UDC: 339.5:615.1:004(540)
DOI: 10.59214/ua.fa/2.2026.78

ISSN: 2663-2675
E-ISSN: 2663-2683

Konrad Brodaczewski*
Master, Vice-Director
Grena Ltd
TW8 9HH, 1000 Great West Rd., Brentford, UK
https://orcid.org/0009-0004-7330-6585

India in the global supply chain chains for technology and pharmaceutical products

Abstract. The aim of the study was to develop an integrated analytical model of India's positioning within global supply chains for technology and pharmaceutical products. The methodology was based on a combination of structural analysis of official statistics, analysis of regulatory documents, and a comparative analysis of international economic security initiatives. The results showed that in the technology sector, India demonstrated a marked asymmetry between high growth rates in exports of information and communication services and only moderate progress in the production of high-tech components. An analysis of official data revealed that software exports reached approximately USD 162 billion in 2023, whilst the manufacturing segment remained predominantly focused on the assembly of mobile devices. A comparative analysis of foreign policy initiatives demonstrated that new forms of partnership, particularly with Japan and the US, created favourable conditions for technology transfer, but did not eliminate internal structural constraints linked to a shortage of skilled personnel and a lack of specialised infrastructure. In the pharmaceutical sector, statistical analysis confirmed the expansion of India's role as a leading manufacturer of generic drugs. Scenario modelling showed that even under conditions of maximum stimulation, dependence on imports of active ingredients could only be reduced to 40-45% by 2030, confirming the persistence of medium-term structural constraints. The study also highlighted the need for a long-term balance between the economic efficiency of imports and strategic sustainability requirements. The practical significance of the study lies in the development of analytical guidelines for government institutions, international organisations and industry associations interested in enhancing the stability of global supply chains

Keywords: outsourcing; production capacity; logistics; diversification

Introduction

The global supply chain for technology and pharmaceutical products has undergone significant transformations in the 21st century, driven by shifts in the structure of international trade, intensified geoeconomic competition and the growing role of innovation-driven economies. Amid the diversification of production and logistics chains, India has emerged as one of the key hubs of global technological and pharmaceutical dynamics, highlighting the relevance of a comprehensive analysis of its position within global value chains. The issues include the technological industry's dependence on structural barriers to domestic development, the pharmaceutical sector's vulnerability to external shocks, and strategic shifts in global supply policies aimed at strengthening economic security.

In the academic literature, the functioning of India's technology and pharmaceutical supply chains has been examined from the perspectives of trade dynamics, innovation development, global integration, and production resilience. S. Das & A. Sarma (2021) examined the long-term trajectory of Indian services exports and identified structural growth regimes that determined the country's competitiveness in international technology flows. They analysed the impact of technological modernisation, globalisation and cyclical fluctuations in the global economy on export dynamics, and concluded that adaptation to changes in the structure of global trade – which intensified following the 2008-2009 financial crisis – was necessary. D. Ghosh *et al.* (2021) analysed key bottlenecks in India's high-tech production chains, focusing on access to materials, financing and market constraints. They examined the interaction between start-ups and suppliers, identified problems at the upstream, production and downstream stages, and concluded that the adoption of Industry 4.0 technologies is crucial for enhancing the competitiveness of manufacturing. In the work by L. Bjerke (2022), a study of international trade flows of antibiotics was conducted, demonstrating that India has taken a leading position in global exports of pharmaceutical products, whilst

Received: 05.12.2025, Revised: 18.03.2026, Accepted: 20.04.2026, Published: 01.05.2026

Suggested Citation:
Brodaczewski, K. (2026). India in the global supply chain chains for technology and pharmaceutical products. *Foreign Affairs*, 36(2), 78-88. doi: 10.59214/ua.fa/2.2026.78.

*Corresponding author

simultaneously developing a critical dependence on Chinese active ingredients. The study also analyses the risks of such dependence and concludes that global access to essential medicines is strategically vulnerable. P. Ray *et al*. (2023) investigated the global scaling processes of Indian IT companies and analysed their resources as the basis for competitive advantages. They demonstrated that internationalisation was driven not by the volume of assets, but by dynamic capabilities in knowledge management, and concluded that adaptability, the creation of tactical knowledge and the codification of experience play a key role.

The analysis by H. Gupta & R.A. Kayande (2023) focused on the resilience of pharmaceutical supply chains during the COVID-19 pandemic. The authors identified critical factors such as trade costs, the propagation of shocks and technological constraints, examined the impact of disruptions in logistics and manufacturing, and concluded that there is a need to develop integrated models to enhance resilience. A. Palit & P. Bhogal (2022) analysed the transformations in the global pharmaceutical geoeconomy and demonstrated that India has gained an opportunity to strengthen its position as a result of pandemic-related changes and efforts to reduce dependence on China. They examined the institutional mechanisms driving the development of the Indian pharmaceutical industry and concluded that vertical integration, investment in R&D (Research and Development), and participation in the SCRI (Supply Chain Resilience Initiative) are necessary. In the study by T. Sekiyama *et al.* (2025), the strategic directions of trilateral cooperation between Japan, India and the European Union (EU) in the field of economic security and the possibilities for diversifying supplies in the semiconductor and pharmaceutical sectors were analysed. The authors concluded that common standards and institutional mechanisms are essential for countering economic pressure. M. Thite *et al*. (2022) investigated the factors influencing the performance of Indian IT companies in China and analysed the inefficiencies of global talent management strategies. They demonstrated the impact of local market barriers and concluded that flexible Go-to-Market (GTM) approaches, adapted to the specifics of the Chinese market, are necessary. C. Shekhar & P. Rai (2024) analysed the strategic development trajectories of the Indian pharmaceutical sector up to 2030 and forecast its growth, taking into account global demand, innovation potential and government incentives. They examined the sector's structural constraints and concluded that there is a need to strengthen vertical integration and increase R&D funding to maintain its position as the "pharmacy of the world".

However, existing studies have not comprehensively characterised India's overall position within the global technology and pharmaceutical supply system, taking into account its strategic role, institutional mechanisms, interdependencies and transformations of value chains. The aim of the study was to develop a comprehensive analytical model of India's position within the global supply system for technological and pharmaceutical products. The objectives were: to clarify the structural and institutional factors determining its role in technology and pharmaceutical value chains; to analyse the interrelationship between internal barriers and external geoeconomic transformations; to assess the prospects and strategic opportunities for deepening integration into the global supply system.

Materials and Methods

The methodological framework of the study was based on a comprehensive combination of regulatory and institutional analysis, the structural-comparative method, policy analysis, empirical evaluation of official statistical data, and scenario-based forecasting. The initial stage involved the systematisation of regulatory documents and government programmes that determine the development trajectories of India's pharmaceutical, chemical, electronics and related sectors. Materials from reports by the Department of Pharmaceuticals (2021; 2025) were used to analyse sectoral policy. In addition, procedural documents regarding the Production-Linked Incentive (PLI) scheme were integrated to promote local production of Key Starting Materials (KSM) and Active Pharmaceutical Ingredients (Department of Pharmaceuticals, n.d.a), as well as schemes for promoting bulk drug parks (Department of Pharmaceuticals, n.d.b). Data from the Ministry of Commerce & Industry (2025a; 2025b) were used to assess the trade and investment environment. Sectoral analytical data were taken from the reference guides of the Pharmaceuticals Export Promotion Council of India (2024) and the Ministry of Commerce & Industry (2025c). During the formal selection of materials, the following criteria were applied: authenticity (official source of data), currency (2018-2025) and relevance (direct link to pharmaceutical exports, API production and industrial policy).

The second stage involved the analytical processing of quantitative data obtained from inter-ministerial reports (Ministry of Electronics and Information Technology, 2025), interdisciplinary studies (IQVIA, 2018) and industry surveys, in particular the report by the Centre for Market Research & Social Development (2023). The choice of the 2018-2025 timeframe is due to: the availability of transparent statistical data; the introduction of key industrial mechanisms – PLI schemes (Press Information Bureau, 2025; Ministry of Electronics and Information Technology, n.d.); and the launch of large-scale pharmaceutical programmes such as Atmanirbhar Bharat (Ministry of Chemicals and Fertilisers, 2025). The following documents were used for the contextual analysis of international cooperation instruments: Cabinet Secretariat (2023), Office of the Principal Scientific Adviser (n.d.a; n.d.b) and Ministry of External Affairs (n.d.). The documents were examined by analysing structural changes in policies, analysing institutional interactions, and comparing stated government objectives with actual indicators of production, exports and investment. In addition, media sources containing direct quotes from officials and aggregated statistical data were examined, specifically DD News (2025), Economic Times (2025) and IANS (2025), which were used solely to verify official figures.

The third stage involved developing a forecasting model based on scenario logic. The empirical basis was provided by official data on pharmaceutical exports published by the Centre for Market Research & Social Development (2023) and the Ministry of Commerce & Industry (2025c). The scenarios were formulated by extrapolating average annual growth rates and comparing them with the implementation rates of industrial policies: PLI for APIs, PLI for electronics (Press Information Bureau, 2025; Ministry of Electronics and Information Technology, n.d.), Department of Pharmaceuticals (n.d.b), as well as on the basis of investment flows (Ministry of Commerce & Industry, 2025b) and the scale of modernisation of production infrastructure. A structural-functional analysis of institutional mechanisms supporting localisation was applied, comparing regulatory obligations with actual progress in programme implementation and assessing the vulnerabilities of global supply chains. Econometric calculations were performed in Microsoft Excel and Python (statsmodels module) to construct the simplest regression model for forecasting based on CAGR (Compound Annual Growth Rate), as well as for scenario adjustments – depending on the level of API localisation and the dynamics of investment programmes.

Results

India in global technology supply chains. The structural parameters of India's technology industry should be examined through the interrelated dimensions of productivity, integration into international markets, and institutional support. The productivity dimension encompasses the volume of exports of information and communication services, the scale of electronics manufacturing, and gradual progress towards semiconductor production. India's ICT (information and communications technology) service exports in 2023 amounted to approximately USD 162 billion, reflecting the sector's strong export orientation and its importance to the country's balance of payments. The country's total service exports in the 2023-2024 financial year were estimated at between USD 220 billion (for the period April-November 2023) to USD 341.1 billion according to central reports, with a significant share accounted for by IT/software and business services (Mishra *et al.,* 2025). These figures demonstrate India's role as one of the world's leading providers of software and outsourcing services.

Against the backdrop of the service segment's dominance, the manufacturing arm of the technology sector takes on particular significance. It is here that the state is seeking to establish a new foundation for industrial development, promoting a shift from outsourcing models to its own manufacturing clusters. The PLI programme serves as a tool for scaling up the production of mobile devices, consumer electronics and components, which has already led to a significant increase in employment and production volumes (Ministry of Electronics and Information Technology, n.d.). At the same time, the India Semiconductor Mission (Office of the Principal Scientific Adviser, n.d.a) is channelling subsidies and projects towards the establishment of domestic chip fabrication and packaging facilities. Despite significant investment announcements and approved projects, during 2024-2025 the country remains at the investment implementation stage with a limited commercial presence in the production of advanced semiconductors, which results in India's intermediate position in global high-tech component supply chains (Press Information Bureau, 2025). Thus, the manufacturing sector is growing but structurally remains in an intermediate phase between mass assembly and the production of high-tech components.

According to A.S. George (2023), India's role in global outsourcing is based on two interrelated factors: a massive labour pool and cost advantages. The labour pool is formed through the annual influx of technical graduates and a significant proportion of students enrolled in STEM (Science, Technology, Engineering, Mathematics) programmes: according to the All India Survey on Higher Education (AISHE), the total number of students enrolled in STEM disciplines in the 2021-2022 academic year was approximately 9.85 million, whilst the number of graduates during this period reached around 10.7 million, ensuring a steady influx of young professionals into the IT sector and related industries (Ministry of Education, n.d.). However, the quality of training reveals a gap between the large number of graduates and their immediate suitability for work in high-tech production chains, which requires targeted investment in the training and retraining of workers.

The sector's spatial and functional organisation exacerbates uneven development. The cluster-based organisation of productivity is concentrated in several geographical hubs that form innovation and production ecosystems. Bangalore and Hyderabad serve as the main centres for software development, R&D and start-up ecosystems; both cities host global IT companies, research centres and venture ecosystems, which has a multiplier effect on the formation of labour demand and service infrastructure (Subrahmanya, 2021). At the same time, manufacturing clusters for mobile and consumer electronics are emerging in Gujarat, Tamil Nadu, and Andhra Pradesh, where PLI-driven investments concentrate value chains from assembly to export-oriented production (Chewpreecha *et al.*, 2021). Such spatial and functional differentiation provides specific competitive advantages, but at the same time creates regional inequality in access to high-tech assets.

An analysis of competitiveness requires a distinction to be made between three classic factors: human capital, price competitiveness and access to external markets. Human capital is embodied in a large pool of engineering and technical personnel and specialised scientific communities; according to aggregate indicators, India is one of the world's largest "suppliers" of IT talent (Kumar, 2023). However, analytical assessments point to gaps in practical skills ("skill mismatch"), which reduces the marginal productivity per graduate and calls for policies in the field of higher education and vocational training (Majumder & Mukherjee, 2025). India's price competitiveness stems from a combination of relatively low labour costs and the capacity for large-scale production of standard IT services and mass assembly of electronics. This creates appeal for companies seeking to diversify their supply chains (friend-shoring). However, analysis shows that the price advantage is gradually diminishing due to inflationary pressure on labour costs, logistics costs and the need for capital investment to raise production standards. Thus, long-term competitiveness requires a shift from a "cheap labour" model to a model of "efficient localisation with high added value", which involves investment in automation, local manufacturing infrastructure and export logistics (Press Information Bureau, 2025). India's access to international markets through exports, investment and integration into global production networks is being strengthened by a series of intergovernmental and institutional agreements. The India-Japan Semiconductor Supply Chain Partnership – MoC (Singh, 2024), signed in July 2023 between the relevant ministries of India and Japan, aims to establish a resilient semiconductor supply chain. The Memorandum provides for cooperation both between governments (G2G) and between business entities (B2B) in the following areas: joint chip manufacturing projects, research and development, skills training, testing and packaging (ATMP/OSAT), as well as technology exchange (Cabinet Secretariat, 2023). This agreement demonstrates India's ambition to integrate into the global cycle of high-tech component production, rather than merely remaining a final assembler.

The institutional framework for cooperation with the US, notably through the United States-India Initiative on Critical and Emerging Technology – iCET (Office of the Principal Scientific Adviser, n.d.b), provides access to cutting-edge technologies, R&D, and investment in critical technology sectors, including semiconductors, telecommunications and digital infrastructure. iCET was launched in 2022, and as early as January 2023, the first meeting took place in Washington, cementing the framework for cooperation in the field of critical and advanced technologies. Such an initiative creates the conditions for technology transfer, investment and the further integration of Indian enterprises into global value chains. At the same time, these agreements and programmes do not yet address a fundamental structural problem: the lack of a developed domestic ecosystem for the production of advanced semiconductor components and high-tech sub-components. The agreement with Japan and the iCET framework represent an initial stage. Implementing the MoC requires significant investment, time for factory construction, workforce development, certification and integration into global technology chains. By the end of 2025, India still did not have a significant number of commercially active advanced chip factories, which limits its ability to produce high-value components independently. Similarly, although exports of mobile phones and electronics are showing rapid growth, this is predominantly assembly and manufacturing, rather than a full production cycle.

The existing structural parameters create real competitive opportunities for India in the service outsourcing and mass electronics manufacturing segments; at the same time, the transition to the production of high-tech components requires systematic investment in capital, skills and logistics. The PLI policy and the ISM (India Semiconductor Mission) initiative provide the tools for transformation, but their impact will be limited without a simultaneous improvement in the quality of education, the acceleration of infrastructure projects, and access to key imported components at competitive prices. In the short to medium term, India will act as a large-scale hub for services and mass assembly, and its progression up the value chain will depend on the synergy between industrial development policy, education and the attraction of private investment. The institutional design of public policy, geoeconomic shifts and critical barriers to India's positioning in global technology supply chains are reflected in Table 1.

Table 1. Instruments of public policy and their impact on the development of high-technology manufacturing in India

Public policy instrument	Instrument characteristics	Key quantitative indicators	Empirical results
Production-Linked Incentive (PLI) scheme in the electronics sector	Introduction of financial incentives linked to value-added growth for manufacturers of electronics and mobile devices; development of industrial clusters in the states of Tamil Nadu, Uttar Pradesh, and Karnataka	Mobile phone production volumes increased from 60 million units in 2014-2015 to 310 million units in 2021-2022 and 390 million units in 2023-2024; smartphone exports reached USD 11.1 billion in 2023-2024	Strengthening of the national manufacturing base and growth of exports; localisation of production capacities of multinational companies; increase in employment by 200-250 thousand jobs in 2020-2024
India Semiconductor Mission (ISM)	Establishment of an institutional framework for the creation of semiconductor fabrication facilities (fabs), ATMP/OSAT enterprises, and research and development centres; provision of state grants covering 40-70% of capital expenditure	Approved investments in 2023-2025 exceed USD 15 billion; implementation of an ATMP factory project in the state of Gujarat valued at USD 2.75 billion	Formation of initial segments of semiconductor supply chains; expected launch of production in 2025-2026; limited technological autonomy due to the absence of fully operational commercial fabs
Foreign direct investment in high-technology industries	Liberalisation of the foreign investment regime (up to 100% in most electronics sectors); development of industrial parks and special economic zones	FDI inflows in 2023-2024 amounted to USD 44.4 billion; cumulative inflows in 2000-2024 exceeded USD 1.02 trillion; the share of high-technology manufacturing is approximately 25%	Intensification of the creation of joint ventures and contract manufacturing; strengthening of India's position in global value chains; uneven effects due to differentiated levels of regional infrastructure development
Geoeconomic transformations and the friend-shoring strategy	Relocation of global supply chains from China within the strategies of the United States, Japan, and the European Union; focus on the development of critical technologies	Increase in the number of investment and production memoranda in 2022-2024; participation of over 30 Japanese companies in joint projects; launch of the CHIPS Partnership initiative (2023)	Enhancement of India's role as a reliable partner in global supply chains; deeper integration into regional production networks; continued dependence on imports of advanced technologies

Table 1. Continued

Public policy instrument	Instrument characteristics	Key quantitative indicators	Empirical results
Critical development barriers (import dependence, infrastructure, regulatory environment)	Significant dependence on imports of active pharmaceutical ingredients (APIs), microchips, optical components, and materials; shortage of high-technology industrial parks; complexity of permitting procedures and regulatory requirements	The share of API imports from China is approximately 65% in 2023-2024; 47 API items remain critically import-dependent	High vulnerability to external shocks; constraints on the localisation of high-technology manufacturing; limited effectiveness of import substitution programmes (coverage <15% of domestic demand); gradual risk reduction through infrastructure initiatives with long-term effects

Note: ISM – India Semiconductor Mission; ATMP – Assembly, Testing, Marking and Packaging; OSAT – Outsourced Semiconductor Assembly and Test; API – Active Pharmaceutical Ingredient; CHIPS – Creating Helpful Incentives to Produce Semiconductors

Source: compiled by the author based on N. Graham (2023), Ministry of Electronics and Information Technology (2025), Economic Times (2025), DD News (2025), IANS (2025), T. Sanjay (2025), Ministry of Commerce & Industry (2025b)

The optimisation of India's national technology policy for 2020-2025 demonstrates a shift away from "assembly of final products" towards efforts to establish a structurally complete technology ecosystem. The PLI has been the main catalyst for growth in the production of mobile phones and electronics. However, the effects of the PLI remain concentrated in the lower segments – assembly and individual components. With the launch of the India Semiconductor Mission, a structural mechanism has emerged for the transition from simple assembly to the formation of a domestic semiconductor industry. The US and Japan view India as a "reliable" political and economic hub capable of partially replacing the Chinese segment of production networks (Ramanathan *et al.*, 2024). However, China's dominance in the supply of APIs, semiconductor materials and components remains firmly established: according to N. Graham (2023), the share of Chinese APIs in 2023-2024 stood at around 65%, and even large-scale localisation programmes have not yet reduced this figure. Overall, India's institutional design for 2020-2025 demonstrates significant progress in attracting investment, developing clusters and diversifying production; however, the lack of deep localisation of high-tech components and the persistence of critical import dependence define the limits of India's technological sovereignty in the coming years. The geo-economic trend of "friend-shoring" creates a favourable context for India: there is a willingness among global partners to diversify risks arising from excessive dependence on China by locating assembly lines and part of production in friendly jurisdictions. Policy initiatives and analytical recommendations from partner countries (the US, Japan, the EU) are expanding access to financial and technological resources, whilst stipulating the need to comply with established standards and regulatory requirements (environmental standards, traceability of production processes, due diligence of supply chains), which raises barriers to entry for Indian manufacturers lacking modern technological platforms.

India's pharmaceutical sector within the global supply chain. India's role in the global pharmaceutical system is defined by a combination of large-scale production of generic medicines, high export activity and government policy aimed at reducing dependence on imports of critical active pharmaceutical ingredients. According to official data from the Department of Pharmaceuticals (2025), the total market size of the pharmaceutical industry in the 2023-2024 financial year was estimated at approximately USD 50 billion, whilst the value of exports stood at around INR 2.19 trillion (approximately USD 27.85 billion). This export-oriented profile is confirmed by the trends: according to official data from the Ministry of Commerce & Industry (2025a), exports in the "Drugs & Pharmaceuticals" category rose from USD 27.85 billion in the 2023-2024 financial year to approximately USD 30.47 billion in 2024-2025. This trend demonstrates a steady recovery and growth in exports following the pandemic. In terms of generic drug supply, India accounts for around 20% of the global volume (by unit), as confirmed by both specialist analytical reviews and industry reports; this makes the country a key "supplier of affordable medicines" for low- and middle-income countries (IQVIA, 2018).

The export structure is distinctive: the majority of export value is generated by finished formulations, whilst the production of critical active pharmaceutical ingredients (APIs) is partly dependent on imports of precursors and KSMs. A government audit and thematic studies have identified a list of approximately 56-58 critical APIs/KSMs for which there is significant import dependency, and for around 45 items, imports cover almost the entire domestic demand (Centre for Market Research & Social Development, 2023). To reduce this vulnerability, the government has introduced a package of measures: a phased PLI scheme for bulk drugs (Department of Pharmaceuticals, n.d.a) and the Promotion of Bulk Drug Parks initiative (Department of Pharmaceuticals, n.d.b), launched with the aim of localising production, creating shared infrastructure and reducing production costs. Budget allocations under the PLI scheme for the active pharmaceutical ingredients (bulk drugs) sector amount to INR 69.4 billion, whilst a total of INR 30 billion has been earmarked for the implementation of the Bulk Drug Parks programme. A number of projects have already been submitted and approved in the states of Gujarat, Himachal Pradesh, and Andhra Pradesh (Ministry of Chemicals and Fertilisers, 2025). The geography of Indian pharmaceutical exports (2023-2025) is shown in Table 2.

Table 2. Geography of Indian pharmaceutical exports (2023-2025) and key risks/policy instruments

Indicator	Characteristics
Total pharmaceutical export volume in the 2023-2024 financial year	Approximately USD 27.85 billion (April 2023 – March 2024)
Total pharmaceutical export volume in the 2024-2025 financial year	USD 30.47 billion, representing a 9.39% increase compared to the 2023-2024 financial year
Main importer of Indian pharmaceutical products (2023-2024)	United States – approximately USD 7.10 billion (largest market by value)
India's share in global supplies of generic medicines	Approximately 20% of global volume (according to international analytical estimates)
Dependence on imports of active pharmaceutical ingredients (APIs) from China	Approximately 65-70% of API imports originate from China; for certain items – up to 100%
Volume of vaccine supplies under the "Vaccine Maitri" initiative	72.34 million doses delivered to 94 countries as of 29 November 2021; significant impact on strengthening "vaccine diplomacy" in 2021-2022
Production Linked Incentive (PLI) scheme for the bulk drugs/API sector	Total funding amounts to INR 69.4 billion
Programme for the establishment of pharmaceutical parks (Bulk Drug Parks/Pharma Parks)	Some parks approved in principle, with several projects under implementation; programmes are aimed at infrastructure development, including centralised wastewater treatment and logistics
Key risks in sectoral development	High dependence on API imports; non-compliance with GMP standards among some manufacturers; tightening environmental requirements leading to increased capital expenditure

Note: API – Active Pharmaceutical Ingredient; GMP – Good Manufacturing Practice
Source: compiled by the author based on Pharmaceuticals Export Promotion Council of India (2024), Y. Yang *et al*. (2024), Ministry of Commerce (2025a), Dhyeya IAS (2025), Ministry of External Affairs (n.d.)

An analytical examination of the geographical structure of Indian pharmaceutical exports in 2023-2025 reveals a shift in India's role from a supplier of affordable generics to a key component of global supply chain security. The pattern evident in the table lies in the dominance of the US market as a stable and high-margin export destination. This structure not only reflects the competitiveness of Indian manufacturers in the market but also indicates the growing dependence of global healthcare systems on Indian supplies, a trend that has intensified in the wake of the pandemic. One of the structural conclusions drawn from the table is that the expansion of exports is taking place against a backdrop of paradoxical technological asymmetry: a high level of exports of finished pharmaceutical products coexists with critical import dependence on Chinese APIs and KSMs. This imbalance is systemic in nature: it increases technological, logistical and geo-economic risks, making even high-tech exports vulnerable to external shocks. An important element in interpreting Table 2 is the strategic dimension of India's pharmaceutical diplomacy. Data on the "Vaccine Maitri" programme (Ministry of External Affairs, n.d.) show that the supply of over 72 million vaccine doses in 2021 to 94 countries served as an instrument of soft power and a factor in strengthening India's position in Africa, Latin America and the Middle East. This component has significantly expanded the geography of exports and raised expectations regarding India's continued participation in global health interventions, particularly in the field of vaccines and biosimilars. Thus, the export geography presented in Table 2 reflects not only trade but also political and diplomatic trajectories.

Despite the measures outlined, two systemic constraints remain. The first is the high degree of import dependency for certain APIs/KSMs (estimates suggest that the share of imports from China reaches 60-70% for certain items), which creates a risk of supply chain disruptions during external shocks (Department of Pharmaceuticals, 2021). The second is operational and regulatory challenges: some enterprises need to update their quality systems and GMP certification to enter premium markets (the US, the EU), whilst environmental standards are becoming a factor in capital investment in the API production process (wastewater treatment in Bulk Drug Parks). Delays in the implementation of infrastructure projects and the need to comply with international standards are slowing the transition to the production of more complex active ingredients. In this regard, policy should combine short- and medium-term incentives: prioritising funding for greenfield projects for a list of critical APIs; completion of Bulk Drug Parks infrastructure (to eliminate environmental and logistical bottlenecks); development of PRIP projects to strengthen R&D and technology transfer; and the scale of training programmes for technological production. The effectiveness of these measures is already reflected in the initial results of the PLI: reports indicate the creation of capacity for several API items (as of August-September 2025) and the approval of a number of Bulk Drug Parks projects (Ministry of Chemicals and Fertilisers, 2025). In terms of market implications, this means that India retains its status as a global hub for the supply of generics and vaccines, whilst undergoing a transformation towards a more innovative and technically self-sufficient profile. For sustainable growth at the upper echelons of global value chains, the consistent implementation of API localisation, infrastructure modernisation and the harmonisation of regulatory standards with the requirements of major export markets are essential.

The Indian pharmaceutical industry is demonstrating steady export growth: according to the Ministry of Commerce & Industry (2025c), exports amounted to approximately USD 27.9 billion in the 2023-2024 financial year and USD 30.47 billion in 2024-2025. This indicates a positive trend and growing global demand for

Indian medicines. API localisation suggests that increased production capacity and intensified government initiatives will significantly reduce the share of imports. The share of API imports is based on estimates that, as of 2023-2024, it exceeds 65-70% (Centre for Market Research & Social Development, 2023). Based on these baseline figures, three scenarios have been developed up to 2030, as shown in Table 3.

Table 3. Scenario framework for the development of pharmaceutical exports and API import dependence for India up to 2030

Scenario	Assumptions regarding export growth and API localisation	Projected exports in 2030, USD billion	Expected API import dependence in 2030, %
Baseline	Continuation of export growth at the current rate, minimal localisation of APIs	~47-48	~63
Moderate	Moderate API localisation combined with the launch of at least one Bulk Drug Park	~41	~50-55
Ambitious	Active API localisation, launch of ⩾1 fully operational park, and coverage of a portion of critical APIs	~53-55	~40-45

Source: compiled by the author based on Centre for Market Research & Social Development (2023), Ministry of Commerce & Industry (2025c), Press Information Bureau (2025), Ministry of Commerce & Industry (2025b), Department of Pharmaceuticals (n.d.b), Ministry of Electronics and Information Technology (n.d.)

The upward trend in exports is consistent: the latest figures show record levels – in the 2024-2025 financial year, pharmaceutical exports amounted to approximately USD 30.47 billion, an increase of 9.4% compared to the previous year. This fact reinforces India's position as a leading supplier of generics and finished dosage forms in global markets, for example, in the segment of affordable medicines for middle- and low-income countries. However, as existing reports and assessments show, dependence on API imports remains critical: even with active localisation policies, the share of imports remains high. This means that the current growth in exports is based primarily on existing production lines and imported raw materials, rather than on full raw material self-sufficiency. In the baseline scenario, even if exports continue to grow, without an increase in domestic API production, import dependency will remain high – at around 63%. For the pharmaceutical industry, this ratio creates systemic vulnerability: any disruptions to supplies from abroad (logistical disruptions, export bans, price changes) could seriously disrupt both production and exports. The moderate scenario reduces this vulnerability to a moderate level – around 50-55%. This creates an acceptable balance between exports and localisation, meeting a significant portion of the demand for APIs through domestic production and reducing the risks of dependency. Such a scenario can ensure stability and gradual growth without excessive risk. The most optimistic – ambitious – scenario offers the theoretical prospect of reducing import dependency to 40-45%. This improves the strategic resilience of the pharmaceutical system and reduces systemic risks – however, even under this scenario, complete independence from API imports by 2030 is not guaranteed. This is due to two main factors: some APIs and precursors remain more cost-effective to import than to produce locally; and the time lags between investment, production start-up, reaching full capacity and product certification, which creates a time gap between policy and its actual impact.

Thus, the results of the scenario-based forecasting have political and strategic implications. To ensure India's sustainable pharmaceutical autonomy, it is necessary not only to support exports but also to systematically invest in API production, promote industrial parks, ensure environmental and regulatory standards, and reduce barriers to capital investment in this sector. Such a policy will allow for the combination of competitive export activity with increased raw material resilience. Overall, provided sufficient measures are implemented, India has a realistic prospect of becoming a more self-sufficient pharmaceutical hub by 2030 – with a reduced risk of dependence on external API sources and a consolidated position in global supply chains. At the same time, maintaining an export-only model without localising the raw material base leaves the country vulnerable to global shocks, underscoring the importance of a comprehensive industrial policy.

Discussion

The findings of the study enabled a comprehensive analysis of India's position within global technology and pharmaceutical supply chains. The comparison allowed for an assessment of the effectiveness of digital and physical infrastructure, government programmes for localising production, innovation networks and strategic international partnerships. The analysis was conducted in the context of the dual nature of the technology sector, the dependence of pharmaceutical production on imports, and the impact of external geoeconomic factors on India's integration into global value chains. The study by N. Yoshino *et al*. (2022) provided empirical evidence of the positive spillover effects of the development of information and communication technology infrastructure in India, in particular demonstrating a direct link between the growth in the number of mobile subscribers and an increase in local tax revenues. The present study confirmed these findings, revealing that digital infrastructure stimulated economic activity in the technology sector, helping to attract private investment and boost software production to USD 162 billion by 2023. At the same time, the analysis showed that the effectiveness of government incentives in the manufacturing sector remained limited due to systemic barriers, including a shortage of skilled labour and long investment realisation cycles, which was partly consistent with the assessment by N. Yoshino *et al.* regarding the need for a stable mechanism for distributing additional tax revenues to support investment.

The systematic review by K. Singh *et al.* (2025) focused on technology transfer in tablet manufacturing, highlighting the role of innovative methods (artificial intelligence, 3D printing) and the optimisation of production processes, as well as internal challenges and government initiatives to strengthen India's position as the "pharmacy of the world". The present study concurred with these findings, establishing that the pharmaceutical sector demonstrated significant export growth (USD 30.47 billion in the 2024-2025 financial year) and a share of around 20% in global generic drug supplies, yet critical dependence on API imports remained high (65-70%). The analysis confirmed that government programmes, notably the PLI for bulk drugs and the Bulk Drug Parks scheme, created conditions for localising production, yet full self-sufficiency remained elusive. A study by A. Sharma *et al.* (2023), conducted using the intuitionistic fuzzy DEMATEL method, classified the risks facing the pharmaceutical industry, identifying financial, operational and market factors as critical to the sector's stability. The present study confirmed the relevance of these risk categories, finding that strategic initiatives, including the "Vaccine Maitri" pharmaceutical diplomacy, mitigated some external risks; however, internal challenges, particularly logistical and human resource-related ones, remained significant obstacles to sustainable growth. The findings aligned with A. Sharma *et al*., demonstrating that resource optimisation and systemic modernisation remain necessary for enhancing the competitiveness of pharmaceutical clusters in the global market.

Research by S. Shukla *et al.* (2023) demonstrated that the use of information and communication technologies in India's agricultural supply chains significantly reduced risks associated with volume uncertainty, fostered collaboration within the supply chain, and enhanced its efficiency, particularly in rural areas. This study concurred with this finding, establishing that digital infrastructure in the technology sector also stimulated economic activity and the development of ICT services, leading to software exports of USD 162 billion in 2023 and an increase in mobile device production to 390 million units in 2023-2024. At the same time, it was found that the impact of government programmes to stimulate the production of high-tech components remained limited due to a shortage of practical skills and systemic barriers, which complemented the findings of S. Shukla *et al*. regarding the need for a comprehensive approach to digitalisation and integration into supply chains. C. Jean's (2022) forecast identified India as a promising player in global supply chains due to its demographic potential, geopolitical context and evolution from a specialisation in software to manufacturing. The study confirmed this trajectory, noting the dual nature of the technology sector, where the dominance of ICT services coexisted with an intermediate phase of high-tech component manufacturing. However, the results showed that the transition to advanced semiconductor manufacturing faced systemic constraints, whilst external initiatives, such as the agreement with Japan and the US-led iCET initiative, created favourable conditions but did not address internal weaknesses. This assessment elaborated on C. Jean's forecast, pointing to the need to strike a balance between external potential and the industry's internal readiness.

A study by R.K. Joseph & R. Arun Kumar (2022) analysed the early experience of the first phase of the PLI scheme in the pharmaceutical sector, highlighting the industry's limited interest due to the economic logic of global supply chains and its reliance on imports of low-cost materials. This study concurred with this conclusion, noting that India's export capacity grew in the 2024-2025 financial year whilst remaining critically dependent on API imports from China. At the same time, government initiatives, including the PLI and Bulk Drug Parks, partially mitigated external risks, whilst the "Vaccine Maitri" programme expanded geopolitical influence; however, scenario modelling up to 2030 demonstrated the impossibility of achieving full raw material self-sufficiency without a comprehensive strategy for technological development and resource optimisation. Thus, the present study confirmed and elaborated on the findings of R.K. Joseph & R. Arun Kumar, emphasising the need to account for the economic logic of global pharmaceutical supply chains in strategic planning.

Research by A. Gosain & S. Ray (2025) revealed that networks of innovators in the Indian pharmaceutical industry, based on USPTO (United States Patent and Trademark Office) patents, were highly active in global value chains, yet were characterised by low geographical dispersion and limited integration with international research centres and universities. The present study confirmed these findings, noting that innovative activity in the pharmaceutical sector did not always correlate with effective integration into global networks. Despite the growth in exports and India's participation in the "Vaccine Maitri" programme, domestic innovation structures remained fragmented, and local private firms demonstrated limited capacity for full participation in international scientific and technological exchange. These findings highlighted that achieving a high level of competitiveness in the pharmaceutical sector required not only the stimulation of production and exports, but also the deeper integration of local innovation networks into global structures.

An analysis by K. Tokas (2022) using the CAGE model showed that Japan's choice between India and China as offshore destinations for IT services was a compromise: China had the edge in terms of cultural and geographical proximity, whilst India had advantages in administrative and economic aspects, including a shared language, a stable legal system and relatively low labour costs. The study confirmed these findings, noting that India's technology sector was characterised by duality: the dominance of ICT services and software exports, valued at USD 162 billion in 2023, coexisted with an intermediate phase of high-tech component manufacturing. Institutional and geoeconomic initiatives, including the semiconductor agreement with Japan and the iCET initiative with the US, created favourable external conditions for integration; however, systemic internal barriers, such as skills shortages and a long investment realisation cycle, limited the full realisation of potential. The identified synergy between administrative stability and economic efficiency confirmed K. Tokas's predictions, whilst detailing the internal factors that hindered progress up the value chain.

The analysis showed that the development of digital infrastructure and the ICT sector had a positive spillover effect on economic activity, yet internal systemic barriers limited the full realisation of the technology sector's potential. In the pharmaceutical sector, the results confirmed the limited effectiveness of government localisation programmes and dependence on imports of active ingredients. Thus, the study provided a more detailed picture of the interaction between internal and external factors, outlining the constraints and potential avenues for enhancing India's competitiveness in global technology and pharmaceutical supply chains.

Conclusions

The findings of the study have significantly expanded the understanding of India's position and trajectory within global supply chains for technology and pharmaceutical products, revealing the complex interplay of structural, institutional and geoeconomic factors that have shaped its current profile. In the technology sector, the analysis clearly revealed a duality, where dominance in the field of information and communication services and software exports, reaching a volume of around USD 162 billion in 2023, coexisted with an intermediate and transformative phase in the manufacturing sector. Government intervention programmes demonstrated a significant catalytic effect, contributing to the rapid growth of mobile device production to 390 million units in 2023-2024 and attracting capital investment in the semiconductor industry amounting to over USD 15 billion, however, these efforts did not lead to immediate structural change. The country remained positioned primarily as a hub for mass assembly and global outsourcing services, whilst the transition to the production of high-tech components, particularly advanced semiconductors, faced systemic barriers, including a lengthy investment realisation cycle, a skills mismatch, and critical dependence on imports of key materials and components. The geoeconomic trend of "friend-shoring" and institutional initiatives, such as the semiconductor agreement with Japan and the US-led iCET initiative, created favourable external conditions for integration, yet they did not address fundamental internal weaknesses.

According to available statistics, India plays a strong and growing role in the pharmaceutical sector as the "pharmacy of the world", with exports rising to USD 30.47 billion in the 2024-2025 financial year and a share of around 20% of global generic drug supplies by volume. However, this export prowess has proved to be built on a paradoxical and vulnerable foundation – a critical dependence on imports of active pharmaceutical ingredients (APIs) from China, which in some cases has reached 65-70%. Government policy responded to this threat with strategic initiatives such as the PLI for bulk drugs and the scheme to establish Bulk Drug Parks, aimed at localising API production. Pharmaceutical diplomacy, epitomised by the "Vaccine Maitri" programme, which has supplied over 72 million doses of vaccines to 94 countries, has expanded India's geopolitical influence and cemented its image as a reliable supplier within global health systems for developing countries. Scenario modelling of the sector's development up to 2030 demonstrated that even under an ambitious scenario of active intervention, import dependence on APIs could only be reduced to 40-45 per cent, indicating that full raw material self-sufficiency would be unattainable in the near future, as well as the need to balance the economic viability of imports with the strategic need for sustainability.

India's competitiveness has been based on traditional advantages such as a large labour pool and relatively low costs, but moving up the value chain requires systematic modernisation of the education system, acceleration of infrastructure projects, and deepening of technology transfer through international partnerships. Prospects for further research lie in conducting a comparative quantitative analysis of the productivity of various Indian technology and pharmaceutical clusters with similar hubs in Southeast Asian countries to identify the detailed factors driving effective integration into global networks.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

References

[1] Bjerke, L. (2022). Antibiotic geographies and access to medicines: Tracing the role of India's pharmaceutical industry in global trade. *Social Science & Medicine*, 312, article number 115386. doi: 10.1016/j.socscimed.2022.115386.

[2] Cabinet Secretariat, Government of India. (2023). *Cabinet approves Memorandum of Cooperation between India and Japan on Japan-India Semiconductor Supply Chain Partnership*. Retrieved from https://www.pib.gov.in/PressReleasePage.aspx?PRID=1970782&reg=3&lang=2.

[3] Centre for Market Research & Social Development. (2023). *Survey for novel/innovative and cost-effective technologies for route of synthesis to decrease the cost of production of APIs which are currently being imported to reduce import dependency (Final report)*. Retrieved from https://surl.li/utdwui.

[4] Chewpreecha, U., Prabhu, V.S., & Mukhopadhyay, K. (2021). Impact of electronics system and design manufacturing and IT policy in selected regions. In K. Mukhopadhyay (Ed.), *Economy-wide assessment of regional policies in India: Applications of E3-India model* (pp. 155-191). Cham: Springer. doi: 10.1007/978-3-030-75668-0_6.

[5] Das, S., & Sarma, A. (2021). Growth behaviour of India's export of services, 1975-2018. *Foreign Trade Review*, 56(3), 329-348. doi: 10.1177/0015732520982187.

[6] DD News. (2025). *India cruising towards $300 billion electronics production by 2026: Centre*. Retrieved from https://ddnews.gov.in/en/india-cruising-towards-300-billion-electronics-production-by-2026-centre/.

[7] Department of Pharmaceuticals, Ministry of Chemicals & Fertilizers, Government of India. (2021). *Annual report 2020-21*. Retrieved from https://surl.li/stzgpn.

[8] Department of Pharmaceuticals, Ministry of Chemicals and Fertilizers, Government of India. (2025). *Annual report 2024-25*. Retrieved from https://surl.li/hrnihl.

[9] Department of Pharmaceuticals, Ministry of Chemicals and Fertilizers, Government of India. (n.d.a). *Production Linked Incentive (PLI) scheme for promotion of domestic manufacturing of critical Key Starting Materials (KSMs)/drug intermediates and Active Pharmaceutical Ingredients (APIs) in the country*. Retrieved from https://pharma-dept.gov.in/schemes/production-linked-incentive-pli-scheme-promotion-domestic-manufacturing-critical-key.

[10] Department of Pharmaceuticals, Ministry of Chemicals and Fertilizers, Government of India. (n.d.b). *Scheme for promotion of Bulk Drug Parks*. Retrieved from https://pharma-dept.gov.in/schemes/scheme-promotion-bulk-drug-parks.

[11] Dhyeya IAS. (2025). *India's pharmaceutical and medical devices sector: Growth, investment, and policy support*. Retrieved from https://surl.li/dzfbkk.

[12] Economic Times. (2025). *PLI for electronics manufacturing attracted Rs 10,213 crore investments: Minister*. Retrieved from https://surl.lu/vodmgy.

[13] George, A.S. (2023). Brain drain or brain gain: Assessing the costs and benefits of India's manpower exports. *Partners Universal International Innovation Journal*, 1(6), 19-37. doi: 10.5281/zenodo.10257669.

[14] Ghosh, D., Mehta, P., & Avittathur, B. (2021). Supply chain capabilities and competitiveness of high-tech manufacturing start-ups in India. *Benchmarking: An International Journal*, 28(5), 1783-1808. doi: 10.1108/BIJ-12-2018-0437.

[15] Gosain, A., & Ray, S. (2025). Integration of Indian inventor networks in global value chains in pharmaceuticals industry. *Innovation and Development*, 15(3), 519-538. doi: 10.1080/2157930X.2024.2413750.

[16] Graham, N. (2023). *The US is relying more on China for pharmaceuticals – and vice versa*. Retrieved from https://www.atlanticcouncil.org/blogs/econographics/the-us-is-relying-more-on-china-for-pharmaceuticals-and-vice-versa/.

[17] Gupta, H., & Kayande, R.A. (2023). Enhancing pharmaceutical supply chain resilience: A study of pharmaceutical companies in multiple geographies. *Indian Journal of Pharmaceutical Education and Research*, 57(2), 603-611. doi: 10.5530/ijper.57.2.74.

[18] IANS. (2025). *PLI scheme for electronics manufacturing has created over 1.37 lakh direct jobs: Govt*. Retrieved from https://cfo.economictimes.indiatimes.com/news/pli-scheme-for-electronics-manufacturing-has-created-over-1-37-lakh-direct-jobs-govt/118114479.

[19] IQVIA. (2018). *Winning in the Indian pharmaceutical market (White paper)*. Retrieved from https://www.iqvia.com/-/media/iqvia/pdfs/india/winning-in-the-indian-pharmaceutical-market.pdf?_=1610873724999&.

[20] Jean, C. (2022). A study of India's role and importance in future global supply chains. *Supply Chain and Sustainability Research (SCSR)*, 1(1), 55-70. doi: 10.14456/scsr.2022.4.

[21] Joseph, R.K., & Arun Kumar, R. (2022). *Reducing import dependence on APIs in the Indian pharmaceuticals sector: An analysis of early experience of the PLI phase-I scheme (ISID Working Paper No. 239)*. doi: 10.2139/ssrn.4008180.

[22] Kumar, N. (2023). Unlocking India's potential in Industrial Revolution 4.0: National innovation system, demography, and inclusive development. *Indian Public Policy Review*, 4(3), 67-87. doi: 10.55763/ippr.2023.04.03.003.

[23] Majumder, R., & Mukherjee, D. (2025). *Skill mismatch in Indian labour market and its impact on productivity: A panel data analysis*. doi: 10.2139/ssrn.5423594.

[24] Ministry of Chemicals and Fertilizers, Government of India. (2025). *A dose of Atmanirbhar Bharat: How Make in India is transforming India's global pharmaceutical footprint*. Retrieved from https://www.pib.gov.in/PressReleasePage.aspx?PRID=2121425.

[25] Ministry of Commerce & Industry, Government of India. (2025a). *The cumulative exports (merchandise & services) during FY 2024-25 (April-March) is estimated to grow by 5.50% at US$ 820.93 Billion, as compared to US$ 778.13 Billion in FY 2023-24 (April-March)*. Retrieved from https://www.pib.gov.in/PressReleasePage.aspx?PRID=2122016&reg=3&lang=2.

[26] Ministry of Commerce & Industry, Government of India. (2025b). *India records USD 81.04 billion FDI inflow in FY 2024-25*. Retrieved from https://www.pib.gov.in/PressReleasePage.aspx?PRID=2131716&reg=3&lang=2.

[27] Ministry of Commerce & Industry, Government of India. (2025c). *Pharmaceuticals Export Promotion Council of India. Hand book 2025*. Retrieved from https://pharmexcil.com/uploadfile/Hand_Book_14_06_2025_final.pdf.

[28] Ministry of Education, Government of India. (n.d.). *Ministry of Education releases All India survey on higher education (AISHE) 2021-2022*. Retrieved from https://www.pib.gov.in/PressReleasePage.aspx?PRID=1999713.

[29] Ministry of Electronics and Information Technology, Government of India. (2025). *Annual report 2024-2025*. Retrieved from https://www.meity.gov.in/static/uploads/2024/12/10fcadec462c330211502fed3d24ea83.pdf.

[30] Ministry of Electronics and Information Technology, Government of India. (n.d.). *Production Linked Incentive Scheme (PLI) for large scale electronics manufacturing*. Retrieved from https://www.meity.gov.in/offerings/schemes-and-services/details/production-linked-incentive-scheme-pli-for-large-scale-electronics-manufacturing-gNyMDOtQWa.

[31] Ministry of External Affairs, Government of India. (n.d.). *Vaccine Maitri*. Retrieved from https://www.mea.gov.in/vaccine-maitri.htm.

[32] Mishra, D., Kedia, M., Reddy, A., Fernandez, C., Shukla, S., Ramnath, K., & Vanguri, S. (2025). *Estimation and measurement of India's digital economy*. New Delhi: Indian Council for Research on International Economic Relations (ICRIER).

[33] Office of the Principal Scientific Adviser to the Government of India. (n.d.a). *India Semiconductor Mission (ISM)*. Retrieved from https://surl.li/edwtlk.

[34] Office of the Principal Scientific Adviser to the Government of India. (n.d.b). *US – India TRUST Initiative (formerly iCET)*. Retrieved from https://www.psa.gov.in/icet.
[35] Palit, A., & Bhogal, P. (2022). COVID19, supply chain resilience, and India: Prospects of the pharmaceutical industry. In A. Palit (Ed.), *Globalisation impacts: Perspectives from the Global South* (pp. 159-181). Singapore: Springer. doi: 10.1007/978-981-16-7185-2_9.
[36] Pharmaceuticals Export Promotion Council of India. (2024). *Hand book 2024*. Retrieved from https://pharmexcil.com/uploads/files/Hand_Book_16_08_2024.pdf.
[37] Press Information Bureau, Government of India. (2025). *PLI scheme: Powering India's industrial renaissance*. Retrieved from https://www.pib.gov.in/PressNoteDetails.aspx?ModuleId=3&NoteId=155082.
[38] Ramanathan, A., Manur, A., Pande, A., Karandikar, M., & Pradhan, S. (Eds.). (2024). *US-India economic ties: To the next level and beyond*. Washington: Hudson Institute.
[39] Ray, P., Ray, S., & Kumar, V. (2023). A knowledge-based view of emerging market firm internationalization: The case of the Indian IT industry. *Journal of Knowledge Management*, 27(4), 1086-1108. doi: 10.1108/JKM-08-2021-0660.
[40] Sanjay, T. (2025). *Economic survey: PLI drove electronics manufacturing to ₹9.52 lakh crore in FY24*. Retrieved from https://www.outlookbusiness.com/budget/economic-survey-pli-drove-electronics-manufacturing-to-952-lakh-crore-in-fy24.
[41] Sekiyama, T., Panda, J., & Shikata, T. (Eds.). (2025). *Trilateral imperatives: Japan-India-EU cooperation on economic security*. New Delhi: Pentagon Press.
[42] Sharma, A., Kumar, D., & Arora, N. (2023). Analyzing pharmaceutical industry risks under uncertainty for performance improvement: An Indian scenario. *Business Process Management Journal*, 29(7), 1961-1988. doi: 10.1108/BPMJ-03-2023-0203.
[43] Shekhar, C., & Rai, P. (2024). *Indian pharmaceutical industry: Past, present, and future outlook (2024-2030)*. doi: 10.2139/ssrn.5162548.
[44] Shukla, S., Kapoor, R., Gupta, N., Garza-Reyes, J.A., & Kumar, V. (2023). Role of information and communication technology in mitigating risks in Indian agricultural supply chains. *Supply Chain Management: An International Journal*, 28(3), 544-558. doi: 10.1108/SCM-08-2021-0386.
[45] Singh, G. (2024). *India-Japan semiconductor supply chain partnership*. New Delhi: Indian Council of World Affairs.
[46] Singh, K., Nainwal, N., & Chitme, H.R. (2025). A review on recent advancements in pharmaceutical technology transfer of tablets from an Indian perspective. *Annales Pharmaceutiques Françaises*, 83(2), 211-227. doi: 10.1016/j.pharma.2024.08.001.
[47] Subrahmanya, M.B. (2021). *Entrepreneurial ecosystems for tech start-ups in India: Evolution, structure and role (Vol. 1)*. Berlin: De Gruyter. doi: 10.1515/9783110679359.
[48] Thite, M., Rammal, H.G., & Ferreira, J.J.M. (2022). Talent management in the "new normal" – case study of Indian IT services multinationals in China. *Thunderbird International Business Review*, 65(1), 131-141. doi: 10.1002/tie.22247.
[49] Tokas, K. (2022). IT services offshoring from Japan: A multi-dimensional comparative analysis between India and China. *Journal of Global Operations and Strategic Sourcing*, 15(1), 1-27. doi: 10.1108/JGOSS-07-2020-0033.
[50] Yang, Y., Husain, L., & Huang, Y. (2024). China's position and competitiveness in the global antibiotic value chain: Implications for global health. *Globalization and Health*, 20, article number 87. doi: 10.1186/s12992-024-01089-x.
[51] Yoshino, N., Siregar, T.H., Agarwal, D., Ram, K.E.S., & Azhgaliyeva, D. (2022). *An empirical evidence and proposal on the spillover effects of information and communication technology infrastructure in India (ADBI Working Paper No. 1330)*. Tokyo: Asian Development Bank Institute (ADBI). doi: 10.56506/DWEH4685.