmaceutical industry risks under uncertainty for performance improvement: an Indian scenario examined the decision-making process in creating a pharmaceutical company's product portfolio amid uncertainty Continuous-time planning and scheduling of internal closed-loop systems in multi-stage supply chain networks with recycling trade-offs. A follow-up clinical trial evaluating the consumer-decides service delivery model. American journal of audiology, 28 (1), 69-84) presented a stochastic single-site capacity planning model that accounts for multiple clinical trial outcomes for each product candidate. The capacity planning decisions face considerable risks, such as product failures during trials, product withdrawals due to side effects, uncertainties around final dosages and treatment plans, and competition from similar products. The demand for medicines is unpredictable and fluctuates, making capacity planning and its effective use a significant challenge for the pharmaceutical sector. Researchers need to develop frameworks to ensure efficient capacity planning in uncertain and ever-changing environments.

E-business capabilities

Recent advancements in information systems and technology have significantly improved the organization and connection of supply chains challenges in implementing healthcare supply chain e-business practices face issues such as inconsistent data, low data quality, and the global presence of suppliers. Also pointed out that e-business technologies can help streamline key important supply chain tasks like buying supplies, delivering goods, and managing inventory are crucial in healthcare. However, many hospitals still use old systems, focusing more on patient care than updating technology for online business processes. Using e-business tools like e-procurement can help cut costs by combining orders and making operations more efficient expanding the supplier network, and enabling procurement analysis across various departments. In countries like India, retailers are hesitant to embrace online retailing or e-business. As a result, there is a need for research to develop effective strategies that encourage the adoption of IT in pharmaceutical industry, especially in developing nations.

Outsourcing logistics activities

Outsourcing involves transferring specific internal tasks and decision-making responsibilities to external providers. In the current competitive market, it has become a widely adopted practice., pharmaceutical companies are increasingly outsourcing to help them grow globally and improve production and sourcing by working with specialized suppliers called third-party logistics (3PLs). While 3PLs used to focus only on warehousing and transportation, their role has now expanded to include many other services. Outsourcing helps pharmaceutical companies save money,

focus on what they do best, and speed up innovation in the industry.

However, outsourcing also comes with risks, like losing control and flexibility, and the possibility of sharing important information with suppliers who might later become competitors. Several factors influence outsourcing decisions, and different outcomes come from these strategies. The main reasons companies outsource include focusing more on their core business, accessing high-quality capabilities, speeding up improvements, sharing risks, and freeing up resources for other activities. While outsourcing in the pharmaceutical industry wasn't well-documented in the past, it is growing quickly now. a model to help companies decide whether to develop the product in-house or outsource its manufacturing to a third-party contractor. A detailed review of outsourcing research has led to a framework that sorts studies based on whether they focus on benefits, risks, reasons, or factors of outsourcing.

Green Supply Chain Practice

Environmental challenges such as climate change, greenhouse gas emissions, & toxic materials. and the depletion of resources have become major global concerns over the past few decades. In response, policymakers and activists have increasingly emphasized the importance of green operations, leading many organizations worldwide to adopt environmentally sustainable practices. Green Supply Chain Management (GSCM) emerged as a concept in the late 1990s as a way to address these environmental challenges. Initially, GSCM focused on reactive measures to manage environmental impact, but it has since evolved to include more proactive strategies, such as recycling, reclamation, reverse logistics (RL), along with innovative strategies. Furthermore, the disposal of expired or unwanted medications presents both a costly and environmentally harmful issue.

Green Supply Chain Opportunities for the Indian Pharma Sector:

As pharmaceutical companies transition towards more sustainable practices, it is crucial to address the entire value chain, beginning with the raw materials used in the synthesis of active pharmaceutical ingredients (APIs), many of which are derived from petroleum-based fossil fuels. The manufacturing process of finished pharmaceutical products is another significant source of carbon emissions. To mitigate this impact, several companies are transitioning from traditional batch manufacturing to continuous manufacturing processes, which are more energy-efficient. For example, GlaxoSmithKline (GSK) achieved a reduction in greenhouse gas emissions by modifying the propellants used in its asthma inhalers, which had previously represented a considerable portion of the company's emissions.

Given the vast global network of pharmaceutical manufacturing facilities, these plants are substantial consumers related to energy. Consequently, adoption Using renewable energy solutions and creating energy systems like solar power has become an important way to reduce the sector's carbon footprint.

Furthermore to manufacturing, logistics Linked to the transportation and distribution of pharmaceutical products also present considerable environmental challenges. Cold-chain logistics, which are necessary for the transportation of temperature-sensitive products such as vaccines, rely on refrigerated transport vehicles. These vehicles are energy-intensive, consuming significant amounts of power to maintain the required temperature conditions for these sensitive products

SWOT Analysis Of Indian Pharma Industry:-

The Indian pharmaceutical industry has experienced significant growth over the past decade made great progress in building strong infrastructure, developing new products, expanding its operations, improving its knowledge, and creating valuable intellectual property. As a knowledge-driven sector, it has been a key contributor to the Indian economy by creating a large number of jobs and helping the country grow. The global presence of the pharmaceutical industry has also helped improve India's image worldwide, along with the IT sector. Additionally, it has created billionaires and built global companies, motivating young people to start careers in pharmaceuticals.

Various internal and external factors may shape the future of the pharmaceutical industry. The Indian pharmaceutical sector has emerged as a success story, both in India and other developing nations, becoming the world's largest producer of medicines in just 30 years. The key drivers of this success are outlined in the SWOT analysis.

SWOT assessment of the Indian pharmaceutical industry.	
Strengths	Weakness
• Expanding population of treatment-naive patients.	• Minimal investment in innovative research and development.
• Affordable innovation, manufacturing, and operational costs.	• Inadequate infrastructure across the board is a significant challenge.
• Increased GDP growth resulting in higher disposable income for the public, along with a positive view on healthcare expenditure.	• Limited access to health insurance coverage
• Data processing procedures for clinical trials.	• Tight pricing regulations that impact the profitability of pharmaceutical companies.
• Adequate safeguarding concerning intellectual property rights. •	• Most companies find it difficult to compete with multinational corporations in global new drug discovery and molecular research due to limited resources

However, despite its growth and success, the Indian pharmaceutical industry still faces several challenges globally, such as gaps in innovation, quality control problems, supply chain issues, marketing difficulties, and adapting to new digital technologies. The author has done thorough research, reviewing academic and business articles and talking to pharmaceutical experts, to better understand the challenges facing Indian pharmaceutical companies.

Opportunities	Threats
• Growing global demand for generic drugs	• Wage inflation
• Government efforts to broaden the coverage of the Drugs Price Control Order (DPCO)	• Influx of foreign companies offering technology-driven products in the Indian market
• Public-private collaborations focused on enhancing infrastructure	• Challenges in conducting clinical trials due to system inefficiencies
• Growth drivers from the liberalization Regarding the health insurance field and the rise in per capita income • Strong export potential as $40 billion worth of drugs in the United States and $25 billion in Europe are set to lose patent protection	• Impractical expense regulations and profitability challenges imposed by the Drug Price Control Order (DPCO) • The Drug Price Control Order imposes unrealistic price limits, affecting product pricing and profitability.

Discussion

A recent study showed that 91% of 75 publicly traded pharmaceutical companies did not have climate goals that align with a 1.5°C pathway by 2022. Additionally, only 4% were on track to meet the Paris climate targets for 2030. On a positive note, some companies have made progress, with 46% of the industry (by revenue) joining the United Nations' Race to Zero Campaign, aiming for net-zero emissions by 2050. To cut down on emissions, pharmaceutical companies can focus on switching to renewable energy, replacing fossil fuels, and reducing emissions from their supply chains (Scope 3 emissions). Working with global energy companies could speed up this process. Indian pharmaceutical companies can also learn from the actions of global companies in sectors like automotive and mining.

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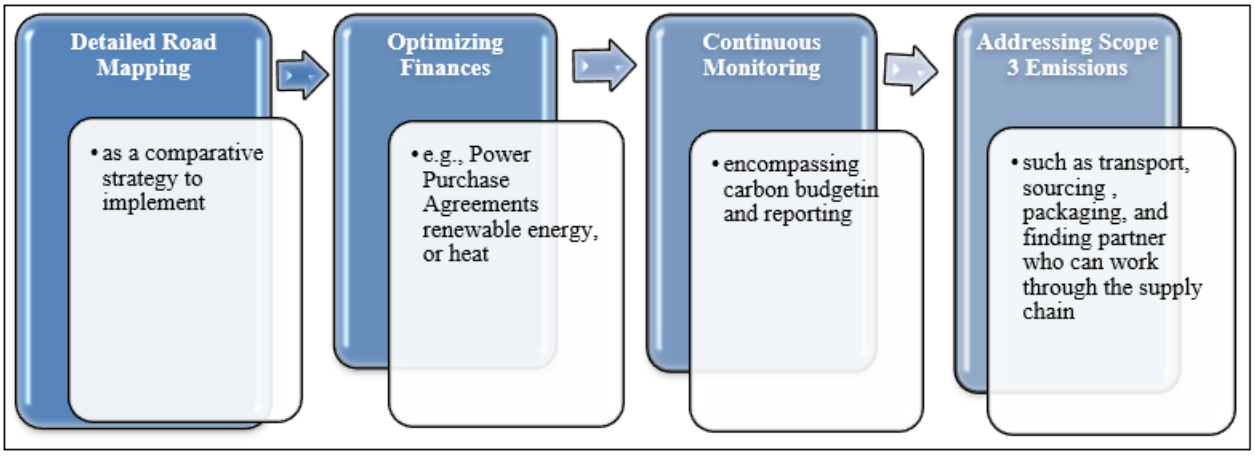
Implication:

Pharmaceutical companies contribute to carbon emissions in many ways, such as through their supply chains, manufacturing processes, and on-site activities. In some cases, their emissions are as high as or even higher than those from the automotive industry. These emissions come from employee commuting, business travel, energy use in company facilities, waste, and making medicines. Additionally, because pharmaceutical supply chains often span different countries, transportation over long distances creates more emissions.

Given the many sources of emissions in the pharmaceutical industry, there are several areas where companies can reduce their carbon footprint. By targeting these areas and adopting sustainable practices, the pharmaceutical industry can make a big difference in fighting climate change



Carbon Emissions within the Pharmaceutical Industry

10. Conclusion

Achieving a sustainable pharmaceutical supply chain presents both challenges and opportunities. Key obstacles include strict regulations, environmental impact, limited transparency, and ethical concerns in sourcing raw materials. Additionally, high costs and technological limitations can slow progress toward sustainability. However, there are several ways to enhance sustainability. Companies can adopt greener manufacturing techniques, implement circular economy principles, and leverage technologies like blockchain and artificial intelligence to improve supply chain efficiency and transparency. Strong collaboration among governments, pharmaceutical companies, suppliers, and consumers is essential to driving meaningful change across the industry. By prioritizing sustainability,

pharmaceutical companies can minimize their environmental footprint, enhance efficiency, and maintain profitability while contributing to public health.

The study emphasizes the need for clear sustainability indicators, which are essential for ensuring long-term success among mitigating challenges that arise from weak supply chain systems. Additionally, the research highlights several effective practices and strategies, such as enhancing inventory management, incorporating advanced technologies, and improving collaboration with stakeholders, all of which can help pharmaceutical companies reduce costs. By implementing these approaches, companies can boost operational capabilities and strengthen their challenging edge in the worldwide market. In conclusion, the study advocates for the ongoing refinement and customization of supply chain management practices, particularly in developing countries, to promote sustainability and cost-effectiveness within the pharmaceutical industry.

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