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Building Supply Chain Resilience in the Indian Pharmaceutical Sector: API Import Reliance, Upstream Vulnerabilities, and Strategic Pathways

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ABSTRACT
Purpose In the pharma sector, API stands for "Active Pharmaceutical Ingredients," which are the most important compounds used as raw materials for making finished medicine products. The core purpose of the study is to respond to growing concerns about India's heavy reliance on imported APIs, which exposed critical vulnerabilities during COVID-19 and trade disputes. Aligned with national health security and industrial competitiveness imperatives, the paper aims to evaluate how API import dependence affects domestic manufacturing resilience and identify strategic measures to reduce systemic risk.
Design/methodology/approach The study employs an exploratory, mixed-methods approach using secondary data to examine how disruptions to the upstream supply chain affect domestic manufacturing. It analyzes trade, production, policy, industry reports, and disruption cases, including pandemic supply interruptions and the Ethambutol Hydrochloride anti-dumping episode. The study explains why these issues arose, details government steps to reduce import reliance and boost API manufacturing, and evaluates strategies to balance domestic production with diversified sourcing to strengthen supply chain resilience.
Findings The results of the study show that concentrated import sourcing causes recurring supply shocks, price volatility, and gradually erodes domestic API capacity, demonstrating that short-term import savings often lead to long-term strategic deficits. The analysis suggests three resilience pathways: building domestic API capacity, risk-based supplier diversification (including nearshoring), and enabling policies like financial incentives and stockpiles. The study guides policymakers and industry to prioritize feasible, impactful interventions with a phased, demand-driven onshoring approach that maintains competitiveness and strengthens supply security.
Originality/value The study's contributions include an integrated resilience framework linking import concentration to manufacturing decline and a policy roadmap tailored to India's pharmaceutical sector. This evidence advocates balanced strategies that combine affordability and supply resilience to strengthen national health security and industrial competitiveness.
Keywords: Active Pharmaceutical Ingredients, API import dependence, pharmaceutical supply chain, supply chain resilience, anti-dumping duties, COVID-19, drug

1. INTRODUCTION

In the Pharma manufacturing sector, India stands out in the global market, supplying low-cost generic drugs to millions of people both within and outside the country. However, Indian pharmaceutical companies procure almost 70% of the active pharmaceutical ingredients (APIs) for their medicines from other countries. The COVID-19 outbreak is one of the historical events that has far-reaching implications for the global economy. However, one of the most significant repercussions is observed in supply chains. Several sectors have been affected by the global supply chain disruptions; among all, the pharmaceutical industry emerged as particularly vulnerable due to its heavy dependence on imported Active Pharmaceutical Ingredients (APIs).

The COVID-19 pandemic underscored the fragility of global supply chains and raised significant concerns regarding India's reliance on other countries' sources for critical pharmaceutical inputs (Joseph and Kumar, 2026). In the context of global health services, the outbreak marked a significant and unprecedented crisis. On one side, in today's rapidly growing economic environment, supply chains have transitioned from simple, traditional ones to highly intertwined, circular, global supply chains (Ivanov & Dolgui, 2020; Nacchiero, 2025). But on the other side, incidents like the COVID-19 outbreak emerged as an unprecedented global health crisis; however, to some extent, ramifications have been made, but not sufficient in the supply chain, and it is still going on.

The COVID-19 pandemic exposed the risks associated with API sourcing in the integration of economic, healthcare, and strategic risks. In response, the Government of India constituted a high-level committee under the chairmanship of Mr. V. M. Katoch, then Secretary of the Department of Health Research, to

develop a long-term strategy for strengthening domestic manufacturing of pharmaceutical ingredients.

As the practitioners understand from the experience of the COVID-19 pandemic, the supply chain of global pharmaceuticals is likely to be interrupted, and the impact on global access to medicine, particularly in low-and middle-income countries (LMICs), will have dramatic consequences. Now, issues like these have gained renewed policy attention, prompting initiatives to enhance domestic production capacity and improve supply chain resilience.

Improving supply chain resilience is becoming critical day by day due to the complexities in various stages. Every stage in the supply chain is being executed diversely across the globe to attain a competitive advantage (World Health Organisation, 2021; Szczepanski, 2021). Even

the commonly used drug 'Paracetamol' gets its raw materials- API (Active Pharmaceutical Ingredients) from China; it is formulated in southern India, packaged in northern India, transported to the USA and Europe, and finally consumed globally throughout the world (U.S. Food and Drug Administration, 2019; World Health Organisation, 2021).

Increasing geopolitical tensions, trade conflicts, and unexpected health crises have led to the disintegration and crashing of these supply webs (Ivanov & Dolgui, 2020). For developing economies such as India, these disruptions have underlined the urgency of reassessing critical pain points, particularly within sensitive industries like pharmaceuticals (Gereffi, 2020). The pharmaceutical supply chain, which is deeply integrated across borders due to heavy import of API, is especially vulnerable to external disruptions (World Health Organisation, 2021; U.S. Food and Drug Administration, 2019). India occupies a leading position in the global pharmaceutical landscape and is called as the "pharmacy of the world" (Chaudhuri, 2021). The country plays a crucial role in the production and trade of affordable generic medicines to developed and developing markets alike (World Health Organisation, 2021). The phenomenal progress by the Indian pharma industry over the last three decades draws the attention of practitioners and policymakers having a strong belief that there are distinct competitive advantages and it should be enhanced by suitable initiatives and policy measures. Focusing on firm-specific actions concerning export, innovation, strategic alliances, and investment can bring Resilient Pharmaceutical Supply Chains. However, even though India is manufacturing and exporting pharma products to the world, it remains heavily dependent on API imports for its formulation processes to be smooth (U.S. Food and Drug Administration, 2019; Joseph & Kumar, 2021). This dependence implies a significant structural shortcoming that costs the nation, especially at times of geopolitical tensions.

By the experience and learning lessons from the COVID-19-induced disruption in supplies, countries like India started adopting measures that focus on promoting resilience in supply chains and reducing dependence on limited sourcing countries.

According to early literature, India has always been self-reliant and independent when it comes to medicine. Its capacity for manufacturing APIs for generic bulk medicines domestically facilitated maintaining import percentages as low as ten per cent in the 1980s (Joseph & Kumar, 2021). Over the past two decades, India has gradually shifted to becoming significantly dependent on API imports, particularly from China, as shown in Figure 2 under the literature review section.

This shift was largely driven by infrastructure, technology, and continued focus on research and development (Joseph & Kumar, 2021). Chinese manufacturers benefited from economies of scale, lower energy costs, state-supported industrial clusters, integrated chemical parks, and relatively streamlined environmental compliance systems (United States International Trade Commission, 2020; Joseph & Kumar, 2021). The Indian manufacturers could not compete with these market rates and incurred higher costs of production. When compared, India found import to be an economical decision over in-house production. This led to the onset of India's import-based production. This move surely ensured short-term cost efficiency, but in the long run, it led to the depletion of India's API manufacturing capabilities (United States International Trade Commission, 2020).

The COVID-19 pandemic was an eye-opener for India, as it threw light on the vulnerability it faced due to supplier dependency. Factory shutdowns, lockdowns, layoffs, and restrictions on transportation and exports led to supply shortages and uncertainties (Gereffi, 2020). Particularly, the pharmaceutical industry faced supplier ambiguity and a scarcity in the import of APIs for bulk generic medicines during the crucial pandemic circumstances, thereby risking national health and medicine continuity (United States International Trade Commission, 2020; Joseph & Kumar, 2021).

Apart from the pandemic, increasing geopolitical tensions, anti-dumping duties, and countervailing measures further complicate pharmaceutical trade and supply chain management (Evenett, 2020). These factors act as physical evidence that API import dependence extends beyond price considerations and represents a strategic risk within the pharmaceutical supply chain.

Existing academic literature predominantly examines API dependence through policy-oriented lenses, focusing on tariff structures, cost competitiveness, and government incentive schemes (NITI Aayog, 2021). While initiatives such as the Production Linked Incentive (PLI) scheme and bulk drug park programs aim to bring back domestic manufacturing capacity, comparatively fewer studies investigate the supply chain impact of the same (Government of India, 2020; NITI Aayog, 2021). Limited research has covered how pharmaceutical firms can design procurement strategies that balance cost efficiency with resilience, diversify supplier portfolios, evaluate backward integration, or incorporate redundancy mechanisms into sourcing decisions (Ivanov & Dolgui, 2020).

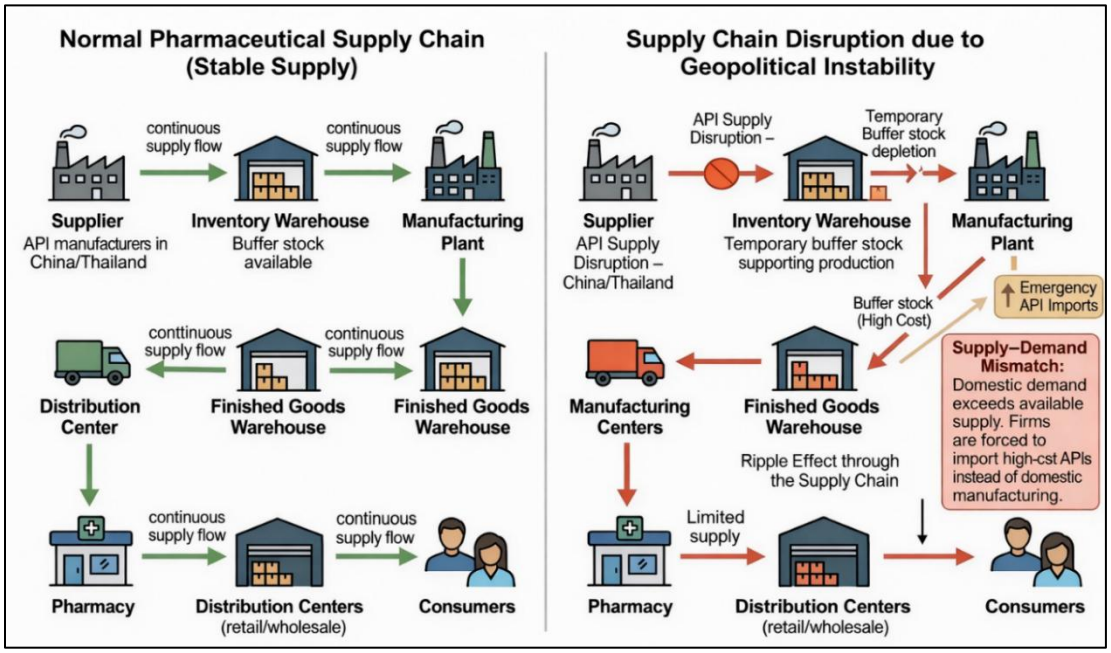

Figure 1. Ripple Effect of API Supply Disruption (Source: Conceptual framework developed by the author)

In operations and supply chain management, a supply chain's resilience to withstand disruptions is valued more than its ability to react and overcome the damage caused by geopolitical tensions (Ivanov & Dolgui, 2020; Ponomarov & Holcomb, 2009). Supply chain resilience encompasses the ability to anticipate disruptions, absorb shocks, adapt to changing conditions, and recover efficiently while maintaining operational continuity (Ponomarov & Holcomb, 2009). Heavy reliance on a single or a few suppliers leads to an increasing cost of switching suppliers. It delays the refurbishing of the buffer stock while trying to finalise the alternate supplier, thereby increasing the price of the commodity for its consumers. This affects supply chain robustness, strategic autonomy, and long-term competitiveness (Ivanov & Dolgui, 2020).

1.1 Rationale of the Study

India is now one of the world's largest generic medicines producers. India contributes nearly 50% of global vaccine demand and holds a significant market share of generic medicines in the international market. Moreover, the strategic market presence of the Indian pharmaceutical industry, Indian industries remain heavily dependent on imported Active Pharmaceutical Ingredients (APIs), particularly from a limited number of countries. Bearing this fact in mind, it is quite clear that this dependence poses significant risks to supply chain resilience, national health security, and continual availability of essential medicines. Therefore, strengthening domestic API manufacturing becomes a strategic priority to overcome the challenges inherent in import dependence and to take the initiative to enhance supply chain resilience. These are crucial to sustain India's leadership in the global pharmaceutical industry at the global level. This study examines the challenges and opportunities associated with reducing India's API import dependence to build a more resilient and sustainable pharmaceutical supply chain. This study seeks to study the reasons behind the decline of the Indian pharmaceutical industry in terms of API manufacturing and analyse its long-term impacts on global supply chains. By integrating concepts from supply chain management theory and risk mitigation strategies, this research aims to:

To examine and analyse the impact of API import dependence on factors like supply chain resilience, operational efficiency, and domestic manufacturing capability, this research work framed the following research objectives (ROs):

RO1: To analyze the root causes of heavy import procurement of Active Pharmaceutical Ingredients (API) from China by identifying key patterns.

RO2: To analyze the impact of rigorous antidumping investigations followed by countervailing duties.

RO3: To propose a strategic framework that integrates supply-chain resilience and competitive advantage principles to help build resilience so that domestic pharma companies can restore their API manufacturing capability.

The study adopts a mixed-methods approach, including qualitative, exploratory, and case-based methods to analyze key disruptions and firm-level responses within the Indian pharmaceutical context. The study proposes strategic recommendations that align economic viability with resilience-building objectives. The study examines India's dependence on imported Active Pharmaceutical Ingredients (API's) through the Supply Chain Management (SCM) perspective, covering how sourcing, procurement, production, logistics, inventory management, risk management, and supplier relationship management have an impact on the resilience and sustainability of the supply chain of the pharmaceutical sector.

The rationale behind the SCM approach is that it covers the entire flow of materials, financial resources, and information from suppliers to pharmaceutical manufacturers rather than relying solely on manufacturing or trade issues.

The study argues that reducing API import dependence is

not merely about protecting domestic counterparts; it fundamentally supports transforming traditional supply chains into stronger, more resilient ones. Examining API dependence through SCM, this research contributes to the broader discourse on building robust, sustainable pharmaceutical supply chains in India.

2. LITERATURE REVIEW AND BACKGROUND OF STUDY

2.1 Indian API Manufacturing Capacity

According to early literature, the Indian pharmaceutical industry had a very robust and reliable manufacturing capacity when it came to manufacturing active pharmaceutical ingredients for generic bulk medicines (Chaudhuri, 2021; Joseph & Kumar, 2021). The industry was well supported by the government, and the local manufacturers were independent (Government of India, 2023). The entire upstream supply chain up to storing the produce in warehouses was within the country. India had a strong hold in the market and constantly focused on research and development, with pharma imports as close to zero (Chaudhuri, 2021). However, after the mid-1990s, several studies showcased a change in the structure of Indian supply chains and in import numbers (Joseph & Kumar, 2021). The cost of production was increasing higher than that of competitors; international pressure from competitors, and changes in industry policies and regulations had reduced India's capability to manufacture its own API and compete with international prices, especially from China (United States International Trade Commission, 2020; Chaudhuri, 2021). India and other developing nations witnessed that importing API from China and formulating it domestically before sale was cost-effective when compared to in-house production. Hence, gradually, India started to adopt an import-based production system, thereby weakening India's global competitiveness in future years (United States International Trade Commission, 2020).

In today's context, India has established itself as a leader in producing and the third-largest manufacturer of medicines globally (Cherian et al., 2021).

India's active pharmaceutical ingredients (API) are very popular and have evolved to meet the international quality standards of medicines production, rather than being a producer of basic bulk generic drugs only (Singh and Popli, 2021; Confederation of Indian Industry, 2020). The identity of India is not accidental; it happened due to the continuous investments in modern manufacturing facilities, focused orientation in export, and close adherence to global regulatory requirements. India holds a strong reputation, as it hosts one of the largest numbers of US FDA-approved pharmaceutical manufacturing facilities outside the United States, which is powerful to highlight India's capability to supply regulated international markets (GME, 2023). In consideration of the legacy, global market presence, and strategic importance in the long term, the Indian government has initiated many strong policy measures to expand and enrich the domestic manufacturing capacity.

Some of the remarkable initiatives are the establishment of pharmaceutical manufacturing zones and fiscal incentives for practitioners; all these measures have been taken to reduce the country's dependencies on imported API's and improve supply chain resilience (Chander et al., 2016; Zhang and Bjerke, 2023)

2.2 Reasons for the increase in API Import

Existing literature has identified a few structural and economic reasons for the increase in API imports by Indian pharmaceutical companies (Joseph & Kumar, 2021; Chaudhuri, 2021). One of the primary reasons is the capability of the Chinese pharmaceutical companies to produce at a substantially lower cost (United States International Trade Commission, 2020). This helps them export the produce at a rate that becomes extremely challenging to compete in the global market by any other competitor.

Authors have given the credit for this capability of the Chinese pharma manufacturers to their perfect use of economies of scale, low energy prices, convenient regulatory policies and approvals, and finally, their integrated chem-parks (United States International Trade Commission, 2020; Organisation for Economic Co-operation and Development, 2020) As per JH Yune in 2016, their green integrated chemical parks help via shared resources and integrated supply chains to cut costs significantly. Literature shows that initially, the difference between the prices quoted by Chinese and Indian pharmaceutical companies was not highly varied (Chaudhuri, 2021). It was gradually, after it became a major exporter of API, that China took advantage of its large-scale production quantity to further cut down the cost of production (Joseph & Kumar, 2021).

Recent work in the field highlights how India started importing certain active pharmaceutical ingredients (APIs) other than China, is becomes possible due to a combination of policy, technological, industrial, and market-related factors.

Indian governments enforce several policies that support pharmaceutical manufacturing and regulatory approvals for new drug formulations, thereby increasing demand for a wider range of APIs from multiple international sources. Another reason behind India's position in meeting the huge demand for specialized APIs is the government's focus on establishing new research and development centres in India. Apart from international demands, India's domestic requirements also increased mainly due to the rising prevalence of chronic and infectious diseases, changing disease patterns, and increasing healthcare expenditure. India's growing population levels and higher consumption of animal-derived food products have also increased the need for veterinary and human pharmaceutical products, thereby diversifying India's API sourcing strategy. (Sahoo, Rout, and Jakovljevic, 2023; Sahu, Kumar, Nagtode, & Sahu, 2024; Karthika, Abraham, Kodali, and Mathews, 2025).

These factors clearly indicate the changing import pattern and future requirements in the domain of API require different management, strategies, and policy measures to improve API import dependence on a single supplier country and look into the evolving healthcare needs, technologies to change and include, and strategic diversification to fit into global supply chains (Stocker, and Zimmermann, 2023; Joseph, and Arun Kumar, 2022).

Rationalizing the factors and what the literature indicates, it is quite clear to understand these multiple drivers for developing resilient pharmaceutical supply chains and formulating policies focusing on how to strengthen domestic API manufacturing while reducing external vulnerabilities.

Literature also shows that changes in Indian policies and rules have made Indian pharmaceutical companies less likely to make drugs in India (Chaudhuri, 2021). Changes to Indian patent laws, along with a lack of investment and long-term policies in the API sector, have made it harder for local investors and producers to do business (Joseph & Kumar, 2021).

2.3 Risks due to heavy import procurement

Strategically, papers claim that increased dependence on APIs on limited foreign suppliers has led to high vulnerability (Joseph & Kumar, 2021; Chaudhuri, 2021). Post-pandemic research papers repeatedly highlight the following risks that India is facing due to heavy import procurement of APIs:

Increased exposure to global supply disruptions:

Developing nations like India are increasingly reliant and dependent on foreign nations for the import of APIs for crucial generic medicines (United States International Trade Commission, 2020). This dependency has exposed us to being victims in case of geopolitical tensions from the geographical cluster that acts as the export hub of API to the world (United Nations Conference on Trade and Development, 2020).

Price volatility in critical APIs:

The sole dependence on such imports has exposed India's vulnerability to the ROW. Any changes in the international market conditions, regulatory policies, or restrictions in the exporting country will directly affect supply and result in price volatility in the domestic country (Organisation for Economic Co-operation and Development, 2020).

Risks to national health security

An interruption in the supply of crucial APIs due to any reason (geopolitical tension or external shocks to the supply chain) would directly lead to supply scarcity, delayed production, supply gap, and eventually risk to national health security (Government of India, 2023). Shortages of critical APIs can also lead to production shutdowns within domestic pharmaceutical companies, affecting the supply of essential drugs (United States International Trade Commission, 2020).

2.4 Current Status

Until the first half of the 1990s, the import of APIs was low, and the European countries were the major source of supplies. Imports from China accounted for less than one per cent during that period. However, towards the end of the 1990s, China's share in India's import of APIs increased to more than 20 per cent and reached 57 per cent by 2010. Although the share of China has declined marginally post-2010, in many cases of APIs, the entire import is sourced from China. Chaudhuri (2021) finds that there are 70 APIs on which India is dependent on China for 100 per cent of imports. As APIs from China are much cheaper, producers in India have begun shutting down API production facilities in India (United States International Trade Commission, 2020; Chaudhuri, 2021)

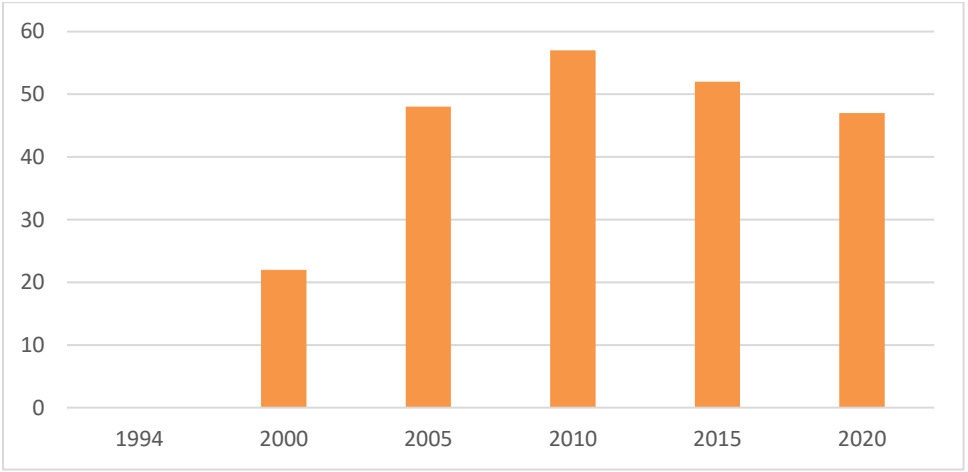

Figure 2. India's Chinese API Import Percentage. (Source: Joseph et al. (2021). Visualization is self-created.

2.5 Government Policy Impacts

Many research papers look at the rules and policies made by the Government of India and how they have affected the country's pharmaceutical industry (Joseph & Kumar, 2021; Government of India, 2020). Some examples of these policies are the Production Linked Incentive (PLI), import-substitution programs, and Bulk-Drug Parks (Government of India, 2020; NITI Aayog, 2021). This literature acknowledges GoI policies for their beneficial effects on reinstating self-sufficiency and reliance by bolstering domestic manufacturing (NITI Aayog, 2021).

But it also indicates negatives about:

The slow pace of implementation

A limited number of APIs covered

High capital requirements, and

Difficulty of competing with established global suppliers.

Different authors have different ideas about whether or not these efforts will help and be enough to bring back the original competitiveness of manufacturing.

Table 1 summarises the secondary data sources that have been examined for this study

Table 1 Summary of Key Literature on API Dependence and Pharmaceutical Supply Chains

Author / Institution	Area of Study	Key Findings
Ivanov & Dolgui (2020)	Supply chain disruption and resilience	Supply chains are vulnerable to ripple effects when upstream disruptions occur.
Ponomarov & Holcomb (2009)	Supply chain resilience theory	Defines resilience as the ability to anticipate disruptions, absorb shocks, and recover quickly from unexpected events.
Joseph & Kumar (2021)	India's API import dependence	Identifies the gradual decline of domestic API manufacturing and increasing reliance on Chinese imports.
Chaudhuri (2021)	India–China pharmaceutical trade	Demonstrates that India depends heavily on Chinese APIs, with some APIs imported almost entirely from China.
United States International Trade Commission (2020)	Global API supply chain structure	China dominates global API manufacturing due to economies of scale, lower production costs, and industrial clusters.
UNCTAD (2020)	Global supply chain disruptions	Global value chains are highly interconnected, meaning disruptions in one region can affect industries worldwide.
Gereffi (2020)	Global value chains during COVID-19	COVID-19 exposed structural weaknesses in supply chains, particularly for medical goods.
OECD (2020)	Risks in global value chains	Over-reliance on geographically concentrated suppliers increases vulnerability to global crises.
World Health Organisation (WHO)	Global health supply systems	Highlights the importance of resilient supply chains for essential medicines and tuberculosis treatment.
World Trade Organisation (WTO)	Anti-dumping and global trade rules	WTO allows member countries to impose anti-dumping duties when imported goods are sold below fair market value.
Directorate General of Trade Remedies (DGTR)	Trade remedy investigations in India	Conducts anti-dumping investigations and recommends duties to protect domestic industries.
Government of India (Department of Pharmaceuticals)	Industrial policy for API manufacturing	Introduced policies such as PLI schemes and bulk drug parks to promote domestic API production.
NITI Aayog (2021)	Policy analysis of the API sector	Identifies structural challenges in domestic API manufacturing and suggests policy interventions.
Stop TB Partnership / Global Drug Facility	Global TB medicine supply chains	Ensures procurement and distribution of TB medicines worldwide.

Although existing literature has researched on and covered API import dependence and policy interventions, only a few studies have spoken on the supply chain implications of this dependence from a resilience perspective.

3. METHODOLOGY

This research has followed a mixed-method approach, involving qualitative and exploratory research designs. The idea is to investigate and develop a deeper conceptual understanding of active pharmaceutical ingredients (API) import dependence and its strategic impact on Indian pharmaceutical supply chains and companies. The

study has relied on analytical and theory-driven reasoning supported by credible secondary data. This approach helps examine the unique characteristics of India's API import dependence from an SCM perspective. The objective behind relying on secondary data is that it constitutes an appropriate and authentic source of evidence, rather than firm-level behavioral phenomena. The study utilized data from government reports, international organizations, peer-reviewed journals, and industry publications to enable a systematic assessment of the structural factors influencing API dependence and pharmaceutical supply chain resilience. Moreover, established SCM and supply chain resilience theories provide a robust conceptual framework for interpreting empirical evidence, identifying supply chain vulnerabilities, and recommending strategic interventions to strengthen domestic API manufacturing and reduce import dependence. This approach is consistent with the literature, which emphasizes that resilient supply chains require integrated analysis of sourcing strategies, supplier dependence, risk management, and policy support, particularly in critical sectors such as pharmaceuticals.

Given that the required data for research include geopolitical relations, global economics, renowned pharmaceutical companies in India, and several Government ministries, the study found the qualitative research style suitable to ensure the credibility and feasibility of the data used. This study has followed all steps necessary for an exploratory style of research as mentioned in Figure 3.

The COVID-19 case study id found useful for examining the effects of global supply chain disruptions on active pharmaceutical ingredient (API) availability, highlighting how dependence on imports affects supply chain resilience and operational continuity. The anti-dumping case study provides insights into the impact of regulatory action and trade policy on domestic manufacturing and their effect on domestic supply chain stability

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Figure 3. Procedural Flow of the research methodology

By examining these cases together, they will allow for cross-study comparisons of the various categories of disruptions, supporting the overall objective(s) of the study, which include identifying patterns of vulnerabilities and providing resilience-centered solutions to the Indian pharmaceutical industry.

4. CASE STUDY I: COVID-19 (API SUPPLY CHAIN FRAGILITY)

4.1 About the World Pharma Supply Chain

The global pharmaceutical industry is diverse and spread across different nations worldwide. The varied steps or stages in the pharmaceutical supply chain include the procurement of raw material, synthesis in the form of API, formulation of the medicine, packaging, and distribution to retailers, wholesalers, or consumers directly (U.S. Food and Drug Administration, 2019). These stages are conducted globally across the world in lieu of lower costs of production, favourable regulatory policies, better technological infrastructure, etc. While this disintegration and connectivity benefit the pharma industry economically, it also leads to interdependency of nations for the smooth functioning of their individual supply chains (United Nations Conference on Trade and Development, 2020).

India and China are both major players in the global pharmaceutical market. While China is commonly referred to as the world's largest API manufacturing hub by the United States International Trade Commission and the World Health Organisation, India continues to acquire a substantial share in the world pharma market for its supply of numerous bulk generic medicines throughout the globe (United States International Trade Commission, 2020; World Health Organisation, 2021). India and China together supply a voluminous quantity of medicines to the world (U.S. Food and Drug Administration, 2019).

However, this integration has led to India being heavily dependent on the Chinese pharmaceutical industry for API import to an extent that a disruption in this supply due to any geopolitical reason or natural calamity would surely cause severe damage to the Indian pharmaceutical supply chain and national health security (Joseph & Kumar, 2021; Chaudhuri, 2021). Table 2 shows India's API Import Statistics

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Table 2. India's API Import Statistics

Indicator	Data / Estimate	Source
Share of APIs imported by India	~60–70% of India's API is imported from foreign countries.	Joseph & Kumar (2021), ISID Working Paper
Number of APIs with extreme dependence on China	Around **58 APIs** were identified with high import dependence; **45 APIs** were entirely imported from China.	Government of India (Press Information Bureau)- Appendix 1
Therapeutic categories with high dependence	Antibiotics, anti-fungal, cardiovascular drugs, diabetes drugs and vitamins show particularly high import dependence.	
China's share in India's pharmaceutical imports	About **73.7% of API and bulk-drug imports** came from China in FY 2024-25	

4.2 The Pandemic and Global Pharmaceutical Supply Chain Disruption

With the unexpected outbreak of the COVID-19 pandemic in late 2019, the entire global supply chain was disrupted and shattered (Gereffi, 2020; United Nations Conference on Trade and Development, 2020). The coronavirus originated in Wuhan, China, which was one of the major chemical processing and pharmaceutical ingredient manufacturing hubs in the country. As the virus spread at a rapid pace, the Chinese Government took strict actions by shutting down factories and regulating public interaction to reduce the impact of the virus (World Health Organisation, 2020).

As a result, factories were shut down, export was curtailed, the majority of their domestic pharmaceutical industries and manufacturing facilities were closed, transport and trade restrictions were imposed, ports were congested, and logistics were compromised significantly (United Nations Conference on Trade and Development, 2020). Since China is one of the major producers and exporters of active pharmaceutical ingredients for the formulation of generic medicines, the entire world faced a supply shortage of raw materials, with few or no alternatives available (United States International Trade Commission, 2020).

This upstream disruption in the supply chains rolled towards the downstream eventually (Ivanov & Dolgui, 2020). Buffer stocks and safety stocks were depleted hastily, creating a situation of supply scarcity, affecting drug manufacturing, distribution, and ultimately patient access to medicines (U.S. Food and Drug Administration, 2019). The disruptions were particularly severe for countries that depended heavily on imported pharmaceutical ingredients (United States International Trade Commission, 2020; World Health Organisation, 2021).

4.3 Impacts on the Indian Pharmaceutical Industry

India is coined as the 'pharmacy of the world' as it contributes to approximately 20 per cent of the total supply of bulk generic medicines to both developing as well as developed nations of the world (Government of India, 2023; World Trade Organisation, 2020). It is renowned for its medical tourism because of its most affordable and high-quality medical facilities, ranging from treatment, medical drugs, equipment, and hospitals, to having the most robust pharmaceutical research and development scientists (Government of India, 2023). Yet, it continues to be heavily dependent on China and other countries for the procurement of API and other intermediate raw materials for the formulation of generic medicines (Joseph & Kumar, 2021; Chaudhuri, 2021).

Before the COVID-19 pandemic, India imported 70 per cent of its API from countries around the world (Joseph & Kumar, 2021). Out of which approximately 50 per cent was imported from China alone (Chaudhuri, 2021). Eventually, when many countries started to face supply scarcity due to disruption in the upstream of the supply chain during the pandemic, nations realised the limitation of geographical clustering of pharmaceutical API manufacturing (United Nations Conference on Trade and Development, 2020). This was an eye-opener for India and the other countries to make their supply chains more resilient by disintegrating this geographical cluster (United Nations Conference on Trade and Development, 2020).

The impact of the COVID-19 pandemic highlighted three significant structural weaknesses in the Indian pharmaceutical supply chain:

This crisis showcased the risk associated with having a single supplier dependency. (Ivanov & Dolgui, 2020). Relying on a particular geographically clustered area for the procurement of crucial pharmaceutical raw materials affected the supply of numerous supply chains globally simultaneously (United States International Trade Commission, 2020). Switching suppliers during the pandemic immediately faced a host of geopolitical constraints and economic factors, due to which demand for generic bulk medicines was not being met (United Nations Conference on Trade and Development, 2020).

The limitations of adopting a cost-based procurement system were witnessed by all developing countries (Gereffi, 2020). While nations, including India, found it economical to import crucial raw materials from China over manufacturing them domestically and invest on research and development, in times of crisis like that of the pandemic, upstream supply chain disruption and its adverse effects had severely affected the production continuity of daily generic medicines (United States International Trade Commission, 2020; Joseph & Kumar, 2021).

Hence, it was realised that maintaining one's own capacity to manufacture its pharmaceutical raw materials, at least for generic medicines, should be prioritised (NITI Aayog, 2021). Having self-reliance and independence to manufacture APIs domestically would have mitigated the supply chain issue of supply shortage efficiently (Government of India, 2020). This would have led to minor import shortages that could have easily been managed by increasing production in-house or by negotiating with the next available supplier for a rather large quantity during the pandemic (NITI Aayog, 2021).

Finally, all the above-mentioned weaknesses point towards the need to build more resilient supply chains instead of merely responsive ones (Ivanov & Dolgui, 2020; Ponomarov & Holcomb, 2009). Resilient supply chains are capable of anticipating disruptions, absorbing shocks, and recovering quickly from unexpected events (Ponomarov & Holcomb, 2009).

4.4 India's Response to Mitigate Impact

The Government and the pharmaceutical companies in India responded to the damage to domestic supply chains caused by the crisis instantly (Government of India, 2020). One of the primary defensive policies implemented by the Government of India was an export restriction on twenty-six pharmaceutical ingredients produced in India, in order to ensure that crucial medicines are available to citizens during times of distress (Government of India, 2020; World Trade Organisation, 2020). These restrictions included several drugs that were part of the World Health Organisation's list of essential medicines (World Health Organisation, 2019).

The export restrictions were a result of the anticipated threat to India's ability to maintain continuous production levels in the event of an upstream supply disruption of

APIs (Government of India, 2020). Most pharmaceutical companies in India were heavily reliant on the imports of APIs to manufacture drugs, which were later sold to the market as formulated medicines (Joseph & Kumar, 2021). These pharma companies were forced to look for alternative ways to mitigate the risks associated with the supplies of APIs. Some pharmaceutical companies attempted to look for alternative sources of APIs in other countries such as South Korea, Japan, and Europe (United States International Trade Commission, 2020). However, the alternative sources were more expensive compared to the Chinese imports.

The crisis provided an opportunity to reconsider the revival of the production of APIs in the country. The Indian government launched a number of policy programs to support the production of APIs in the country. The programs included the PLI scheme and the establishment of bulk drug parks (Government of India, 2020; NITI Aayog, 2021).

4.5 Learnings for SCM

The COVID-19 pandemic helped the world realise the need for supply chains to focus more on resilience rather than on cost-efficiency to strike a perfect balance.

If supply chains adopt a solely cost-efficient procurement pattern, it eventually leads to an acute supply shortage due to high dependency on a single supplier. This was witnessed evidently in the case of the coronavirus pandemic, where developing countries like India faced a supply scarcity of raw materials due to heavy reliance on China for the import of APIs for crucial generic medicines.

On the contrary, if supply chains had prioritised resilience and economic factors equally, India would have continued maintaining its API manufacturing capability while importing a rather insignificant quantity from foreign nations, thereby protecting its domestic supply chains from damage caused by the pandemic. Lastly, the pandemic highlights the need to incorporate risk management principles into the design of the supply chain itself. Strategic stockpiling, diversification of suppliers, and investments in local manufacturing capabilities can all play a role in building supply chain resiliency (Organisation for Economic Co-operation and Development, 2021).

5. CASE STUDY II: ANTI-DUMPING CASE (ETHAMBUTOL HYDROCHLORIDE)

5.1 About the Ethambutol Hydrochloride API

Ethambutol Hydrochloride is a vital active pharmaceutical ingredient for the formulation or production of medicines that cure Tuberculosis (TB) (World Health Organisation, 2023). It is one of the key components in first-line tuberculosis treatment as recommended by global health authorities (World Health Organisation, 2023). In developing countries like India, Tuberculosis is a major health challenge, and these ethambutol hydrochloride medicines are crucial for its treatment (World Health Organisation, 2023). In these countries, the demand for such medicines is regular and constant.

India is a key manufacturer and exporter of anti-tuberculosis medicines for both developing and developed nations around the globe (Government of India, 2023). The country supplies a significant portion of TB drugs to international organisations such as the Global Fund and other public health procurement programs (Stop TB Partnership, 2022). As a result, the stability of India's pharmaceutical manufacturing system is directly linked to the availability of life-saving medicines in many parts of the world (World Health Organisation, 2023). Table 3 presents the Demand and import requirement of Ethambutol Hydrochloride (India).

Table 3. Demand and import requirement of Ethambutol Hydrochloride (India)

Indicator	Data	Unit / Notes	Source
Estimated TB incidence in India	2.82 million	Annual TB cases (2022 estimate)	WHO Global TB Report
Share of global TB cases from India	~28%	The highest TB burden country	
Standard TB treatment regimen drugs	Isoniazid, Ethambutol, and Pyrazinamide	Ethambutol is included in the intensive phase	WHO Treatment Guidelines
Duration of the intensive TB treatment phase	2 months	Ethambutol is used daily during the intensive phase	
Recommended adult ethambutol dose	15–25 mg/kg/day	WHO standard dosage range	WHO Essential Medicines
Typical ethambutol tablet strength in India	400 mg, 800 mg	Used in TB therapy regimens	
Estimated annual ethambutol tablet requirement	Hundreds of millions of tablets annually	Based on TB treatment course requirements	NTEP procurement data- Annexure 2

Despite holding such a robust position in the world pharmaceutical market, India continues to remain highly dependent on China for the import of APIs for several generic bulk medicines, similar to the anti-tuberculosis drugs (Joseph & Kumar, 2021; Chaudhuri, 2021). The Ethambutol Hydrochloride case showcases the disadvantages of this import dependence and the strategic vulnerabilities it can create for the Indian pharmaceutical industry (United States International Trade Commission, 2020).

5.2 Emergence of the Anti-Dumping Investigation

Dumping refers to a scenario wherein a country exports a certain good or product to another country in large quantities at prices that are substantially lower than the prevailing market price (World Trade Organisation, 2023). The motive behind these acts is usually to destroy competition. In such a case, the World Trade Organisation allows countries to conduct an anti-dumping investigation to analyse the motive behind the export and ensure fair trade practices (World Trade Organisation, 2023). In India, the investigation is conducted by the Directorate General of Trade Remedies (DGTR) and countervailing duties are then imposed by the Ministry of Finance to protect its local manufacturers (Government of India, 2023).

Since the 1990s, India has become one of the most active users of anti-dumping measures (Lakshmikumaran & Sridharan, 2014; Parikh & Sidhpuria, 2018). Between 1995 and mid-2014, India had initiated about 715 anti-dumping investigations, imposing duties in hundreds of cases — more than most other WTO members (Lakshmikumaran & Sridharan, 2014).

In the beginning of 2024, the Indian pharmaceutical companies collectively raised concerns about the increasing volume of ethambutol hydrochloride imports from China and Thailand (Directorate General of Trade Remedies, 2024). Domestic manufacturers argued that these imports were entering the Indian market at artificially low prices, which significantly undercut the prices offered by local producers (Directorate General of Trade Remedies, 2024). In response to these concerns, Lupin Limited, an Indian pharmaceutical manufacturer, filed a petition requesting an anti-dumping investigation into imports of ethambutol hydrochloride (Directorate General of Trade Remedies, 2024). The complaint alleged that foreign exporters were selling the API in India at prices lower than their fair market value, thereby causing material injury to domestic producers.

Following this petition, the Directorate General of Trade Remedies (DGTR), operating under India's Ministry of Commerce and Industry, initiated a formal anti-dumping investigation concerning imports of ethambutol hydrochloride originating from China and Thailand (Directorate General of Trade Remedies, 2024). The investigation sought to determine whether dumping practices existed and whether such practices were causing injury to India's domestic pharmaceutical industry.

5.3 Investigation Findings and Analysis

The investigation was done over the period from April 2024 to March 2025 (Directorate General of Trade Remedies, 2025). During the investigation, it was found that the imports of ethambutol hydrochloride had increased significantly. The data showed that the imports of the API increased substantially over a short period. For example, the imports increased from $0.14 million to $4.5 million in a matter of just one year (Directorate General of Trade Remedies, 2025). This shows the rapid increase in the penetration of the foreign market. It was identified through the investigation report that the exporters were engaging in the practice of price undercutting. The products imported were sold at a much lower price compared to what the Indian manufacturers were offering. This posed a problem to the Indian manufacturers because it was difficult to compete at such low prices.

It was identified through the preliminary investigation report of the DGTR that the imports from China and Thailand were dumped into the Indian market at a low price (Directorate General of Trade Remedies, 2025). This caused injury to the pharmaceutical manufacturers in India because the prices were low, which impacted the profitability of the companies. As a result of the investigation (Annexure 2), it was recommended by the DGTR to charge a provisional anti-dumping duty on the imports of ethambutol hydrochloride. The duty ranged from $5,124 to $6,513 based on the exporting companies (Directorate General of Trade Remedies, 2025).

5.4 Pharma Supply Chain Impact

Although the antidumping investigation, followed by the countervailing duties are imposed by the Government in favour of the domestic manufacturers, it comes with its own share of challenges (World Trade Organisation, 2023; United States International Trade Commission, 2020). Once CVD is imposed, the in-house manufacturers struggle to meet the demand for the product due to insufficient domestic capability to manufacture (United States International Trade Commission, 2020). This happens due to the adoption of a cost-based procurement pattern instead of developing a self-reliant supply chain (Joseph & Kumar, 2021). Even if the cost-based pattern is economical in the short term, it exposes the country to be vulnerable at times like these (Joseph & Kumar, 2021).

Taking the current case, a developing nation like that of India requires a large quantity of ethambutol hydrochloride for its high tuberculosis numbers (World Health Organisation, 2023). However, they are imported from China and Thailand and then formulated in India (Directorate General of Trade Remedies, 2025). When ADD and CVD were imposed, the Indian pharmaceutical companies faced capability constraints alongside the constantly prevailing demand for anti-tuberculosis medicines (Directorate General of Trade Remedies, 2025).

Another issue that the country faces after CVD is the temporary supply gap due to the time taken for manufacturing and synthesising the API into drugs (United States International Trade Commission, 2020). Since API synthesis takes time for infrastructure installation, facility expansion, and regulatory compliance, a temporary gap is created between supply and demand in the market (Government of India, 2023). The cost of producing the same ethambutol medicine

would increase. That said, consumers will have to pay more than they usually do for the same. This creates market price volatility throughout the market (Organisation for Economic Co-operation and Development, 2021). Furthermore, domestic suppliers may be required to obtain various certifications or obtain regulatory approvals before they can engage in large-scale supply operations (Government of India, 2023). This process often involves adhering to specific industry standards and meeting compliance requirements set by governmental and regulatory bodies, ensuring that their products meet safety and quality benchmarks.

5.5 Learnings for Indian Pharma SCM

The Ethambutol Hydrochloride case helped us witness the two major strategic weaknesses of our Indian pharmaceutical supply chain.

In the event of an unprecedented situation, such as an anti-dumping and countervailing duty case, addressing the resulting damage proves to be more challenging in terms of cost, time, production, and supply. Conversely, in a similar scenario, a resilient supply chain would have prevented any country from engaging in the dumping of an Active Pharmaceutical Ingredient (API) to gain a competitive advantage.

Decisions taken by a country usually has severe impact on manufacturing capacity, pricing structures, and market stability in another country. Thus, it is important for all global supply chains to strike a balance between economical sourcing and independent manufacturing capability to minimise the risk of geopolitical tensions.

6. CASE ANALYSIS

Both the case studies discussed in this study together help identify the structural weaknesses of our Indian pharmaceutical supply chains and exposes its vulnerability. The first case study depicts an unexpected external disruption to the supply chain, while the ethambutol hydrochloride case, on the other hand, explains a scenario of geopolitical trade disruption as a trigger. The first case highlights the challenges of managing the damage caused by a pandemic to global supply chains. Connversely, the second case illustrates the complications faced by the domestic pharma companies to overcome an ADD and CVD situation. Together, they clearly convey the negatives of being heavily dependent on imports for API of crucial drugs.

A common highlight identified in both cases was the fact that the Indian pharmaceutical industry is heavily dependent on China for the import of active pharmaceutical ingredients for various crucial generic medicines. Subsequently, when the supply is hit either due to an external trigger (COVID-19) or due to trade/legal restrictions (Anti-Dumping and Countervailing Duties), the upstream is disrupted. This disruption rolls downstream, thereby causing a state of supply scarcity in the market.

This dependence is due to the adoption of a cost-effective model of procurement, as importing from China and Thailand was cheaper than domestic manufacturing due to its competitive advantage of shared infrastructure and economies of scale. This allowed short-term cost competitiveness but compromised long-term supply chain resilience. It is thus important to balance economic advantage and resilience, as the current cost model has severely impacted India's capability to manufacture its own API in competition with global leaders.

The coronavirus pandemic illustrated the risks of this dependence explicitly. The pandemic originated in China's Wuhan area, which is the global hub for chemical ingredients and pharmaceutical manufacturers of critical APIs. As a result of the pandemic, factories and pharmaceutical manufacturing companies were shut, export was restricted, transportation was stopped, and trade with the ROW was put to halt. Since the majority of India's API requirements are sourced from China, this triggered the disruption of Indian pharmaceutical supply chains. Delays in shipments, shortages of raw materials, and rising input costs affected the continuity of drug production. This situation exposed the effects of having a globally clustered hub for supplying API to the world.

The pandemic ideally elaborates the basic principle of supply chain risk management that says any disruption in the upstream will roll down to become a downstream disruption as well, if not curtailed instantly. As the buffer stocks ran low and the availability of alternative suppliers was scarce or at a premium, the drug firms faced a slowdown in their operations. These challenges were particularly critical for the pharmaceutical sector, as any disruption in the manufacture of drugs can have a direct impact on the health sector.

On the other hand, the Ethambutol Hydrochloride case illustrates a different type of supply chain problem. This case damage is the result of the nature of international trade. Indian pharmaceutical firms identified the problem of Ethambutol Hydrochloride APIs entering the country in large quantities from China and Thailand at prices significantly lower than the market level. The problem was that these lower prices made it difficult for Indian producers to compete with. Subsequently, ADD and CVDs were imposed post investigation. While these were intended to restore fair competition and protect domestic manufacturers, they also create short-term operational challenges.

These sudden restrictions led to a temporary supply gap due to additional time consumed by the manufacturers. The reason behind the delay was either to arrange for an alternate supplier or regulatory compliance, or to independently formulate ethambutol hydrochloride that was earlier being imported from China and Thailand. The scenario became further complicated with an increase in the cost of production, causing higher prices of all ethambutol medicines in the market.

On a detailed analysis of both the cases discussed above, a pattern is observed that points out the strategic weaknesses and vulnerability of the Indian pharmaceutical supply chains. This pattern can be disintegrated into the following four major components:

Both cases showcase the limitations of being heavily dependent on a single supplier and reliant on them for the import of active pharmaceutical ingredients of crucial generic medicines. In the case of the COVID-19 pandemic, due to factory shutdowns and trade restrictions, the supply of various APIs required for crucial drugs from

China was put to halt. In the case of Ethambutol Hydrochloride, the CVDs resulted in an immediate supply shortage of the API in the country. These were the effects of being dependent on a geographically clustered supplier. Secondly, both cases highlight the disadvantages and implications of having a cost-based procurement model. This model surely proves to be economical and fruitful in the short run. However, in the long term, it degrades a country's ability and capacity to manufacture its own active pharmaceutical ingredients. Hence, at times of geopolitical trade conflict or external shocks to the supply chain, countries lack resilience and are unable to scale up their production capacity to meet demand.

These cases pointed out that once the supply chain is disrupted, the damage caused becomes difficult to curtail because of the fact that India failed to maintain its manufacturing capability and ensure that it is self-reliant. Indian pharma supply chains focused more on economical gains over capacity building and infrastructure investment. For a country like India, where the demand for generic medicines is high, having to maintain a manufacturing capability is a must.

Finally, to ensure that these disruptions do not affect national health security and the supply of medicines to consumers in future, building resilient supply chains should be prioritised. Indian pharmaceutical companies should opt for supply chain resilience over responsive supply chains and continue working towards reviving their manufacturing capabilities.

Thus, the conclusions drawn from both the COVID-19 pandemic and the Ethambutol anti-dumping process indicate that for India's pharmaceutical supply chain, there is a need for structural reform. While pharmaceutical companies have focused mainly on low-cost imports, building a more robust and sustainable pharmaceutical supply chain should be the priority.

7. CONCLUSION AND RECOMMENDATIONS

India holds a strong position in the global healthcare and pharmaceutical market. It is one of the leading suppliers of affordable bulk generic medicines to both developing as well as developed nations. This study highlights that despite having such a commanding hold in the market, the Indian supply chain network has structural weaknesses that require immediate attention. The current procurement system involves heavy import (of API) dependence on geographically clustered suppliers, i.e. China, due to cheaper import prices. This proved to be economical in the short term, but it is now affecting the supply chain resilience and flexibility in the long term at times of disruption.

The primary focus of this research is to analyze how dependence on imported API's has affected supply chain resilience, operational functioning, and domestic production capacity. Using qualitative exploratory methods, secondary data analysis; and case studies, this research highlights the impact of global supply chain integration and company decisions on the level of dependency for these products. Literature shows that cost considerations were mostly responsible for India's shifting from a self-dependant and self-sufficient manufacturer of pharmaceutical raw materials (Active Pharmaceutical Ingredients or API) to an import-dependent model since the early 1980s. The Chinese manufacturers gained cost advantages through:

Efficiencies of economies of scale
Their ability to provide an API from chemical clusters
Providing lower energy sources of power, and
Better compliant regulatory environments

As a result, the Chinese manufacturers price their API much cheaper than Indian manufacturers, who faced challenges including higher costs of production without long-term government support and regulatory constraints, thereby leading to a gradual decline in the amount of capacity used to produce API domestically. Indian pharmaceutical companies thus gained the ability to remain competitive internationally with respect to their API pricing; however, this transition also had negative effects, as single supplier dependency posed a potential risk of supply scarcity at times of distress. The results of this study show that the dependence of Indian pharmaceutical markets on others is much more than a simple economic relationship; it is also a structural risk. The two examples used to demonstrate this are the COVID-19 Pandemic and the anti-dumping case for Ethambutol Hydrochloride.

In this instance, COVID-19 was an external shock, causing many global supply chains to be disrupted, especially those that were dependent for upstream manufacturing operations. Specifically, the restriction of Chinese production and resulting trade led to problems with the supply shortage in India's pharmaceutical supply chain. Shortages of some of the most important active pharmaceutical ingredients (APIs), delays in drug manufacturing, and increased uncertainty of supply continuity were some of the major problems created by these circumstances. This case demonstrates the risks of over-reliance on geographical concentration and demonstrates how a "ripple effect" is created by an upstream disruption, which then affects downstream operations.

The Ethambutol Hydrochloride Case study shows how trade-induced shocks can disrupt supply chains. The imposing of both ADD and CVD was meant to protect domestic producers; however, they resulted in immediate supply constraints because of low levels of domestic production capacity. This case also demonstrates the contradiction in India's pharmaceutical sector; although policy measures are designed to promote self-reliance within the sector, a reliance on imports continues to limit the ability of domestic companies to react positively to these types of interventions. Both cases also illustrate that there are numerous sources of international supply chain disruption, including those caused by an external shock and those caused by internal policies. In both cases, import dependency increases the negative impact of disruptions on supply chains.

A significant reflection that has been noticed in this study is the strategic trade-off between cost efficiency and maintaining domestic manufacturing for building more resilience into Indian pharmaceutical supply chains. The existing procurement pattern is a cost-effective one. This model compromises on log term sustainability and resilience while contributing towards short-term benefits

for global competitiveness effectively. This study argues that resilience should not be viewed as a substitute for efficiency, but rather as an objective that must be integrated into supply chain design simultaneously to ensure self-dependency.

To combat these challenges, the study suggests reconsidering the procurement patterns currently being followed by the Indian pharmaceutical manufacturers. Complete independence in terms of manufacturing APIs would also not prove to be a good option, both economically and international-trade relation wise. Thus, a balance between imports and self-manufacturing has to be maintained. The execution of the same could be in a phased manner, wherein the import-to-domestic-manufacturing ratio will be monitored and improved over a three-year period.

Simultaneously, expanding the supplier base and disintegrating the geographical cluster so created should also be prioritised. This will reduce dependence on a single geographical region, stockpiling of critical APIs to buffer against short-term disruptions, and encourage investment in domestic manufacturing infrastructure for essential drugs. Manufacturers should focus on including elements of risk assessments to increase SCM resilience while investing in supply chain technologies. This can be ensured by:

Developing contingency plans

Incorporating resiliency metrics into performance evaluations

Potential risks to supply reliability and availability, and

Making necessary investments to reduce risks

This study adds to existing academic research by connecting the very different worlds of policy-oriented conversations around API dependence and supply chain management. Previous studies have primarily focused on cost dynamics and related to policies, while this research focuses on creating operational and strategic insights into the impact of API import dependence on pharmaceutical companies. By linking macro-level policy initiatives to micro-level supply chain issues, this research provides a more holistic view of the overall problem.

The reduction of India's dependence on imports for APIs is a necessary aspect of economic growth, but more importantly is critical for ensuring the security of health in the nation as well as for the stability of the global supply chain. Recent events have showcased the value of moving away from the current low-cost supply chain models to more resilient and adaptive supply chain models. The goal of balancing both will strengthen India's position in the global market as well as provide the ability to produce APIs domestically.

Future research can be conducted to enhance this study by collecting and analysing quantitative data to assess supply chain resilience. This type of research will also be able to provide additional information about the real-world challenges and opportunities that exist when attempting to reduce the reliance on imports for APIs. This type of research will help develop a more complete understanding of how developing economies can successfully adjust to the realities of the global supply chain without becoming dependent on imported supplies

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