

Article

Comparative Trade Performance of India's Pharmaceutical Industry and Leading Global Exporters: A Multi-Index Analysis at the Sectoral and Product Levels

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Abstract

This study examines the comparative trade performance of India's pharmaceutical industry vis-à-vis leading global pharmaceutical exporters, particularly the United States, Germany, and Switzerland, over the period 2005–2024, using sectoral (HS 30) and product-level (HS 3001–3006) trade data. The study employs a multi-index analytical framework integrating symmetric and weighted measures of revealed comparative advantage to evaluate export competitiveness and import dependence while accounting for product-weight distortions. The findings reveal that India maintains a positive and strengthening trade balance in the pharmaceutical sector, primarily driven by low-cost generics and bulk formulations. However, India continues to lag behind advanced economies in innovation-intensive segments such as biologics and patented formulations. The Weighted Revealed Export Advantage (WRXA) estimates indicate that India's export competitiveness remains relatively limited and is still largely dependent on cost efficiency rather than innovation-led exports. In contrast, the Weighted Revealed Trade Advantage (WRTA) values consistently demonstrate strong competitiveness at the sectoral level. This study argues that India's long-term export competitiveness cannot rely solely on generic pharmaceuticals and, therefore, requires strategic investments in biologics, advanced APIs, research and development, and innovation ecosystems. The findings further emphasise the need for policy support aimed at R&D financing, active pharmaceutical ingredient (API) self-sufficiency, and export diversification to transform India into a globally competitive hub for complex generics and high-value pharmaceutical products.

Keywords: pharmaceutical industry; export competitiveness; India; RCA; RMA; RXA; RTA; symmetric and weighted indices; biologics; innovation trade

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1. Introduction

The global pharmaceutical sector stands as an anchor of both sustainable public health and robust economic activities, underpinning technological progress and trade in high-value pharmaceutical products measurable in hundreds of billions of dollars. Worldwide drug exports surpassed 850 billion U.S. dollars in 2025, making the sector not merely an

option for industrial planning; rather, it has become fundamental. Trade flows of pharmaceutical products hinge on the ability to innovate, manage costs, adhere to stringent and evolving regulations, and absorb disruptive external shocks like the pandemic. The COVID-19 pandemic demonstrated that pharmaceutical manufacturing capacity serves as a core economic resilience building block and a strategic lever of geopolitical power, accelerating export competitiveness (Chaudhuri, 2021; World Health Organization [WHO], 2024). Viewed through this lens, India has consolidated a decade-long ascendance in medicines by serving as the “Pharmacy of the World”, supplying systematically high-quality, cost-effective generics to more than two hundred destinations around the world, including major markets such as the USA, Europe, Japan, and Australia. According to the India Private Equity Report 2024, the Indian pharmaceutical industry’s sustained cost advantage depends on multi-plant manufacturing economies of scale, strong supply-chain integration for active pharmaceutical ingredients, and a highly trained workforce in research, process development, and compliance. Nevertheless, despite supplying almost 20% by volume of global generic doses, the nation has yet to translate those volumes into a commensurate export-value share, still ranking 11th in revenue, indicating considerable scope for upgrading intellectual property, expanding patent-driven exports, and strengthening collaborations through premium multinational joint ventures.

Advanced markets, led by the United States, Germany, and Switzerland, command the high-value, innovation-centric tiers of the pharmaceutical sector by cultivating robust R&D networks, building extensive patent portfolios, and harnessing powerful brands (Maskus & Saggi, 2014). India’s pharmaceutical exports, by contrast, remain dominated by low-margin generics, achieving only modest inroads into the higher-value domains of patent-protected formulations, biologics, and other innovation-intensive categories (Chaturvedi & Chataway, 2006). Widespread structural bottlenecks, most notably the chronic reliance on imported active pharmaceutical ingredients (APIs) and persistent exposure to global price competition, have perpetuated the country’s position within the lower tiers of the global value hierarchy (Singh et al., 2021). Although past scholarship has surveyed the mechanics of India’s pharmaceutical trade (Kumar & Sahu, 2013; Pahuja & Chatterjee, 2019), these analyses have largely been confined to short temporal horizons, aggregate metrics, or isolated indices such as the Balassa revealed comparative advantage (RCA). Systematic longitudinal analyses, comparative multi-index frameworks, and sectoral-product pair analyses with the leading global peers remain, to date, insufficiently explored.

In the present study, India’s pharmaceutical sector is analysed using a dual analytical framework, comprising one analysis at the sectoral level and the other at the product level. We compared its performance with the top three leading exporters in the world, namely, the United States, Germany, and Switzerland, for the period 2005–2024, thereby filling the previous knowledge gap by using different indices. Pharmaceutical exports from India expanded from USD 19.1 billion in 2018–19 to USD 27.9 billion in 2023–24, and the sector’s share of total merchandise exports increased from 5.8 percent to 6.4 percent (ET Manufacturing, 2024); nevertheless, its penetration of high-margin, research-intensive segmented global markets remains narrow. By integrating several indices over a twenty-year period, the present analysis identifies persistent competitive strengths, persistent underperforming niches, and potential policy settings to facilitate the transition of the national export strategy from predominant volume leadership to evidence- and capability-driven value creation.

2. Literature Review

Global pharmaceutical exchange is governed by an intricate constellation of determinants: capacity for innovation, the architecture of intellectual property rights, the integrity

of regulatory systems, cost and scale advantages, and conditions governing market access. Foundational studies by Lanjouw (1998) and subsequently by Lanjouw et al. (2014) documented the manner in which patent rights and subsequent-generation patents conditioned the pace of therapeutic diffusion and influenced trade flows. Parallel empirical work by Chaudhuri et al. (2006) examines the Indian experience of TRIPS compliance as a case study in reconfigured incentives and altered trajectories of market entry. The recent ascendancy of biologics, vaccines, and intricate dosage forms, further heightened by pandemic exigencies, has significantly recalibrated global trade architectures, as reported by the OECD (2008), the World Trade Organization [WTO] (2023) and the World Health Organization [WHO] (2024). In response, forward-looking policy blueprints for India, such as those of Bain and Company (2024) and the Indian Council for Research on International Economic Relations (ICRIER) (Ray & Miglani, 2020), explicitly advocate scaling up innovative capabilities and strategically strengthening active pharmaceutical ingredient supply chains.

Studies on international trade have mostly relied on the revealed comparative advantage (Balassa, 1965). RCA often provides a unilateral measure of competitiveness, and its susceptibility to size-related bias means that it does not always provide the full picture. So, researchers came up with Revealed Export Advantage (RXA), Revealed Market Advantage (RMA), and Revealed Trade Advantage (RTA) as alternative measures (Vollrath, 1991). They were further refined through normalisation and weighting approaches, thereby improving comparability over time and across countries (Yu et al., 2009; Laursen, 2015). Using weighted measures reduces the influence of product-level trade value outliers and provides researchers with a more robust analysis. Empirical applications of RXA, RMA, and RTA in knowledge- and innovation-intensive industries, particularly pharmaceuticals, demonstrate that these refinements retain strong explanatory power.

India has evolved from a domestic pharmaceutical producer to a global pharmaceutical leader, driven by generics. Averaging out large-scale production and leveraging a well-trained workforce accelerated this transformation, and supportive regulations from the 1970s laid the foundation (Chaudhuri, 2012; Sampat & Shadlen, 2015; Kale & Little, 2007). The 2005 policy reforms then gave firms a boost into key markets by establishing bioequivalence standards and complying with WHO-GMP requirements. Still, weaknesses remain in high-tech biologics, newly patented pharmaceuticals, and in achieving self-sufficiency in active pharmaceutical ingredients (APIs) (Pradhan, 2007). Most of the research on India's pharmaceutical trade, however, provides only cross-sectional evidence, relies on a single index, or lacks comprehensive cross-country comparisons (Kumar & Sahu, 2013; Pahuja & Chatterjee, 2019). A handful of papers examine product-level trade patterns (Arora et al., 2021) or analyse trade determinants using gravity models (Kapoor & Singh, 2023), yet the field still needs comprehensive, weighted, multi-index analyses that cover a longer study period, particularly the last twenty years.

Past research on India's pharma trade still leaves several important gaps. The majority of the papers focus on either the overall sector data or on a handful of drugs, but do not combine the two. That means the bigger picture of India's trade competitiveness remains incomplete. Most authors still rely on the revealed comparative advantage (RCA) index, even though it provides only a limited assessment of trade competitiveness. Advanced metrics like the Weighted and Symmetric Revealed Export Advantage (W/SRXA), Weighted and Symmetric Revealed Import Advantage (W/SRMA), and Weighted and Symmetric Revealed Trade Advantage (W/SRTA) are rarely used, especially over longer time horizons like twenty years. Short-term analyses make it difficult to understand how and why competitive forces are shifting. Finally, few studies compare India directly with the leading pharmaceutical exporters like the United States, Germany, and Switzerland while using different indices. Bridging this benchmarking gap through a comprehensive

and consistent framework remains limited. This paper addresses these gaps by tracking Indian pharma performance from 2005 to 2024 and by analysing both the sectoral (HS 30) and product-level (four-digit HS) dimensions.

3. Data and Methodology

For this study, export and import data for the pharmaceutical industry were utilised from the ITC Trade Map database, which collects official customs statistics reported by national authorities into internationally comparable trade data. This study covers the period 2005–2024, enabling the analysis of changes in pharmaceutical trade competitiveness across major global economic events, including the pre- and post-2008 global financial crisis and the disruptions associated with the COVID-19 pandemic. India was compared with the United States, Germany, and Switzerland, which have consistently ranked among the world's leading pharmaceutical exporters during the study period. The analysis follows the Harmonised System (HS) classification and focuses on HS Chapter 30 and six major 4-digit pharmaceutical product groups (HS 3001–3006), as presented in Table 1. Since this study spans multiple HS revisions (HS 2007, HS 2012, HS 2017, and HS 2022), trade data were extracted directly from the ITC Trade Map database using the applicable HS nomenclature for each reporting year. To maintain consistency and comparability throughout the study period, the analysis was conducted at the 4-digit HS level, where the selected pharmaceutical product groups remained broadly comparable across successive HS revisions. Therefore, the HS revisions do not materially affect the consistency or comparability of the product categories analysed in this study.

Table 1. HS Codes: representing major pharmaceutical categories.

S.N.	Product Code	Product Description
1.	HS Code 30	All Pharmaceutical Products (Entire Sector)
2.	HS Code 3001	Dried glands and other organs for organo-therapeutic uses, whether or not powdered; extracts. . .
3.	HS Code 3002	Human blood; animal blood prepared for therapeutic, prophylactic or diagnostic uses; antisera. . .
4.	HS Code 3003	Medicaments consisting of two or more constituents mixed together for therapeutic or prophylactic. . .
5.	HS Code 3004	Medicaments consisting of mixed or unmixed products for therapeutic or prophylactic uses, put. . .
6.	HS Code 3005	Wadding, gauze, bandages and the like, e.g., dressings, adhesive plasters, poultices, impregnated. . .
7.	HS Code 3006	Pharmaceutical preparations and products of subheadings 3006.10.10 to 3006.93.00

Source: ITC Trade Map.

We have used these indices for analysis, explained briefly as follows:

A. Symmetric Revealed Export Advantage (SRXA)

The Symmetric Revealed Export Advantage (SRXA) is a transformation of the Revealed Export Advantage (RXA), mapping values to a -1 to $+1$ range for balanced interpretation. The symmetric transformation addresses the asymmetry of the traditional RCA measure and strengthens more meaningful comparisons across countries and time (Dalum et al., 1998; Laursen, 2015). SRXA is expressed as below.

$$SRXA_{ij} = \frac{RXA_{ij} - 1}{RXA_{ij} + 1}$$

where

$$RXA_{ij} = \frac{\left(\frac{X_{ij}}{X_{it}}\right)}{\left(\frac{X_{wj}}{X_{wt}}\right)}$$

X_{ij} = Exports of product j by country i , X_{it} = Total exports of country i , X_{wj} = World exports of product j , X_{wt} = Total world exports, $SRXA > 0 \rightarrow$ Revealed export advantage, and $SRXA < 0 \rightarrow$ Revealed export disadvantage.

B. Symmetric Revealed Import Advantage (SRMA)

The Symmetric Revealed Import Advantage (SRMA) applies the same transformation to the Revealed Import Advantage (RMA), decreasing the skewness connected with conventional import competitiveness measures and improving comparability across products and countries (Dalum et al., 1998; Laursen, 2015). The manuscript used this form SRMA.

$$SRMA_{ij} = \frac{RMA_{ij} - 1}{RMA_{ij} + 1}$$

where

$$RMA_{ij} = \frac{\left(\frac{M_{ij}}{M_{it}}\right)}{\left(\frac{M_{wj}}{M_{wt}}\right)}$$

M_{ij} = Imports of product j by country i , M_{it} = Total imports of country i , M_{wj} = World imports of product j , M_{wt} = Total world imports, $SRMA > 0 \rightarrow$ Higher import dependence than world average, and $SRMA < 0 \rightarrow$ Lower import dependence than world average.

C. Symmetric Revealed Trade Advantage (SRTA)

The Symmetric Revealed Trade Advantage (SRTA), derived from the Revealed Trade Advantage (RTA) proposed by Vollrath (1991), integrates both export competitiveness and import dependence to provide a more comprehensive measure of trade performance. By combining SRXA and SRMA, the symmetric version further enhances interpretability and facilitates comparisons across countries and time (Vollrath, 1991; Laursen, 2015). Thus, we have utilised this form of SRTA.

$$SRTA_{ij} = SRXA_{ij} - SRMA_{ij}$$

If $SRTA > 0 \rightarrow$ Net trade advantage, and $SRTA < 0 \rightarrow$ Net trade disadvantage.

D. Weighted Revealed Export Advantage (WRXA)

Although the RCA family of indices is widely used to measure comparative advantage (Balassa, 1965; Vollrath, 1991), conventional measures may overestimate the magnitude of competitiveness for products with very small export values. To diminish this distortion, the Weighted Revealed Export Advantage (WRXA) modifies RXA by weighting each product according to its share in the country's total pharmaceutical exports, thereby improving the economic relevance of the competitiveness measure (Yeats, 1985). Therefore, we have used this form of WRTA.

$$WRXA_{ij} = RXA_{ij} \times \frac{X_{ij}}{\sum_j X_{ij}}$$

WRXA reduces the distortion from products with small export volumes but artificially high RXA values.

E. Weighted Revealed Import Advantage (WRMA)

Likewise, WRMA weights the Revealed Import Advantage (RMA) by each product's share in total pharmaceutical imports. This weighting procedure shows the actual economic significance of import dependence and diminishes the influence of products with small trade values (Yeats, 1985; Vollrath, 1991). For calculating WRMA, we used this functional form.

$$WRMA_{ij} = RMA_{ij} \times \frac{M_{ij}}{\sum_j M_{ij}}$$

It reflects the actual economic weight of import dependence for each product.

F. Weighted Revealed Trade Advantage (WRTA)

The Weighted Revealed Trade Advantage (WRTA) integrates the weighted export and import measures to give a more robust measure of trade competitiveness. By including product-level trade shares, WRTA captures both export specialisation and import dependence while decreasing the influence of extreme values connected with low-volume products, thereby enhancing the reliability of competitiveness assessments (Yeats, 1985; Vollrath, 1991). WRTA is calculated as follows.

$$WRTA_{ij} = WRXA_{ij} - WRMA_{ij} \quad (1)$$

If $WRTA > 0 \rightarrow$ Net weighted trade advantage, and $WRTA < 0 \rightarrow$ Net weighted trade disadvantage.

By using six tools, SRXA, SRMA, SRTA, WRXA, WRMA, and WRTA, this research checks beyond just whether Indian medicine is competitive. It also tells us whether the competition is steady across what India sells and what it buys, whether each drug's trade score matters to the economy, and how India stacks up against the best in the world across different years.

4. Results

I. Sectoral Analysis (HS Code 30)

When we analysed the data at the sectoral level, we used symmetric indicators SRXA, SRMA, and SRTA because they standardise net trade figures across different products, preventing one large product from distorting the results. These symmetric measures reduce the effect of outliers, giving us a balanced assessment of comparative advantage across the sector as a whole. Due to the paucity of space, we have included only one table presenting the data analysis, i.e., at the sectoral level, whereas the remaining analyses are presented through graphs for better visual presentation.

Looking at the SRXA (Figure 1), focused on HS Code 30, the pharmaceutical sector, India trails Germany and Switzerland from 2005 to 2024.

The SRXA (Figure 1) for India is close to zero or only marginally positive, while the advanced economies remain consistently between 0.7 and 1.3. India's SRMA (Figure 2 and Table 2) stays deeply negative over the same period, showing that the country is not heavily importing drugs; in contrast, the comparator economies show positive SRMA figures, especially after 2010, indicating that they are importing relatively larger quantities of pharmaceutical products in this category.

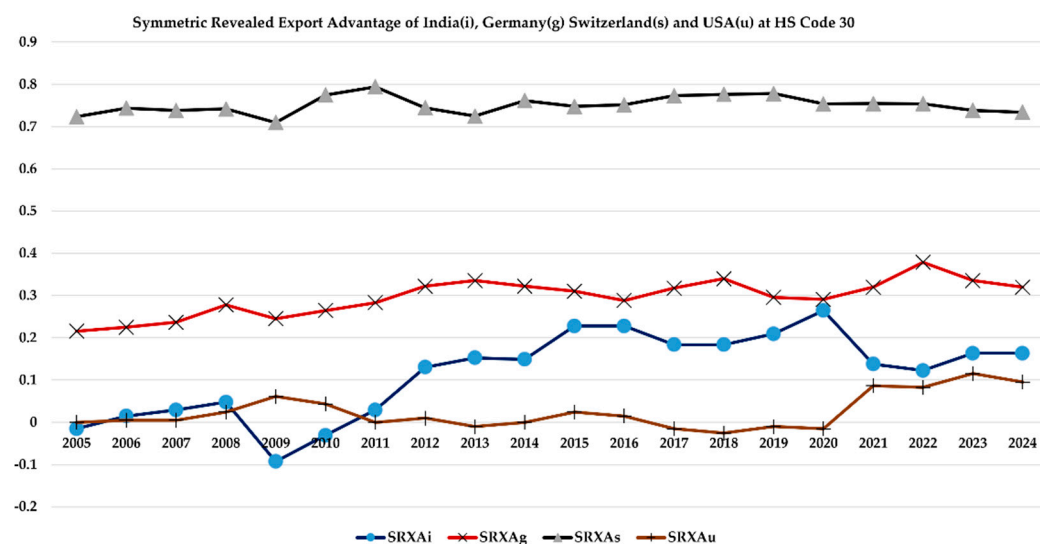


Figure 1. Symmetric Revealed Export Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at HS Code 30. Source: calculated by authors.

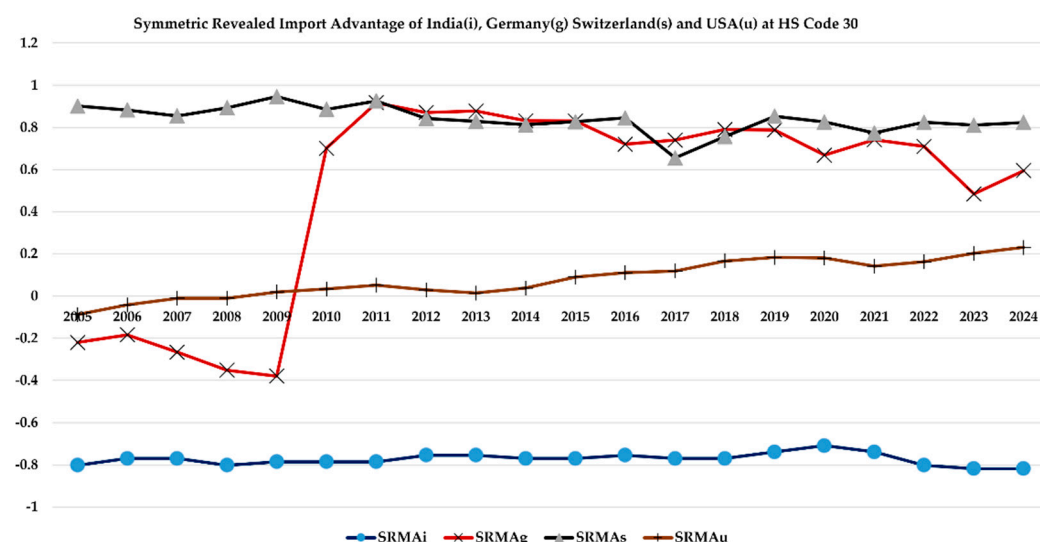


Figure 2. Symmetric Revealed Import Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at HS Code 30. Source: calculated by authors.

Table 2. Symmetric Indices of India(i), Germany(g), Switzerland(s), and the USA(u) at HS Code 30. Source: calculated by authors.

Year	SXi	SMi	STi	SXg	SMg	STg	SXs	SMs	STs	SXu	SMu	STu
2005	−0.0152	−0.8018	0.78657	0.21569	−0.2195	0.4352	0.72337	0.90104	−0.1777	0	−0.087	0.08696
2006	0.01478	−0.7699	0.78469	0.22481	−0.1834	0.40824	0.74359	0.8829	−0.1393	0.00498	−0.0417	0.04664
2007	0.02913	−0.7699	0.79904	0.23664	−0.2658	0.50246	0.73788	0.85455	−0.1167	0.00498	−0.0101	0.01508
2008	0.04762	−0.8018	0.84942	0.27798	−0.3514	0.62933	0.74194	0.89299	−0.1511	0.02439	−0.0101	0.03449
2009	−0.0929	−0.7857	0.69282	0.24528	−0.3793	0.62459	0.70972	0.94618	−0.2365	0.06103	0.01961	0.04143
2010	−0.0309	−0.7857	0.75479	0.26471	0.70149	−0.4368	0.77477	0.88604	−0.1113	0.04306	0.03382	0.00925
2011	0.02913	−0.7857	0.81484	0.28315	0.91663	−0.6335	0.79424	0.92582	−0.1316	0	0.05213	−0.0521
2012	0.13043	−0.7544	0.88482	0.32203	0.87105	−0.549	0.74425	0.84264	−0.0984	0.0099	0.02913	−0.0192
2013	0.15254	−0.7544	0.90693	0.33555	0.87783	−0.5423	0.72452	0.82877	−0.1042	−0.0101	0.01478	−0.0249
2014	0.14894	−0.7699	0.91885	0.32203	0.83193	−0.5099	0.76134	0.81221	−0.0509	0	0.03846	−0.0385
2015	0.2278	−0.7699	0.99771	0.31034	0.83051	−0.5202	0.74779	0.82744	−0.0796	0.02439	0.09091	−0.0665
2016	0.2278	−0.7544	0.98219	0.28826	0.72067	−0.4324	0.75155	0.8452	−0.0936	0.01478	0.11111	−0.0963
2017	0.18367	−0.7699	0.95358	0.31741	0.73958	−0.4222	0.77299	0.65517	0.11781	−0.0152	0.11894	−0.1342
2018	0.18367	−0.7699	0.95358	0.33993	0.79014	−0.4502	0.77629	0.75669	0.0196	−0.0256	0.16667	−0.1923
2019	0.20949	−0.7391	0.94862	0.29577	0.78814	−0.4924	0.77827	0.85316	−0.0749	−0.0101	0.18367	−0.1938
2020	0.26471	−0.7094	0.97411	0.29078	0.66833	−0.3775	0.75369	0.82563	−0.0719	−0.0152	0.18033	−0.1956
2021	0.13793	−0.7391	0.87706	0.31973	0.74194	−0.4222	0.7543	0.77401	−0.0197	0.08676	0.14163	−0.0549
2022	0.12281	−0.8018	0.92461	0.37888	0.71014	−0.3313	0.754	0.82441	−0.0704	0.08257	0.16318	−0.0806
2023	0.16318	−0.8182	0.98136	0.33555	0.48454	−0.149	0.73856	0.81096	−0.0724	0.11504	0.20319	−0.0881
2024	0.16318	−0.8182	0.98136	0.31973	0.59514	−0.2754	0.73404	0.82363	−0.0896	0.09502	0.23077	−0.1357

Where SX is Symmetric Export Advantage, SM is Symmetric Import Advantage, and ST is Symmetric Trade Advantage.

In Figure 3 and Table 2, we can see that India's Symmetric Revealed Trade Advantage (SRTA) stayed consistently between approximately 0.75 and 0.98. That is particularly noteworthy, especially with its export numbers, which are not particularly high, and its imports, which still account for a relatively larger share; the home market remains a major contributor to its trade performance, and the country's drug output is expanding rapidly. Germany and Switzerland exhibit a different pattern.

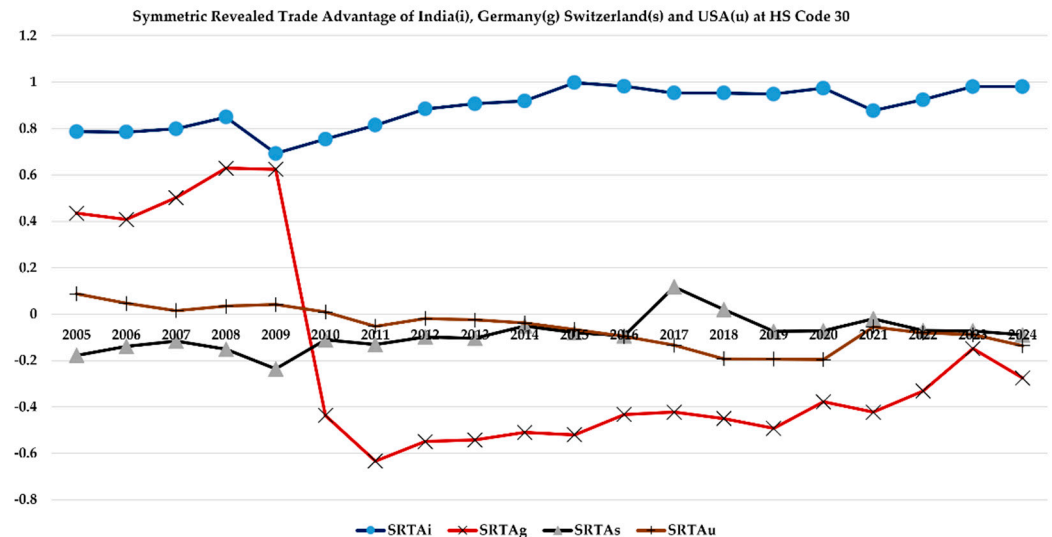


Figure 3. Symmetric Revealed Trade Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at HS Code 30. Source: calculated by authors.

Both are strong in exports, yet their SRTA scores are highly variable or remain in the negative zone, indicating that imports are increasing so substantially that they sometimes reduce the leeway their strong exports usually enjoy. The U.S. scores remain in the middle, with a stable positive value on both the export side and the overall trade advantage. Therefore, India is making significant progress on the overall trade advantage ranking, without doubt. But the country still has not yet caught up with the well-established market leaders if the focus is on how much manufacturing capability its trade numbers actually reveal.

II. Product-Level Analysis (HS Code 3001–3006)

When we examine more closely at the product level, we used the weighted versions of the indices, i.e., WRXA, WRMA, and WRTA. This is due to the fact that we have to assess how each HS-4 product's trade dynamics fit into the bigger picture of its share of total trade. By weighting the index, we ensure that small, low-value products do not distort the results, and the major, economically important goods receive appropriate consideration.

i. Product 3001

From Figure A1 of Appendix A, looking at product HS 3001, India's WRXA numbers are virtually flat, remaining almost at zero, indicating that there has been no significant improvement in export competitiveness since 2005 and none is projected through 2024. Interestingly, Germany, Switzerland, and the USA have the same pattern; their WRXAs are also almost zero, which indicates that none of these nations exports substantial quantities of HS 3001 products to the global market. Coming to WRMA in Figure A2 of Appendix A, India's numbers are small but still slightly above zero, which suggests that India is not dependent on imports to meet domestic demand for the HS 3001 market. Germany and Switzerland, on the other hand, drift into positive WRMA in the later years, indicating that they are gradually importing more of these goods to satisfy demand. The USA maintains a

low and steady WRMA, with no substantial variation, but they were never the first choice for export anyway.

Analysis of WRTA in Figure 4 demonstrates that India maintains a marginal but steady trade edge year after year for HS 3001, meaning it exports slightly more than it imports for that item compared to the others. Germany, on the other hand, shows mostly negative WRTA scores, which means it is importing more HS 3001 than it is exporting to the rest of the world, so it is at a trade disadvantage on this product. Switzerland is slightly negative, remaining close to the zero point, while the USA maintains a marginally positive WRTA too. Looking at the overall pattern, India still has that little plus sign on HS 3001, but the magnitude is so small that it does not really indicate strong competitiveness. The other usual exporters, namely, Germany, Switzerland, and the USA, overall do not show any significant advantages in this particular four-digit code, so no country exhibits a clear competitive advantage in that product line.

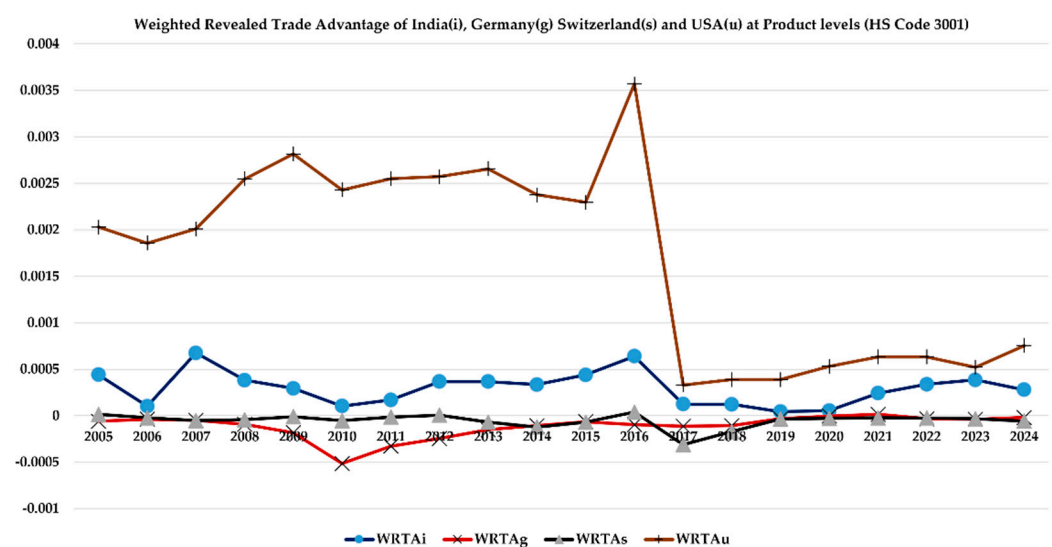


Figure 4. Weighted Revealed Trade Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at Product levels (HS Code 3001). Source: calculated by authors.

ii. Product 3002

Results in Figure A3 of Appendix A reveal that, in HS Code 3002, India has been showing modest but steady WRXA scores, indicating that there is a limited level of exports, but it is minimal. By contrast, Germany and Switzerland exhibit WRXA values ranging from 0.8 to 1.5, indicating that they maintain a strong position in exports. The values for the USA are so small that they are practically zero, so the USA is not a significant exporter of this product. In Figure A4 of Appendix A, looking at the WRMA, it is clear India mostly imports this product and hardly retains any for domestic use, though the totals are still relatively low. Germany and Switzerland are the opposite, with their WRMA values gradually increasing, showing they are importing increasing quantities of this product. The USA sits in the middle, showing a low to moderate import intensity of this same product.

Analysis in Figure 5 reflects that India's WRTA for HS 3002 consistently reflects a steady, though marginal, positive trade surplus each year, indicating that higher-value pharmaceutical products are gradually increasing their share of the overall trade basket. In contrast, Switzerland continues to demonstrate a markedly strong WRTA, underscoring its position as a global leader in this segment, persistently exceeding 0.7 and at times reaching as high as 1.38, thereby reinforcing Switzerland's position as a benchmark leader in the international market for pharmaceutical products under HS Code 3002.

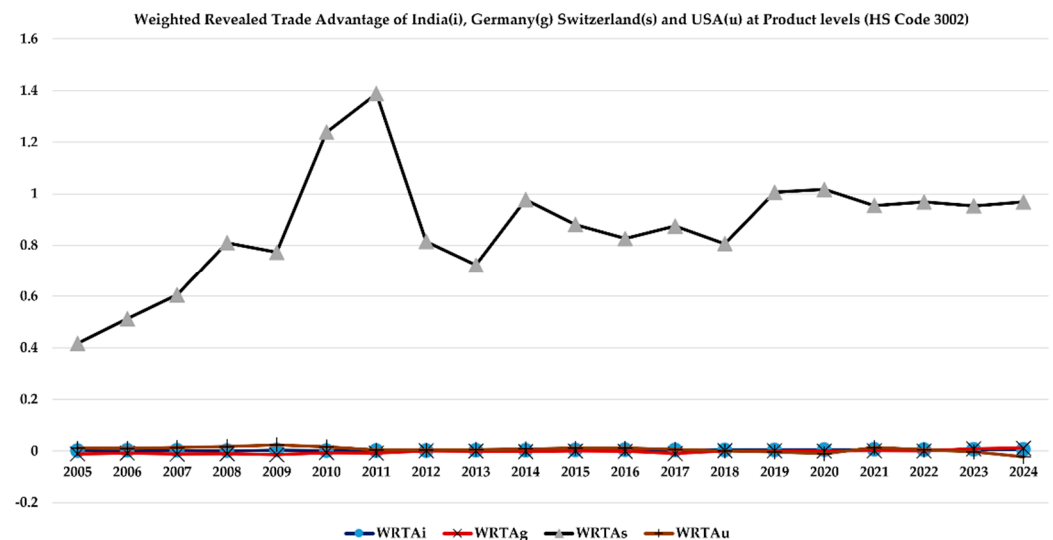


Figure 5. Weighted Revealed Trade Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at Product levels (HS Code 3002). Source: calculated by authors.

Germany, overall, continues to record a WRTA that remains at or dips below the zero line, signalling that its production capacity is not converting into a net surplus for the item. The USA's increase is too slight, staying moderately positive or barely remaining above the zero threshold. To conclude, we can say that Switzerland continues to dominate in export volumes and trade surpluses, whereas India exhibits incremental but limited improvements in competitiveness over time.

iii. Product 3003

Figure A5 of the Appendix A shows that India's WRXA values for HS 3003 stay persistently low during the observed interval, at 0.005 to 0.01, signalling negligible revealed export excellence for this pharmaceutical line. Germany and Switzerland present similarly minimal WRXA indicators, hovering near zero, which confirms that the entire quartet lacks a pronounced revealed export leadership in this category of pharmaceutical product. Conversely, in Figure A6 of Appendix A, WRMA analysis shows that Germany and Switzerland exhibit moderate reliance on imports, with WRMA estimates around 0.07 to 0.09 in the earlier observations and a downward trajectory thereafter, while India's WRMA values are so modest that they denote almost no imports of these products from abroad. The USA's WRMA readings, in contrast, are limited and stable, indicating a steady, marginal level of imports without marked fluctuation. The WRTA results from Figure 6 reveal that India retains a narrow but persistently favourable edge on HS 3003 products, even though the margins are small, suggesting a slight trade surplus despite the broader low level of export competitiveness. In contrast, Germany records negative WRTA values for almost the entire observation period, signalling a long-standing export weakness in this product line.

Switzerland is in a narrow band of close-to-neutral WRTA, alternating between slight positive and negligible negative readings, while the USA produces mostly low and modestly positive WRTA values throughout the series. Taken collectively, the product HS 3003 is not a major contributor to export competitiveness for any of the reviewed nations, yet the Indian numbers indicate a marginal advantage which arises from the country's relatively greater and increasing reliance on this particular code in its trade structure.

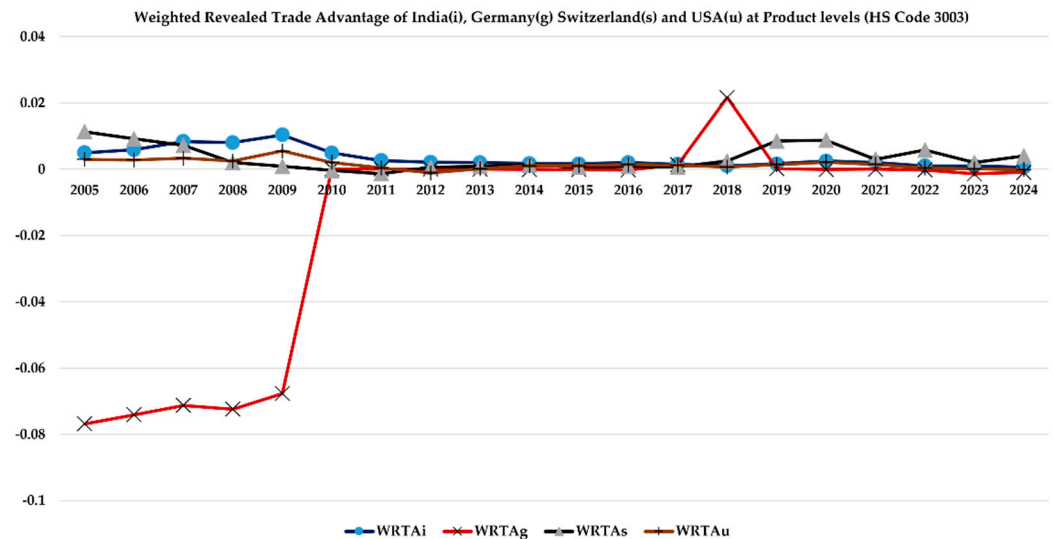


Figure 6. Weighted Revealed Trade Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at Product levels (HS Code 3003). Source: calculated by authors.

iv. Product 3004

Figure A7 of the Appendix A reflects that HS 3004 products from India exhibit a WRXA profile that is low yet distinctly positive, indicating a slight export edge that has remained steady; the pharmaceutical formulation category is the context here. Germany records WRXA figures that are in the moderate bracket, whereas Switzerland's ratios are marked by pronounced strength, frequently falling in the 0.7 to 1.1 range, thereby evidencing a robust and enduring revealed comparative export advantage that has persisted throughout the entire observation period. The USA displays WRXA that is almost negligible. Figure A8 of the Appendix A presents WRMA analysis, showing that Switzerland's quantity-based ratios hover between 0.17 and 0.77, which implies marked import dependence; a meaningful segment of its overall activity in this HS Code 3004 relies on external shipments, even in the face of its prolific export volume. Germany and the USA display moderate WRMA ratios, suggesting a similar pattern, while India's evidently low WRMA indices demonstrate markedly limited dependence on external supplies for this formulation.

The results in Figure 7 show India's WRTA modestly positive values, albeit at diminished magnitudes, pointing to a narrow but present trade edge in HS 3004. Switzerland, in contrast, registers exceptionally elevated WRTA scores of 0.32 to 0.87, underscoring a notable competitive position.

Germany's WRTA continues to increase, albeit at a moderate pace, conveying a strengthening but still moderate trade capability. The USA, however, reports negative WRTA results across the majority of the observed period, indicative of a long-standing trade shortfall in the same product category. In summary, Switzerland occupies a leading position in HS 3004, assessed from both export and net trade perspectives; Germany follows a gradually positive course; India preserves a modest, yet consistently positive net trade position; and the USA is at a comparative disadvantage.

v. Product 3005

Figure A9 of the Appendix A reflects that HS 3005 exhibits uniformly low WRXA figures across the four benchmark countries, signalling that the sector presents no notable export advantage for any of them. Of the group, India and Germany exhibit marginally elevated WRXA scores when compared to the narrower spreads of Switzerland and the USA, yet each effectively remains clustered near the horizontal axis.

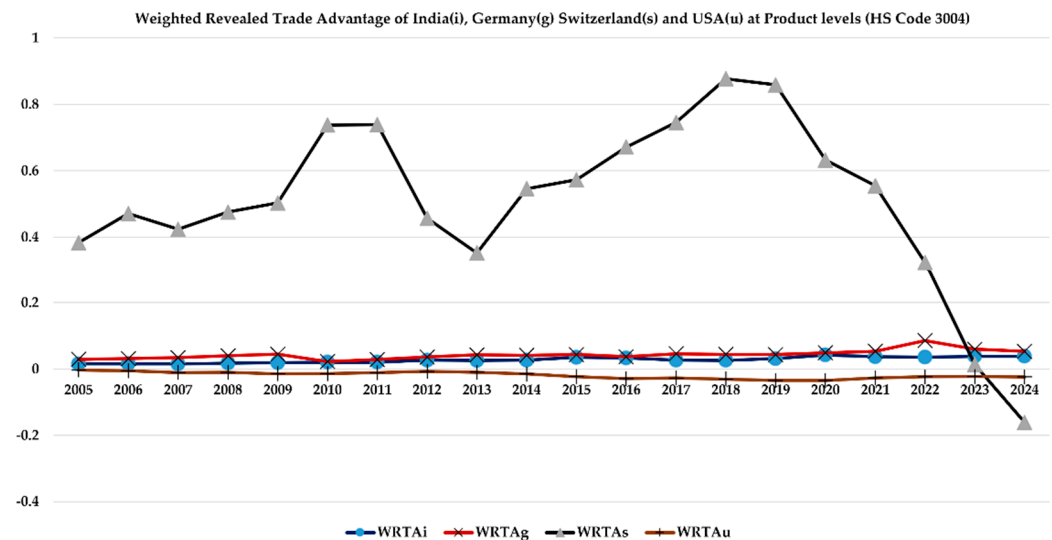


Figure 7. Weighted Revealed Trade Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at Product levels (HS Code 3004). Source: calculated by authors.

The corresponding WRMA results (Figure A10 of Appendix A) show that, with very low values, the product's role is very limited in overall pharmaceutical imports across nations. Switzerland alone shows a slightly upward WRMA relative to the others. Therefore, while the product plays a modest supporting role in Switzerland's pharmaceutical sector, in India its import levels are too low to have a material impact on domestic formulations.

Figure 8 shows the WRTA results; we can see that India and the United States maintain positive, albeit tiny, trade advantages in the HS 3005 category. In contrast, Germany and Switzerland generally post negative WRTA values, signalling minimal and, quantitatively, mild trade disadvantage. What is particularly striking is the consistently low-magnitude single-digit WRTA figures year after year across the entire dataset.

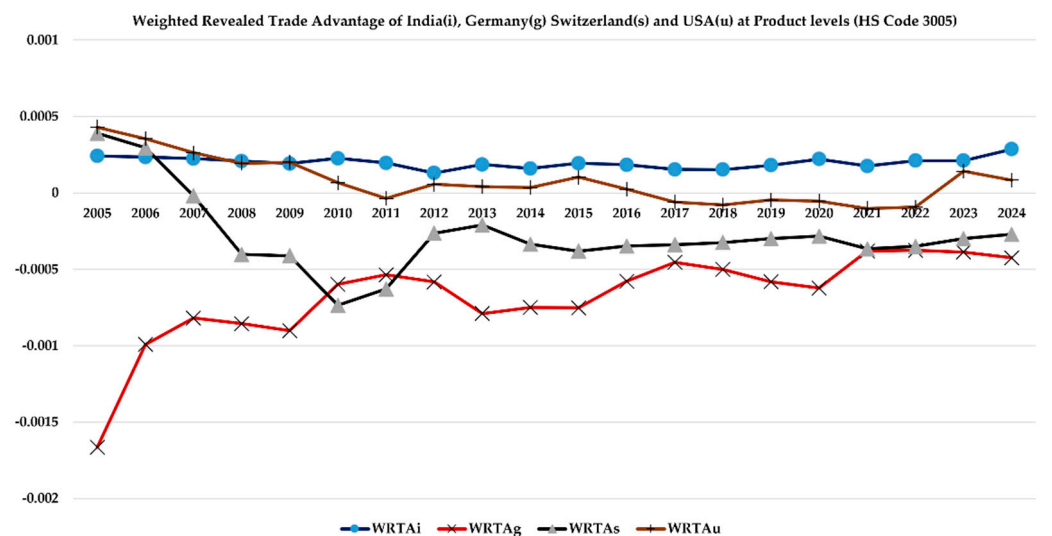


Figure 8. Weighted Revealed Trade Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at Product levels (HS Code 3005). Source: calculated by authors.

Pharmaceutical code 3005 remains a marginal element in the trade structures of all four nations. Differences are negligible and dominated by statistical noise, offering no clear competitive edge or material gains. Export activity is limited, with temporary increases, while in both the United States and India, the trade share appears largely incidental.

vi. Product 3006

In Figure A11 of Appendix A, we can see that across the HS 3006 product line, the WRXA scores remain exceptionally low for each of the four countries and throughout the observed years, signalling a lack of significant export strength for the product overall. Nevertheless, Germany and Switzerland display WRXA values that, while still low, exceed those of India and the USA, suggesting a modestly stronger export stance for the two European nations.

Results of the analysis in Figure A12 of Appendix A show the WRMA values mirror the export trend and are low for all economies; however, Germany and Switzerland record values that are again marginally elevated, suggesting a trace of reliance on imports. India's WRMA, on the other hand, is negligible, revealing that the product contributes negligibly to the country's import pattern within this harmonised grouping.

In Figure 9, results of the WRTA present a small yet consistent trade gain for India across the observed years; conversely, Germany and Switzerland record substantially elevated WRTA levels, suggesting a comparatively stronger balance, although on a diminished scale in the value of the HS 3006 Products. The USA frequently records a positive WRTA for HS 3006. However, the values are so insignificant that they hardly matter in trade terms. For all four countries, this product line is secondary within their wider pharmaceutical industries. Germany and Switzerland normally maintain robust positions. India, by contrast, only achieves a small surplus, indicating a strategy focused more on exports than domestic absorption. The other two industrial front-runners benefit from knowledge spillovers, but their trade surpluses continue to be too small to carry real economic weight.

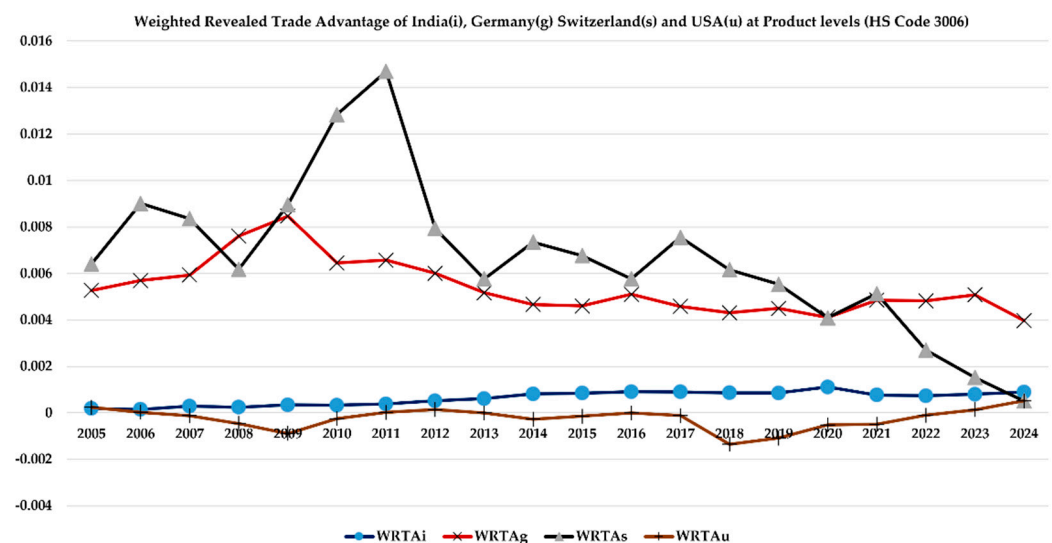


Figure 9. Weighted Revealed Trade Advantage of India(i), Germany(g), Switzerland(s) and USA(u) at Product levels (HS Code 3006). Source: calculated by authors.

The complete set of supplementary tables and figures supporting the product-level WRXA, WRMA, and WRTA analyses for each product and country is available in the Supplementary Materials.

5. Conclusions

Across the period of analysis, the Indian pharmaceutical industry has displayed a moderately favourable trade surplus, reflecting a strengthening but not overwhelming position. India's export strength is relatively weak, as shown by its low WRXA values. This places it well behind leading exporters like Germany, Switzerland, and the U.S. The observed strong WRTA, therefore, does not stem from absolute export prowess, but from a

domestic production landscape that has expanded rapidly, comparatively low variable and fixed production costs, and a substantial share of the global generic formulations market. The underlying balance thus remains consistently positive, a finding also supported by earlier studies (Chaudhuri, 2012). For high-income countries, high WRXA values show strong export ability, but their mixed WRTA scores suggest they rely heavily on imported inputs and have a diverse composition of final and intermediate products. This matches earlier WTO findings that advanced economies often source key inputs from abroad (WTO, 2020). Overall, India's pharmaceutical trade position is best described by its consistent net trade performance, rather than by the less reliable measures of export complexity that are often highlighted.

At the product level across the six four-digit pharmaceutical codes, disparity remains high. India retains a narrow yet stable trade edge in codes HS 3001 and 3003, which cover dried human or animal substances and non-dosage medicinal preparations. This performance is attributable to the country's standing as a bulk drug hub. Nevertheless, export dynamism is weak, with WRXA indices remaining at extraordinarily low levels. India's position weakens for HS 3002 and 3004, where disaggregated data show a different trend. Switzerland and Germany lead in these categories with elevated WRXA and WRTA scores that demonstrate the countries' high-level firm-wide capabilities. Such numbers attest to extensive concentration in proprietary medicines and biosimilars. India achieves HS 3002 gains and a small HS 3004 surplus, but its role remains narrow in fermentation-intensive and genomic-product fields that dominate the advanced scientific value chain.

Dressings under HS 3005 (first-aid, cotton, etc.) and the more residual 3006 (pharmaceutical goods and residual items) have very weak revealed comparative advantages (WRXA, WRMA, and WRTA) across Germany, Switzerland, the USA and India, suggesting they do not act as strategic products. The finding that these trade advantages fluctuate close to zero, underscoring limited global interest and limited differentiation, is also supported by the study of (Simoes & Hidalgo, 2011). Switzerland and Germany, both upstream centres, show moderately higher WRTA for 3006, yet the product's volume remains insignificant in national export portfolios. The USA shows a comparative disadvantage in most four-digit items. The only exceptions are niche products in HS 3002 and HS 3004. This means U.S. pharma is more focused on meeting domestic needs. Its international presence is modest. At the same time, it relies heavily on imported inputs.

Overall, the Indian pharmaceutical sector excels in established, lower-value segments where production excels through cost leadership and sizeable economies of scale, while maintaining a net positive trade balance. Nevertheless, segments linked to new-product development and lifecycle innovations, including patented biologics, remain limited. Notably, Switzerland's and Germany's firms sustain leadership in high-value segments of the biologics market and in patented formulations, an alignment that mirrors their enduring innovation-driven ecosystems. Aggregate sector accounts substantiate India's expanding global trade stature, yet the more granular product perspective suggests that enduring market strength cannot rely on an inherited cost base alone. Consistent with our findings, progress in scaling up biologics, a continuous focus on higher-value technology segments, and stronger R&D investment are highlighted both in Chaudhuri's (2012) findings and in the WTO's (2020) assessments. The comparative balance of trade confirms Indian competitiveness on a broad scale, yet the narrow channel of advanced formulation and late-stage development clearly signals that premium export strength remains the established domain of sophisticated, R&D-rich advanced economies.

6. Policy Implications and Future Research Prospects

This study shows that India's pharmaceutical trade strength is driven by sizeable, low-cost generics rather than cutting-edge, innovation-led output. Accordingly, a staged policy pivot from sheer volume to developing high-value, tech-rich capability is essential. Direction should focus on mission-financed R&D in biologics, biosimilars, and inventive compounds (HS 3002, 3004). At the same time, a concerted build-up of national API and essential intermediate manufacture is necessary, reducing the weighted return minimum area (WRMA) and strengthening underlying competitive margins. Increased emphasis on funding innovation, deep public-private R&D synergies, and systematic workforce training, paired with global quality-related regulatory alignment, could enhance India's global standing in high-value categories. Simultaneously, active promotion of export diversification, coupled with coherent branding measures, should reposition India as the international mainstay of complex generics and speciality products. Future empirical investigation may broaden the comparative exercise to a wider set of global partners, overlay input-output and value-added trade matrices, and couple product- and firm-level trade variables with an innovation perspective to examine technological convergence. Further work should trace the extended effects of the pandemic on the industry's trade profile and global supply continuity, with particular emphasis on pandemic-related vaccines and incomplete commodity categories outside standard sections. Looking ahead, these insights strengthen the case for industrial policies that prioritise innovation through timely, comprehensive policies that encourage research and development rather than short-term incentives. At the same time, the results call for more rigorous inquiry into the underlying structural factors that govern the evolution of the worldwide pharmaceutical value chain.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/economics14070278/s1>.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

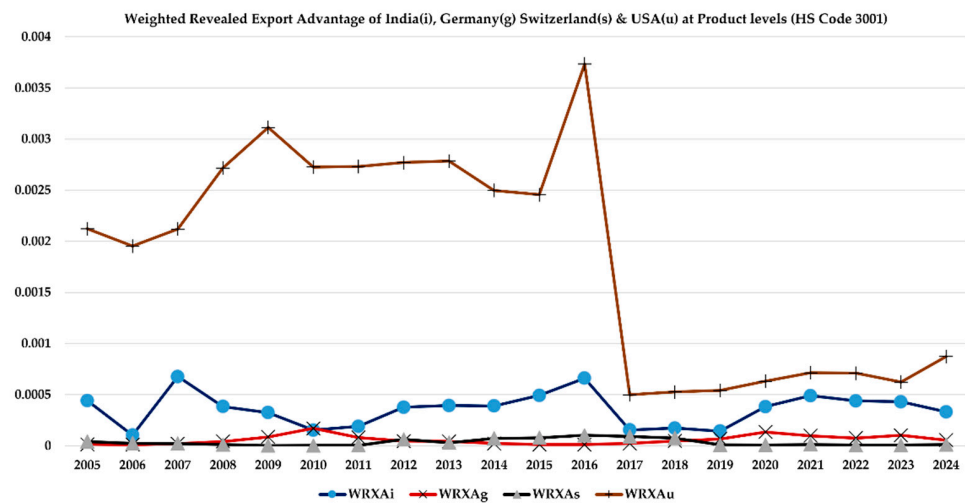


Figure A1. Weighted Revealed Export Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3001). Source: calculated by authors.

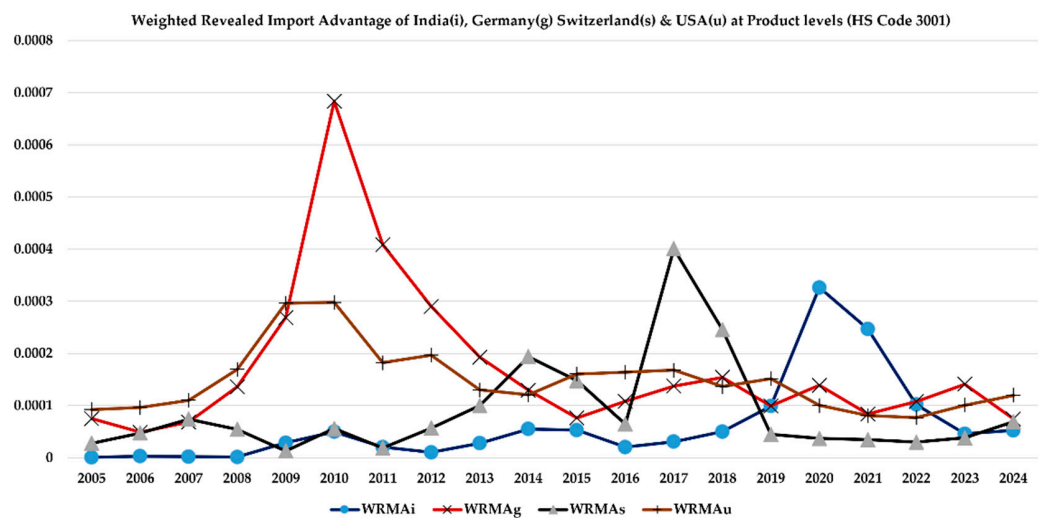


Figure A2. Weighted Revealed Import Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3001). Source: calculated by authors.

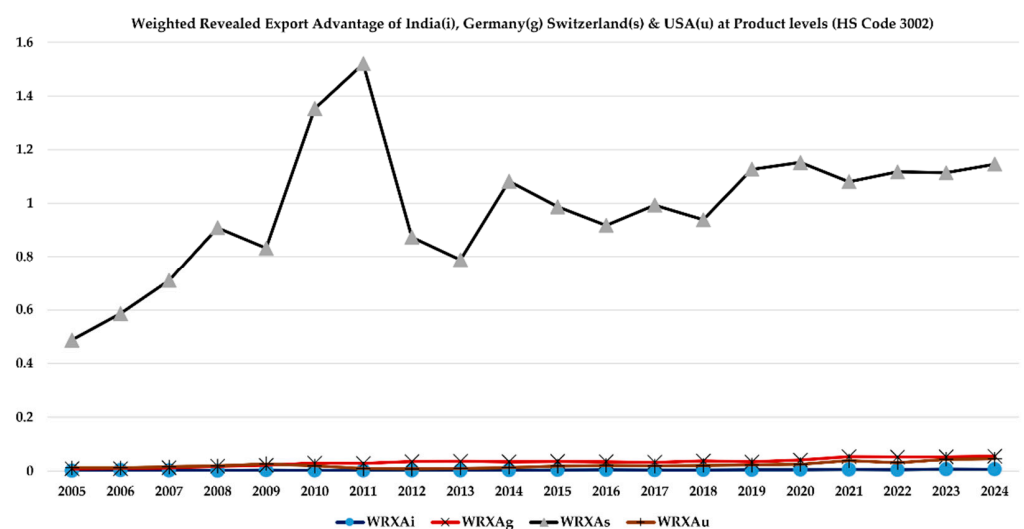


Figure A3. Weighted Revealed Export Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3002). Source: calculated by authors.

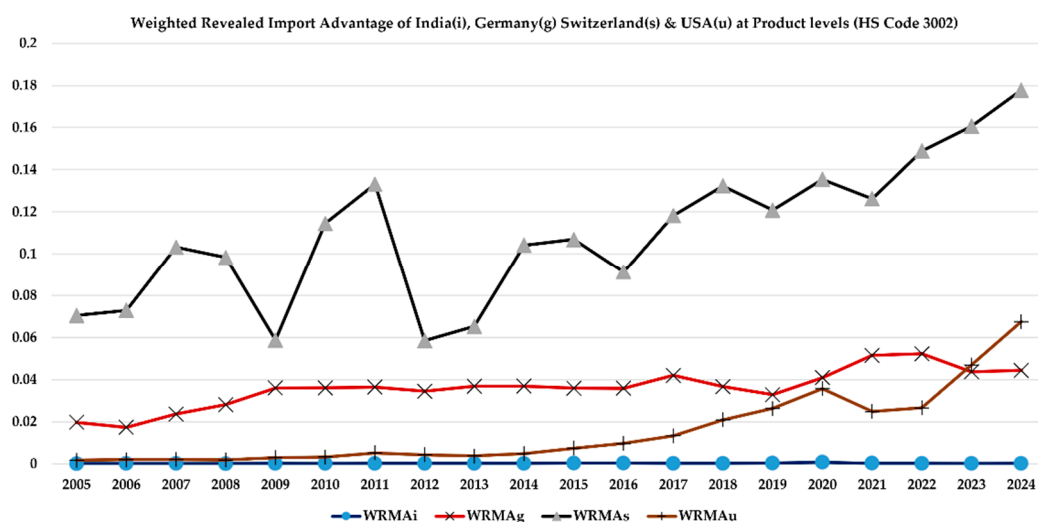


Figure A4. Weighted Revealed Import Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3002). Source: calculated by authors.

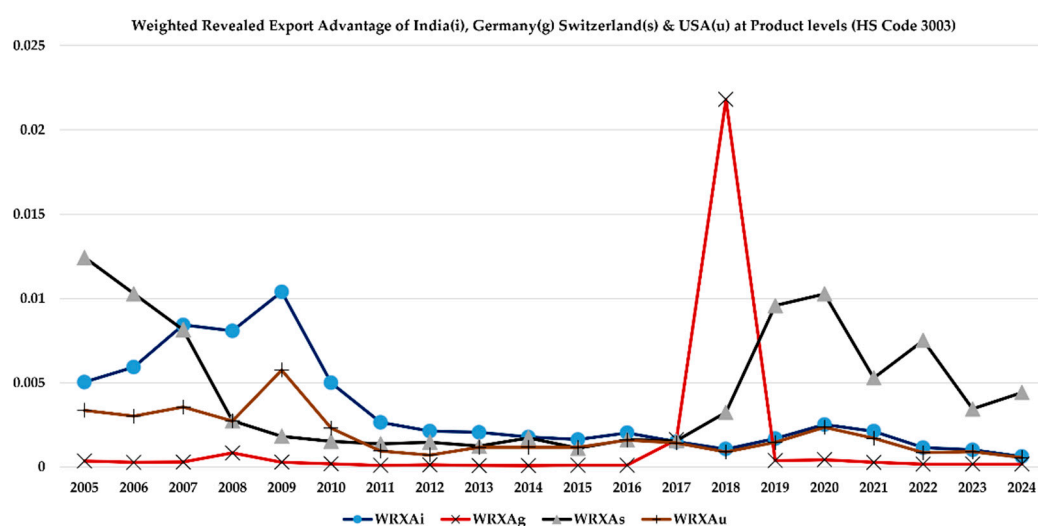


Figure A5. Weighted Revealed Export Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3003). Source: calculated by authors.

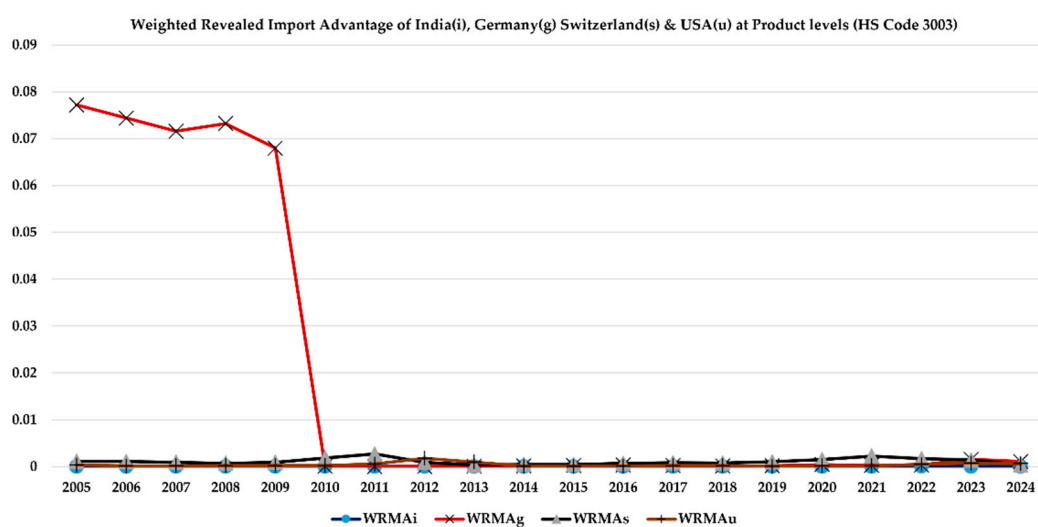


Figure A6. Weighted Revealed Import Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3003). Source: calculated by authors.

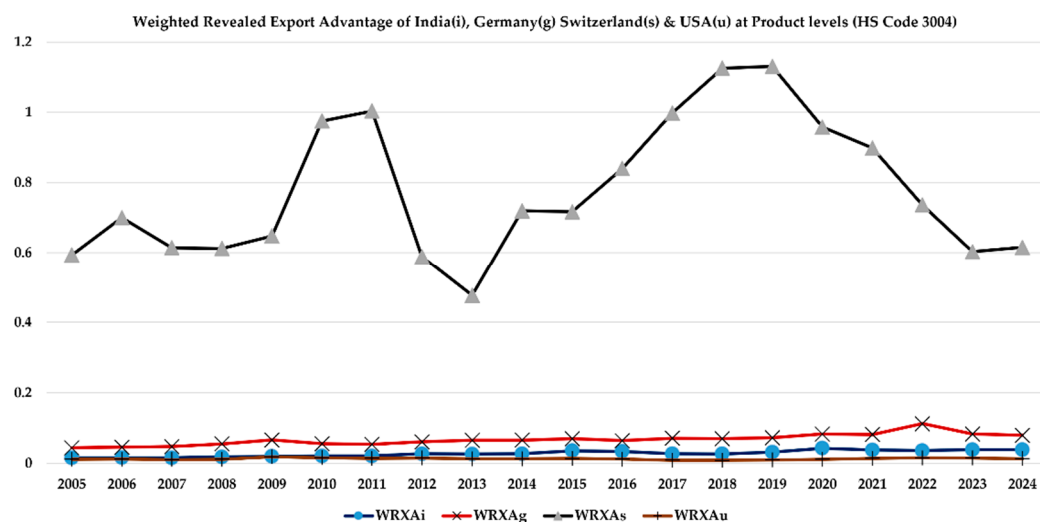


Figure A7. Weighted Revealed Export Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3004). Source: calculated by authors.

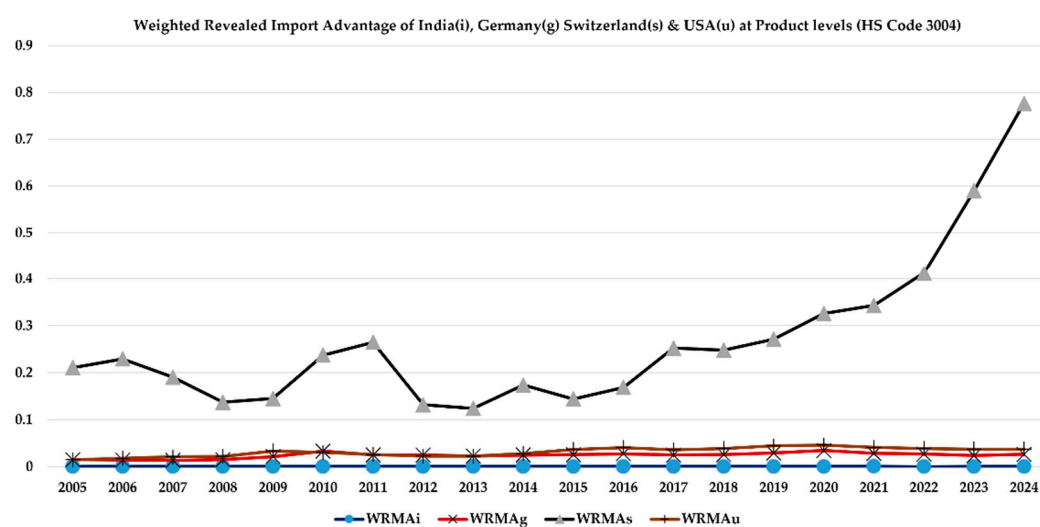


Figure A8. Weighted Revealed Import Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3004). Source: calculated by authors.

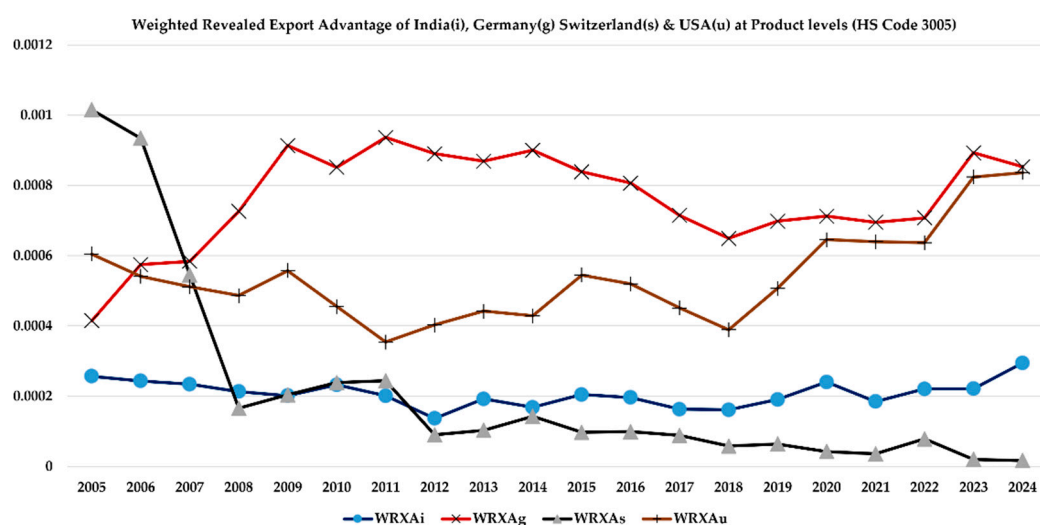


Figure A9. Weighted Revealed Export Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3005). Source: calculated by authors.

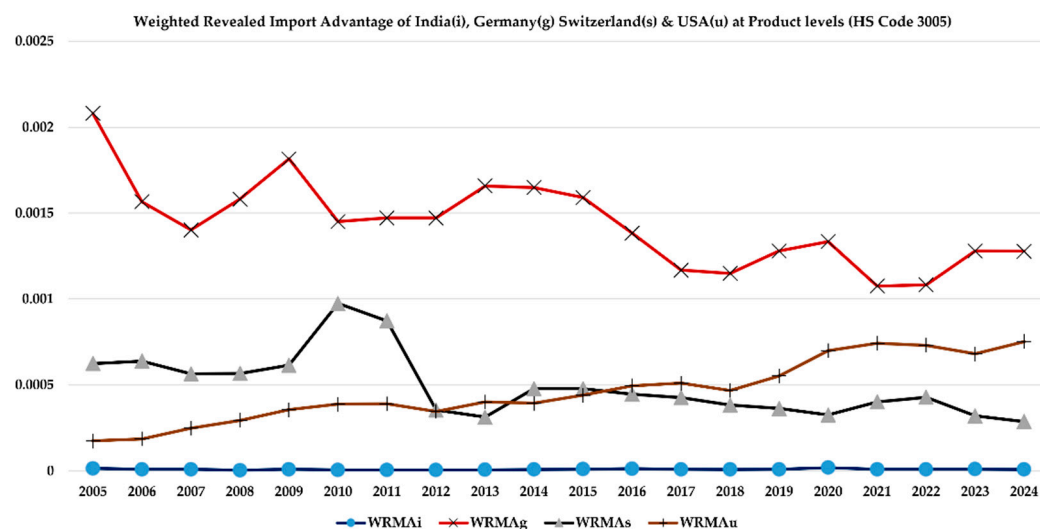


Figure A10. Weighted Revealed Import Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3005). Source: calculated by authors.

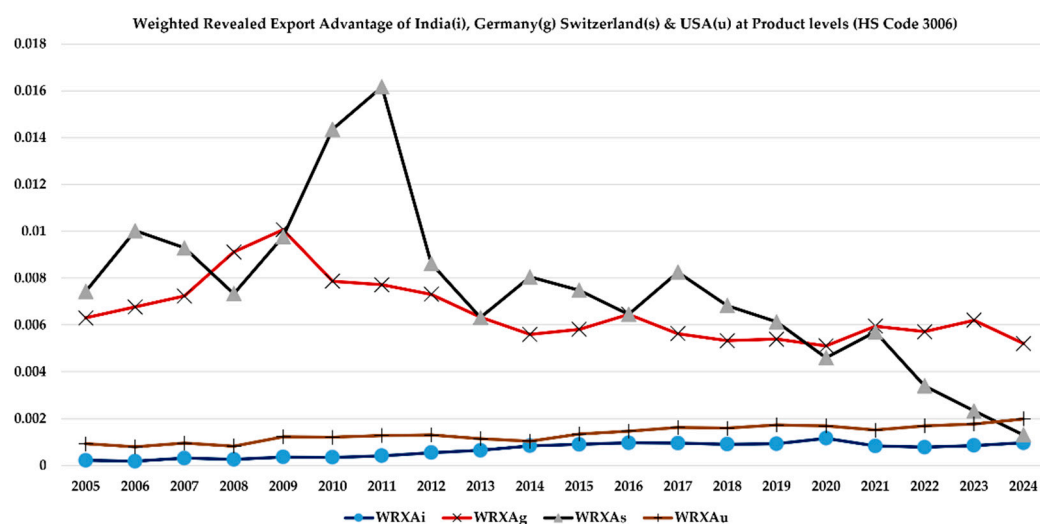


Figure A11. Weighted Revealed Export Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3006). Source: calculated by authors.

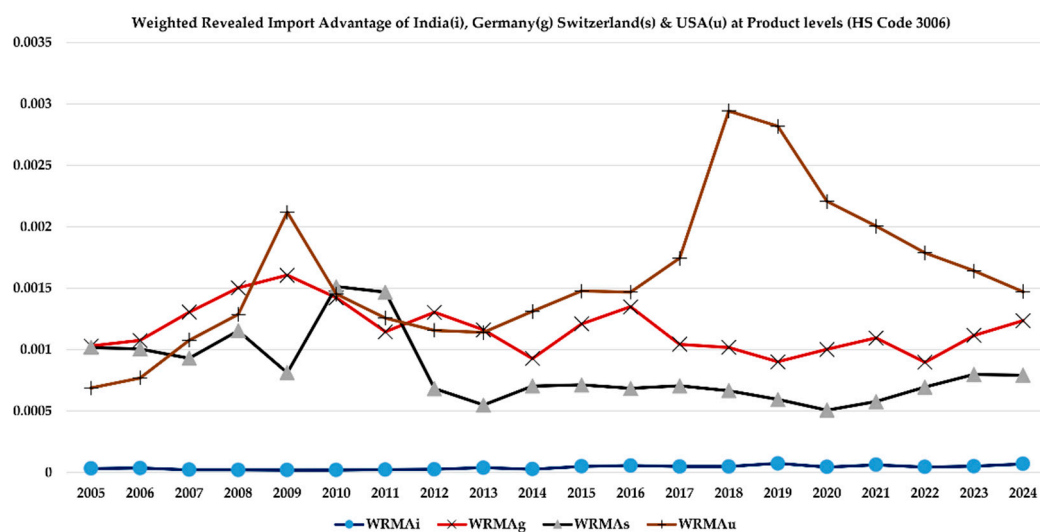


Figure A12. Weighted Revealed Import Advantage of India(i), Germany(g), Switzerland(s) & USA(u) at Product levels (HS Code 3006). Source: calculated by authors.

References

- Arora, N., Bansal, V., & Sharma, R. (2021). India's pharmaceutical exports: An analysis of product diversification and trade competitiveness. *Journal of Economic Policy and Research*, 16(2), 45–62.
- Bain & Company. (2024). *Indian pharma 2024: Driving innovation and global leadership*. Bain & Company.
- Balassa, B. (1965). Trade liberalisation and “revealed” comparative advantage. *The Manchester School*, 33(2), 99–123. [\[CrossRef\]](#)
- Chaturvedi, K., & Chataway, J. (2006). Strategic integration of knowledge in Indian pharmaceutical firms: Creating competencies for innovation. *International Journal of Business Innovation and Research*, 1(1–2), 27–50. [\[CrossRef\]](#)
- Chaudhuri, S. (2012). The gap between successful innovation and access to medicines: India's pharmaceutical industry in perspective. *Indian Journal of Human Development*, 6(1), 29–45.
- Chaudhuri, S. (2021). India's import dependence on China in pharmaceuticals: Status, issues, and policy options. *SSRN Electronic Journal*. [\[CrossRef\]](#)
- Chaudhuri, S., Goldberg, P., & Jia, P. (2006). Estimating the effects of global patent protection in pharmaceuticals: A case study of quinolones in India. *American Economic Review*, 96(5), 1477–1514. [\[CrossRef\]](#) [\[PubMed\]](#)
- Dalum, B., Laursen, K., & Villumsen, G. (1998). Structural change in OECD export specialisation patterns: De-specialisation and ‘stickiness’. *International Review of Applied Economics*, 12(3), 423–443. [\[CrossRef\]](#)
- ET Manufacturing. (2024, April 24). Pharma exports rise 46% in five years, touching \$27.9 billion. *The Economic Times*.
- Kale, D., & Little, S. (2007). Innovation and knowledge networks in Indian pharmaceuticals. *Global Networks*, 7(1), 53–71. [\[CrossRef\]](#)
- Kapoor, A., & Singh, R. (2023). Drivers of India's pharmaceutical exports: Evidence from a gravity model. *Foreign Trade Review*, 58(3), 265–285.
- Kumar, A., & Sahu, S. K. (2013). India's pharmaceutical exports: An assessment of comparative advantage and competitiveness. *Journal of Economic Studies*, 40(4), 476–490.
- Lanjouw, J. O. (1998). *The introduction of pharmaceutical product patents in India: “Heartless exploitation of the poor and suffering”?* [NBER working papers. Paper no. 6366]. NBER. [\[CrossRef\]](#)
- Lanjouw, J. O., Cockburn, I., & Schankerman, M. (2014). Patents and the global diffusion of new drugs. In W. G. Park, & J. L. Putnam (Eds.), *Intellectual property rights and the global economy* (pp. 51–75). University of Chicago Press.
- Laursen, K. (2015). Revealed comparative advantage and the alternatives as measures of international specialization. *Eurasian Business Review*, 5(1), 99–115. [\[CrossRef\]](#)
- Maskus, K. E., & Saggi, K. (2014). International technology transfer: An analysis of the pharmaceutical sector. *World Economy*, 37(7), 1104–1123. [\[CrossRef\]](#)
- OECD. (2008). *Pharmaceutical pricing policies in a global market* [OECD health policy studies]. OECD Publishing. [\[CrossRef\]](#)
- Pahuja, N. S., & Chatterjee, V. P. K. (2019). India's pharmaceutical exports: Performance and prospects. *Artha Vijnana*, 61(2), 203–222.
- Pradhan, J. P. (2007). Strengthening intellectual property rights globally: Impact on India's pharmaceutical exports. *Economic and Political Weekly*, 42(52), 2370–2377.
- Ray, S., & Miglani, S. (2020). *India's GVC integration: An analysis of upgrading efforts and facilitation of lead firms* (No. 386) [Working paper]. Indian Council for Research on International Economic Relations (ICRIER).
- Sampat, B. N., & Shadlen, K. C. (2015). Drug patenting in India: The changing role of the state. *Economic and Political Weekly*, 50(5), 39–45. [\[CrossRef\]](#)
- Simoes, A. J. G., & Hidalgo, C. A. (2011). The economic complexity observatory: An analytical tool for understanding the dynamics of economic development. *Scalable Integration of Analytics and Visualization*, 11(7), 39–42.
- Singh, P., Tatambhotla, A., Kalvakuntla, R., & Chokshi, M. (2021). India's road to independence in manufacturing active pharmaceutical ingredients: Focus on essential medicines. *Economies*, 9(2), 71. [\[CrossRef\]](#)
- Vollrath, T. (1991). A theoretical evaluation of alternative trade intensity measures of revealed comparative advantage. *Weltwirtschaftliches Archiv*, 127(2), 265–280. [\[CrossRef\]](#)
- World Health Organization (WHO). (2024). *Global report on access to medicines and vaccines 2024*. WHO.
- World Trade Organization (WTO). (2023). *World trade report 2023: Re-globalization for a secure, inclusive, and sustainable future*. WTO.
- WTO. (2020). *Trade in medical goods in the context of tackling COVID-19* [WTO's secretariat information note, April 3rd.]. WTO.
- Yeats, A. J. (1985). On the appropriate interpretation of the revealed comparative advantage index: Implications of a methodology based on industry sector analysis. *Weltwirtschaftliches Archiv*, 121(1), 61–73. [\[CrossRef\]](#)
- Yu, R., Cai, J., & Leung, P. (2009). The normalized revealed comparative advantage index. *The Annals of Regional Science*, 43(1), 267–282.

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