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ISID Institute for Studies in Industrial Development
An institution of Indian Council of Social Science Research (Ministry of Education)
4 Vasant Kunj Institutional Area, New Delhi – 110 070
Phone: +91 11 3510 4511 | *E-mail:* info@isid.org.in | *Website:* https://isid.org.in

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Comparative Advantage and Intra-Industry Trade in Medical Device Industry of India

Shailender Kumar Hooda [*]

Abstract: *This study examines the applicability of traditional and modern intra-industry trade (IIT) theories in Indian medical device (MD) sector using HS-8 and HS-6 digit data from 2009 to 2024. We find that India is yet to establish strong relative comparative advantage, trade specialization and competitive advantage especially in high-tech MD segments. The disposable devices segment demonstrated strong IIT, however, for electro diagnostic and surgical equipment it remained low but improving, and very low for therapeutic and testing kits. Marginal IIT shows a shift toward inter-industry trade in certain device segments. Traditional trade theories offer a useful lens to understand India's medical trade structure, as the sector has some strength in labour-intensive, low-tech products but weak in capital- and technology-intensive devices. While the industry exhibits emerging potential in low-tech segments, significant progress in domestic innovation, technological capability, and targeted policy support will be critical to achieving sustained competitiveness in the high-tech medical device market.*

Keywords: *Medical Device, Trade Competitiveness, RCA, Intra-Industry Trade, Labour-Capital Intensive Devices*

JEL Classification: *F11, F12, F14, I11, O33*

[*] Associate Professor, Institute for Studies in Industrial Development, New Delhi 110 070
Email: hoodask@isid.org.in

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1. Introduction

International trade reflects the ability of a country to participate in global market. While trade creates opportunities, but its competitiveness determines a nation's success in global market. Trade theories have increasingly emphasized on comparative advantage for assessing and comparing international competitiveness of a country, as comparative advantage drives specialisation in goods with lower opportunity costs, promote efficient trade and economic development (Salvatore 2012). These theories suggest that a country would specialise in exporting goods that make intensive use of its abundant resources and anticipate a complete specialization across industry groups. However, in practice, countries increasingly found engaging in simultaneous exports and imports within the same product categories of an industry due to specialisation in niche product lines (Dixit and Stiglitz, 1977), economies of scale in production and consumer preferences for product variety (Krugman, 1979 & 1980). This phenomenon of simultaneous trade of different intermediate, semi-finished or finished products is termed as intra-industry trade (IIT) (Balassa, 1966), which have gained importance in the recent past. The trade liberalisation including tariff reforms, integration of similar economies and blocks, product differentiation, rising global value chains (GVCs) and technological advancement have made the trade more complex and fuelled the occurrence of intra-industry trade (Banik and Das 2014; Taguchi 2014; Aggarwal and Chakraborty 2022). Krugman, way back in 1981 explained that the extent of IIT tends to increase as trading countries become more similar in terms of factor endowments (Krugman 1981), in levels of technology and in ability of capital and skilled labour. The process of economic integration expanded the boundaries of advanced countries that have influenced tendencies of changes in intra-industry trade. The IIT has surged in Asia as well, especially due to specialization in specific product segments, cross-border value chain integration in manufacturing, and tariff reforms (Taguchi, 2014; Aggarwal and Chakraborty 2022). The new literature on trade highlights that IIT analysis offers a more nuanced understanding on competitiveness in modern trade compared to comparative advantage, as IIT enables countries to leverage their comparative advantages while accessing a broader range of products at lower costs. However, both these principles are being used to illustrate how nations optimize resources and broaden trade possibilities.

India, following the 1991 trade liberalisation, shifted its focus towards an export promotion strategy. Overtime, the country entered into numerous Free Trade Agreements (FTAs) with East, Southeast and South Asian economics as well as with major advanced economics, to facilitate bilateral trade through trade and tariff reforms. These reforms have significantly deepened India's integration into regional and global value chains, particularly with Japan, South Korea and ASEAN countries across industrial sectors (Aggarwal and Chakraborty 2022; Veeramani and Dhir 2017). Government launched Make-in-India (MII) programme in 2014 with an aim to boost export by attracting foreign players to set up production units and transfer cutting-edge technologies to India, along with facilitating the import of intermediate goods, semi-finished products, and components from their global supply network partners. These developments are likely to influence inter and intra-industry trade. What has been the nature and trend in inter and intra-industry trade, is examined for medical device (MD) sector of India. Sector specific analysis is relevant especially to understand the inherent product heterogeneity within the sector and whether it exhibits characteristics of inter-industry or intra-industry trade.

The medical device case is important because Indian medical device market is set to grow exponentially with a size of USD 12-15 billion in 2023 to about USD 50 billion by 2030[1]. Medical device sector was considered as sunrise sector under MII and also gained prominence and policy supports through Medical Device Park (MDP) and Production-Linked Incentive (PLI) schemes (Hooda 2025) where domestic manufacturers are aimed to expand their presence in market through scaling up of manufacturing capabilities and innovation in high-tech segment. To assess how India has fared its position in global market, analysis of India's medical devices trade and applicability of trade theories via evaluating trade competitiveness and intra-industry trade assume important. This study aims to examine the trend and extent of IIT with India's key medical device trading partners during the period 2009-2024. To gain a deeper insight into IIT dynamics, medical devices are categorised by their functional and technological classifications, as discussed in method section. This approach helps in assessing India's potential for upward movement in high-tech medical device segments and its progression toward a higher level of IIT. Such segmentation gives insights about areas where India holds competitive advantages and identifies the segments where it faces disadvantaged. For instance, from the perspective of Heckscher-Ohlin (H-O) model, India, being a labour-abundant country, is expected to export labour-intensive, low-end medical device products, while import capital- and technology-intensive high-end product. In this context, the study seeks to examine whether India has comparative advantage in low-end medical device products or Indian high-end medical products face competitive disadvantages globally measured through comparative, competitive and IIT indices.

The structure of the paper is as follows. Section 2 provides conceptual framework and a brief literature on India's trade competitiveness and IIT. Section 3 outlines the methodology used for empirical analysis and discuss the data sources. Section 4 analyses India's comparative advantage in medical device. Sections 5 presents intra-industry trade analysis. Section 6 discusses the results and concludes the paper.

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[1] IBEF (2023): Valued at US$15.35 billion in 2023, expected to grow to US$20.51 billion by 2029 at a CAGR of 5.35%. EY India (2023-24): Valued at US$12 billion, projected to reach US$50 billion by 2030.
Market Research Future (2023): Valued at US$6.7 billion in 2023, expected to reach US$13.4 billion by 2032 at a CAGR of 9%. Custom Market Insights (2024): Valued at US$5.84 billion in 2024, projected to reach US$16.99 billion by 2033 at a CAGR of 12.6%.

2. Theoretical and Conceptual Framework

2.1. On the Theories of Comparative/Competitive Advantage

The classical theory of international trade, as introduced by Adam Smith, argues that countries differ in their ability to produce products efficiently (Hill 2015). According to this framework, products with an absolute cost advantage (ability of a country to produce products with less labour or resources than others) are inherently more competitive in international market, i.e., trade competition is driven by absolute advantage (Chen and Ouyang 2012; Pugel 2016). Therefore, a country exports goods in which it has absolute cost advantage and imports goods where it has absolute cost disadvantage. Thus, countries specialise according to their absolute advantages to enhance global production efficiency. While advancing the Smith's framework, David Ricardo supported Smith's free trade idea, however, demonstrated that nations can gain from trade, even without an absolute advantage, if they specialise in products in which they have comparative advantage. That is, it is not the absolute cost, but relative efficiency or opportunity cost is critical to determine the grain from trade (Carbaugh 2015; Cavusgil et al. 2017). Heckscher-Ohlin (H-O) extended the classical framework and emphasised that factor endowments is the basis for trade. H-O theorem argues that international trade pattern is determined by difference in factor endowments, rather than differences in productivity (Hill 2015). That is, countries will export goods that use their abundant and inexpensive factors of production intensively, and import goods that require their scarce and costly factors. These theorems advocated that free trade (open markets) will enhance the global production efficiency through division of labour, differences in technology or factor endowment.

A large body of literatures emphasized on comparative advantage, focusing on factors such as technology and resource endowments. However, recent literature have introduced the concept of competitive advantage. According to Michael Porter (1980), competitive advantage arises from a nation's ability to innovate and upgrade its industries, making the concept more dynamic than traditional trade theories. Competitive advantage is tied to a firm or nation's positional strength, enabling superior performance through value creation and the deployment of dynamic capabilities (Porter, 1980; Ofori and Appiah-Nimo, 2021). Compared to static trade models, Porter's theory integrates the evolving nature of competition and innovation, offering valuable insights for policymakers seeking to enhance a country's global competitiveness (Beaudreau, 2016).

2.2. On the Theories of Intra-Industry Trade

The classical and neo-classical comparative advantage trade theories primarily focused on inter-industry trade, wherein each country specialize in the production of specific commodities for which they possess relative efficiency or abundant factors of production –assuming that all production stages for a given good occurred domestically– and subsequently exchange these goods with trading partners and import goods from other countries where they are less efficient (Krugman, Obstfeld, & Melitz, 2018; Appleyard, Field, & Cobb, 2010). However, in the post-war era, it became evident that international trade no longer follows the traditional pattern of exchanging fundamentally different products (Agarwal and Betai 2022). Instead, trade increasingly involves the exchange of goods within the same product category. This pattern of exchange was termed as intra-industry trade (Balassa, 1966). That is, the simultaneous export and import of similar or differentiated products within the same industry is referred to as intra-industry trade (IIT). It typically occurs among countries with comparable economic structures and is driven by factors such as economies of scale, product differentiation, and consumer preferences (Helpman & Krugman, 1985; Salvatore, 2012; Carbaugh, 2015). Early research on intra-industry trade was predominantly empirical and lacked a robust theoretical foundation. This gap was first addressed by Krugman (1979), who demonstrated that trade in similar yet differentiated products arises from economies of scale in production and consumers' preference for product varieties. These factors not only explain the existence of IIT but also contribute to the associated gains from trade. In subsequent work, Krugman (1981) further established that the extent of IIT tends to increase as trading countries become more similar in terms of factor endowments.

The Product Life Cycle Theory, proposed by Vernon (1966), added a new dimension to trade theory by emphasizing how technological innovation and standardization impact comparative advantage over time (Husted and Melvin, 2013; Kreinin, 2010). This theory posits that a country's initial advantage in innovative products may diminish as production processes become standardized and shift to lower-cost locations. In Vernon's point of view, technological innovations play an important role in foreign trade, which can affect comparative advantage and pattern of trade (Zhang and Chatwin 2023). The initial comparative advantage of innovative products and the loss of comparative advantage formed by technology transfer and diffusion, determine the pattern of change in international trade (Carbaugh, 2015). This dynamic process contributes to the transformation and advancement of a country's industrial structure and highlights the role of technology in shaping comparative advantage. As referred by Hill (2015), United States transits from being an exporter to an importer as production relocated in low-cost countries, as reflected from the pattern of trade –a consequence of the product life cycle.

Aforementioned theories emphasised on the supply-side dimensions of the source of comparative advantage. Stefan Linder proposed the 'Similarity of Preferences' theory which presents a demand oriented theory of trade. Linder proposed that trade in differentiated manufactured products likely to be more intense between similar per capita income levels (Linder, 1961). His hypothesis contends that the developed countries will tend to trade with other developed (rich) countries, and developing countries are more likely to trade with other developing countries, because countries with similar per capita income will have overlapping demand structures and demand the similar types of manufactured products (Zhang and Chatwin 2023). As per his postulation, countries with similar demand patterns would increase the volume of reciprocal trade between economies in differentiated goods, explaining intra-industry trade (IIT) –the mutual (two-way trade or simultaneous export and import) exchange of similar products within the same industry. Lancaster (1980) also argues that countries with the same factor endowments would exhibit pure IIT. As the extent of similarity between endowments reduces, IIT would reduce. Helpman (1981) measured similarity as an absolute difference in income between countries and showed the negative correlation between similarity and bilateral IIT. IIT can be explained by economies of scale and product differentiation (Carbaugh, 2015; Appleyard et al., 2010; Gerber, 2011; Salvatore, 2012). IIT occurs in order to take advantage of important economies of scale in production (Salvatore, 2012), because average costs reduce as production expands (Gerber, 2011).

2.3. On the Empirical Evidences on IIT and Comparative Advantages

Initial research on intra-industry trade (IIT) focused on developed countries. Verdoorn (1960) and Balassa (1963) noted that European trade shifted from inter-industry to intra-industry patterns. They states that this is a common trend across developed nations but largely absent in developing ones. It was widely believed that developing countries lacked the scale economies and had stark factor endowment differences which limit the IIT. Balassa (1979) however found evidence of IIT among developing countries and between them and developed countries, especially in manufactured goods. Regional integration and trade agreements were key drivers. Later, Manrique (1987) indicated the presence of IIT in developing economies. Numerous studies have examined India’s IIT and highlighted its unique patterns and key drivers. Trade liberalisation reported to be a major factor in boosting IIT through resource reallocation within industries (Veeramani 2002). The reduced trade barriers and efficient resource use led to greater specialisation and IIT in India (Burange and Chaddha 2008). Aggarwal and Chakraborty (2019) confirmed that multilateral reforms have increased IIT at aggregate and sectoral levels. Aggarwal and Chakraborty (2019) and Das and Dubey (2014) showed that India's FTAs have strengthened IIT, while Varma and Ramakrishnan (2014) found that SAFTA and ASEAN agreements enhanced IIT in both manufacturing and agriculture sectors. On export-import dynamic, Veeramani (2002) attributes rising IIT to increased exports, whereas Bagchi (2017) links it to rising imports. Bhadouria and Verma (2012), however, note a decline in textile IIT due to growing net exports. Traditional factors like similarity in income and factor endowments offer mixed insights. While theory suggests higher IIT with similar (developing) economies. Veeramani (2002) and Srivastava and Medury (2011) found that India trades more IIT with developed, dissimilar economies, largely due to vertical IIT. Agarwal and Betai (2022) found that trade between countries was increasingly dominated by Intra-industry trade (IIT), where countries exchanged products that fall in the same sectors. According to Aggarwal and Chakraborty (2022) vertical IIT, efficiency, trade facilitation reforms, trade agreements and product differentiation better explain India’s IIT pattern at sector level. These studies reveals that while India's IIT has increased in recent years, it is not the dominant form of trade between India and its key partners.

With regards to determinant factors, studies revealed that India's comparative advantage and trade agreements play a positive and significant role in increasing IIT. The geographic distance, rising income and economic size, efficiency, and relative comparative advantage are the other important determinants of IIT. Higher income and economic size boost demand, fostering IIT, while RCA reflects production efficiency, influencing supply-side IIT. Overall, the deepening of global production networks, along with the rise in simultaneous exports and imports with key trade partners in specific sector has led to rise in India's bilateral IIT over the past decade at aggregate level. Despite being the high importance and need of conducting sector-specific IIT and comparative advantage, sector-specific analyses remains relatively underexplored in India. Building on these insights, this paper aims to deepen the understanding of India trade in medical devices by examining whether it exhibits characteristics of inter-industry or intra-industry trade. This analysis is especially relevant due to the considerable product heterogeneity inherent in the medical devices sector.

3. Data and Method

3.1. Data Sources

The study utilised medical device trade data from the World Integrated Trade Solution (WITS) developed by World Bank in collaboration with UNCTAD and WTO. We also utilised trade statistics provided by Directorate General of Commercial Intelligence and Statistics (DGCI&S) under the Ministry of Commerce and Industry, Government of India. The WITS data provides standardized international trade data up to 6-digit level of Harmonized System (HS) classification and enable cross-country comparisons of medical device trade flows and trade competitiveness. The DGCI&S provides trade data at more disaggregate HS-8 digit level and allow for a deeper analysis of specific types and characteristics of medical devices being imported and exported. This study uses HS-6 data to assess international benchmarking and HS-8 data for India's MD trade structure across various products. Both these data enable a comprehensive analysis of trade trends, key trading partners, product composition, India's position within the global medical device market, and to assess trade-competitiveness and intra-industry trade. The WITS HS-6 data is used when India's trade is compared with other countries, otherwise DGCI&S HS-8 data is employed.

3.2. Classification of Medical Devices

The medical device industry encompasses a wide array of products, ranging from basic, low-tech items like bandages to highly sophisticated, high-tech capital equipment. These products can generally be grouped into four main categories:

a. Disposables – These are the simplest and most frequently used products, typically intended for single use like the bandages, surgical gloves, plastic syringes, catheters, and needles. Due to their low complexity and minimal risk to patients, these devices are subject to fewer regulatory hurdles. While they require adherence to quality standards, their manufacturing demands less specialized medical expertise compared to other device types. These devices generally fall into low-tech classes.

b. Surgical Equipment – This category includes tools used in a wide range of medical procedures, from routine surgeries to advanced operations such as organ transplants like the medical scissors and dental drills. They are slightly more complex than disposables, production of these instruments is increasingly influenced by cost considerations. These devices generally fall into mid-tech classes.
c. Therapeutic Devices – These devices assist in managing health conditions and disabilities, and may be either implantable or external. Implantable devices like pacemakers, hearing aids, and prosthetics require advanced expertise, particularly concerning biocompatibility, and are subject to rigorous regulatory standards. Non-implantable therapeutic tools, such as ventilators and infusion pumps, also play a crucial role in treatment and patient care. Due to their technical nature and specialized application, these devices generally fall into mid to high-tech classes.
d. Electro Diagnostic – Represents the most technologically advanced segment, this category includes large-scale devices used for diagnostics, patient monitoring, and imaging. Equipment such as CT scanners, MRI machines, and infusion pumps are typically high-value. The production of these devices require a long-term investments and high capital funds. Their acquisition often involves multiple stakeholders due to the significant capital involved.
e. Hospital infrastructure like the bed and invalid carriage for disabled person and optical lenses are the other categories that fall under low-tech classification.

Measuring Comparative and Competitive Advantage and IIT

3.3.1 Revealed Comparative Advantage

As discussed, Balassa (1965) proposed a Revealed Comparative Advantage (RCA) index which is a widely used measure to assess a country's comparative advantage reflected through its export volumes. The RCA index helps identify the relative strength of a country's export in a particular sector. The index is calculated as the ratio of a country’s export share over world export share for a specific industry/product. It is estimated using the following formula:

$$\mathrm{RCA} = \frac{\frac{Xij}{Xj}}{\frac{Xwi}{Xw}}$$

where, RCA is Balassa’s index of revealed comparative advantage; Xij represents the export volume of good *i* from country *j*; Xj is the total export volume of country *j*; Xwi is export of good i by all countries in the world; and Xw is the total export by all countries in the world.

If the value of RCA is greater than one (RCA>1), the country j has a revealed comparative advantage in exporting the product i to the global market. If the value of index is less than one (RCA≤1), the country j has a revealed comparative disadvantage in the trade of product i to world market. The trends of RCA shows that changes in export share of product i to country j and any large fluctuation will be a clear proof of absence an apparent strategy for export of that product (Balassa, 1965).

The revealed comparative advantages can also be assessed in relation to export of related sector. Since, medical device is closely associated with pharmaceutical sector, the RCA analysis is extended in relation to pharma export using the same formula.

3.3.2 Trade Competitiveness (TC) or Trade Specialisation (TS) Index

The Trade Competitiveness (TC) Index, also known as the trade specialisation (TS) index, measures whether a country holds a competitive advantage in exporting a particular product compared to the same product supplied to the world market. It is widely used to measure the international competitiveness of a product. This index also serves as a tool to illustrate a product's life cycle in international trade. Its changing value reflects the progression of a product through various stages ranging from being primarily imported, to domestic production (import substitution) stage, to export expansion stage, and mature stage as against the imports stage (Chen and Ouyang, 2012; Zhang and Chatwin, 2023). The TS index formula is described as:

$$\text{TSI} = \frac{Xij - Mij}{Xij + Mij}$$

where, X*ij* and M*ij* represents the export and import of product *i* by country *j*

The value of TC or TS index lies between -1 and +1. The upward movement of the index from -1 to +1 reflects the changing process from net import to net export and vice versa. If TS index is positive and close to 1, it means that the country has specialisation in producing the product i and is a net exporter of product i. That is, a TSI close to 1 suggests that total exports far exceeds the total amount of imports, indicating that the product has a competitive advantage in international market. On the other hand, a TSI value close to -1 implies that import volumes are much higher than export and the competitiveness of the product is weak in the global market (Jiang & Lin, 2019).

3.3.3 Competitive Advantage (CA) Index

The CA Index is an extension of RCA that involves both export volumes and import volumes (Vollrath 1991). The formula for the CA index:

$$CA = RCA - \frac{\frac{Mij}{Mj}}{\frac{Mwi}{Mw}}.$$

where, Mij is the import volumes of product i in country j; Mj is the total import volumes of country j; Mwi is the world import volumes of product i; and Mw is the total import volumes of the world.

A value of CA > 0 indicates that country j's product i has comparative advantage in the global market. If CA < 0, it shows that country j's product i does not have comparative advantage in the global market. The higher the CA index, the stronger the international competitiveness (Zhang and Chatwin, 2023).

3.3.4 Measuring Intra-Industry Trade: The Grubel-Lloyd (GL) Index

Studies have employed a range of indices to measure IIT. There is no common consensus on a single preferred index for capturing intra-industry specialization. However, the Grubel-Lloyd index remains the most widely used index for measuring the extent of two-way intra-industry trade (Grubel and Lloyd, 1975). This index is defined as GL or IIT index and measured as:

$$\text{GL} = \frac{(Xi + Mi) - |Xi - Mi|}{Xi + Mi} = 1 - \frac{|Xi - Mi|}{Xi + Mi}$$

where, Xi and Mi are exports and imports of product i during a particular period.

The value of GL index ranges between 0 and 1. If the GL index is equal to 0, this means that a country has only exports or imports in a certain industry (Xi = 0 or Mi = 0). If GL index is equal to 1, it means that a country's exports or imports in a certain industry are equal. The closer the GL index is to 0, the lower the level of IIT. The closer the GL index is to 1, the higher the level of IIT (Zhang and Chatwin, 2023; Zhang, 2017; Ren, 2017; Sawyer and Sprinkle, 2006). A GL index higher than 0.5 implies an intra-industry dominated pattern, while a GL index lower than 0.5 indicates an inter-industry dominated pattern. It is important to note that the value of GL index is sensitive to the level of product aggregation. A higher levels of product aggregation tend to produce higher values of the index. Thus, using data at most disaggregated level for evaluating the IIT is essential. We used 6-digit and 8-digit level Harmonized System (HS) classification for the individual products that make up the medical devices sector.

It is important to note that the GL index is more precisely defined for bilateral trade between specific countries. Aggregating trade partners into broader regions can introduce geographic bias, thereby diminishing the interpretive accuracy of the index. The narrower the definition of the trade partner, the more reliable the GL index becomes. Given the wide array of India's trading partners for medical devices, it is beyond the scope of this study to calculate bilateral indices for all partners. Instead, we compute the GL index for different segments of medical devices in India's trade with the world to provide a general understanding of trade patterns. The GL is calculated for India's medical device trade with its 15 largest trading partners in medical devices that include the United States, China, Germany, Singapore, Japan, France, Netherlands, UK, Korea, Switzerland, Ireland, Belgium, Italy, and Malaysia. Our estimates suggest that these partners together account for three-fourth of India's medical device trade in recent past decade.

3.3.5 Marginal Intra-Industry Trade Index

Although the GL index is commonly used index, but it fails to capture the dynamics of changes in intra-industry trade, as trends in trade patterns are relay on absolute trade values. To address this limitation, recent theoretical developments stress on the importance of marginal intra-industry trade. Several indices of marginal intra-industry trade have been developed. The first attempt to develop an index for marginal intra-industry trade (MIIT) was made by Hamilton and Kniest in 1991. They argued that the commonly used Grube-Lloyd index was inadequate for capturing changes in trade flows over time. Instead, they emphasized the need to analyse how intra-industry trade evolves at the margin, particularly to assess the adjustment implications of trade expansion. They introduced an index that measures the proportion of changes in exports and imports attributable to intra-industry trade (Hamilton & Kniest, 1991). However, the most popular measure used by most of the studies is proposed by Marius Brulhart (1994), which is essentially a dynamic version of the Grubel–Lloyd index, adapted specifically to track changes in trade flows over time. Brulhart (Bi) formula is defined as:

$$\text{Bi or BIIT} = 1 - \frac{|\Delta Xi - \Delta Mi|}{|\Delta Xi| + |\Delta Mi|}$$

where, Xi and Mi have the same meaning as in the case of the GL index; Δ is the change in trade flows between two years. Similar to the GL index, BIIT index range between 0 and 1, where 0 value indicates the pure inter-industry trade and 1 indicates the pure intra-industry trade, respectively.

4. Summary Statistics of RCA, TS, CA, GL and MIIT Indices

The Figure-1 provides a summary result for RCA, TS, CA, GL and BIIT. To make a broad understanding, the trends in these indices are classified using their range values. In case of RCA, if RCA>1, the product has a comparative advantage and if RCA≤1, the product does not have comparative advantage in the global market. To have a better understanding about India's comparative advantage, this range of RCA is subdivided as: if RCA>1, the product has strong competitive advantage, if 0.75<RCA<1, the product has a medium comparative advantage and if RCA <0.75, the competitiveness of the product is low. The data analysis suggests that RCA value for India's medical device ranges between 0.27–0.43. This indicates that country does not has revealed comparative advantage in this sector relative to its overall exports. However, the RCA value shows an increasing trend which increased from 0.27 in 2009 to 0.43 in 2023, indicating that competitiveness in medical device exports is improving over time, but remained very low competitiveness in global market.

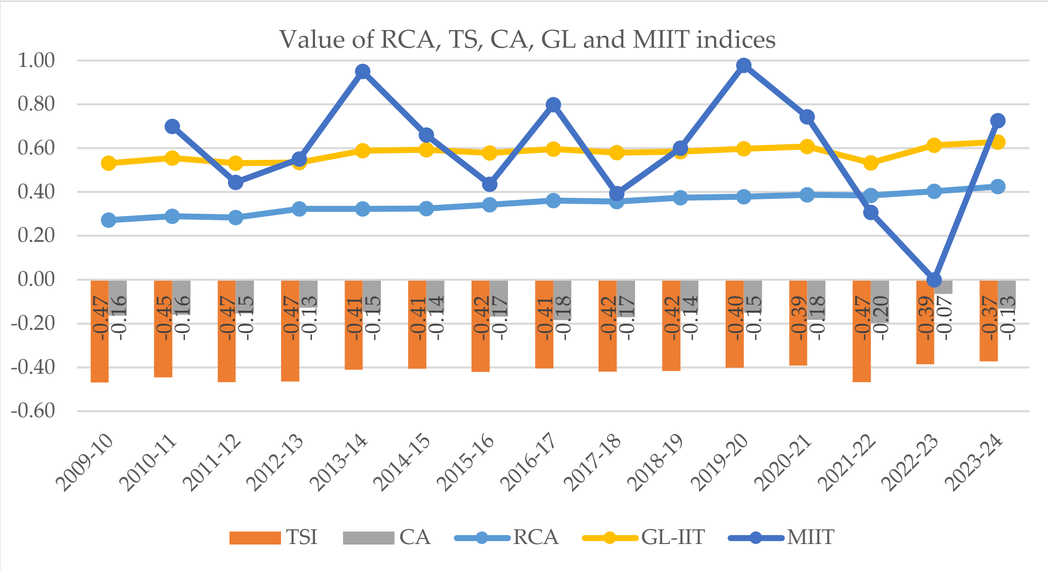
The TS index generally range between -1 to 1, which has also been subdivided as: if the value of TS index is between -1 to -0.5, it means the product has great competitive disadvantage. If the value of TS is between -0.5 to -0.25, it means the product has a competitive disadvantage. If the value of TS is -0.25 to 0, it means the product has a weak competitive disadvantage. If the value of TS is between 0 to 0.25, it means that product has a weak competitive advantage. It the value of TS is between 0.25 to 0.5, it means the product has a competitive advantage. If it lies between 0.5 to 1, it means the product has great competitive advantage. The data analysis suggests that TS index value consistently remains in the negative range, indicating that imports continue to exceed exports. The TS index value ranges between -0.37 to -0.47, indicating that the product has a competitive disadvantage in global market. However, we see an upward movement in TS index from -0.469 in 2009 to -0.372 in 2023, suggesting a modest increase in product comparative advantage.

The CA ranges 0<CA>0. A higher value of CA indicates stronger competitiveness. That is, if CA>0, it means the product has competitive advantage and if CA<0, the product does not have competitive advantage in global market. The results show that Indian medical devices do not have competitive advantage. The estimated value of CA index remained consistently negative throughout 2009–2023 ranging between -0.20 and -0.13, which is less than zero. This indicates the country lacks a competitive advantage in medical device product during the entire period. There was a slight improvement in 2022, but overall competitive advantage remains weak.

Value of GL index ranges between 0 and 1. The closer the GL index is to 0, the lower the level of IIT, while closer the GL index is to 1, the higher the level of IIT. We have subdivided GL range as: a GL value close to one refers to intra-industry dominated trade pattern and a value of GL range between 0.5-0.8 implies moderate level of intra-industry trade pattern, while a GL index lower than 0.5 indicates an inter-industry dominated pattern. Analysis shows that the GL index value remained more than 0.5 throughout the study period. It increased from 0.53 to 0.63 between 2009 to 2023, suggesting a moderate level of intra-industry trade across the entire medical device sector, with a slight upward trend towards more balanced trade in recent years.

Although GL index is commonly used index, but fail to capture the change in trade flows over time. The marginal intra-industry trade (MIIT) gained theoretical importance, as it emphasized the need to analyse how intra-industry trade evolves at the margin, particularly to assess the adjustment implications of trade expansion. The MIIT index value though range, similar to GL index, between 0 and 1, where 0 value indicates the pure inter-industry trade and 1 indicates the pure intra-industry trade, respectively. The data analysis suggests that MIIT value increased from 0.70 in 2010 to 0.98 2019-20, prior to Covid-19 period, reflects a strengthening of marginal intra-industry trade. That is, trade flow are moving towards IIT pattern over time, though, it shows highly fluctuating pattern during and after the Covid-19 period. (Figure 1).

Figure 1: Overall RCA, TS, CA, GL and MIIT indices Values



Source: Author's estimates using data from WITS & DGCI&S

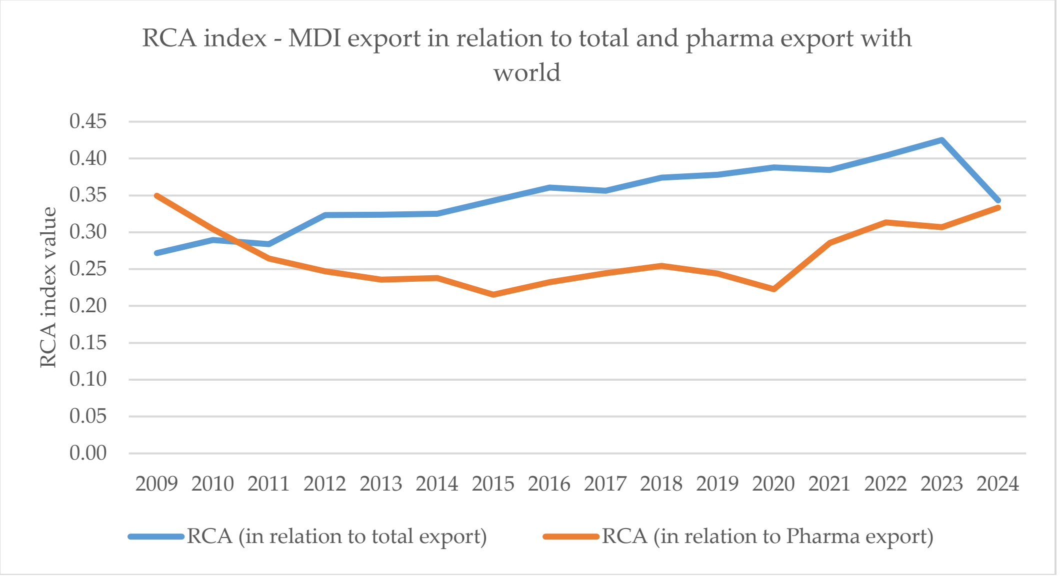
As reported, medical device industry encompasses a wide range of diversified products, spanning from low- to high-tech segments. The value of these indices might vary across different segments, which has been analysed in the subsequent section.

5. Analysis of Comparative and Competitive Advantages

5.1. The Revealed Comparative Advantage

RCA value in relation to total export shows an increasing trend, which increased from 0.27 in 2009 to 0.43 in 2023 with a slight dip in 2024 (Figure 2). This indicates that competitiveness in medical device exports is improving over time. However, RCA remained below one throughout the period, indicating that country does not have a revealed comparative advantage in this sector relative to its overall exports. RCA is also estimated in relation to pharmaceutical export (Figure 2). It shows a declining trend from 0.35 in 2009-10 to a low of 0.22 in 2015-16, however, a modest recovery is observed after the Covid period 2020. This indicated that comparative advantage of medical devices was declining before the launch of make-in-India when sector was declared as sun-rise sector, a slight upward trends was observed thereafter. The RCA recorded 0.33 in 2024 from 0.22 in 2015, indicating a gradual increasing in comparative advantages of medical device sector.

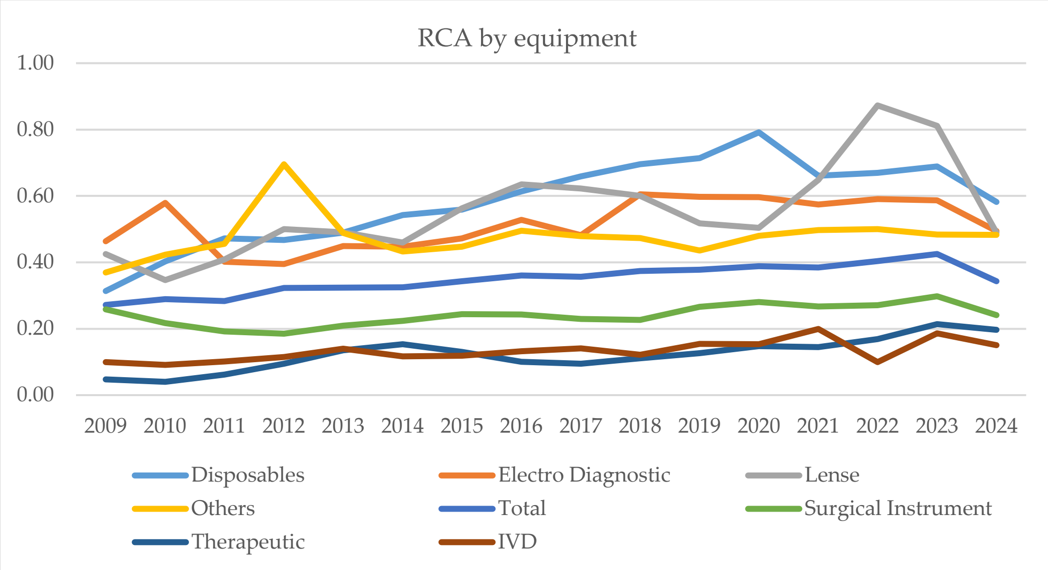
Figure 2: Revealed Comparative Advantage Index in relation to total and pharma export



Source: Author's estimates using data from WITS

The RCA analysis by functional classification indicates a consistent lower than one value of across different functional classification though with significant variation, which reflect the diverse technological spectrum of the sector (Figure 3). Amongst the other segments, the disposable devices consistently show strong performance, with index values rising from 0.31 in 2009 to a peak of 0.79 in 2020, before declining to 0.58 in 2024. Electro Diagnostic devices exhibit a rise in RCA value from 0.39 in 2011 to 0.59 in 2023 before it dropped to 0.49 in 2024, suggesting an improvement in its comparative advantage but at moderate level. The Lenses category experienced a steady growth between 2011 to 2021, reaching to 0.87 in 2022. The RCA of others' category remained relatively stable throughout the period. The other medium-technology segments such as Surgical Instruments, Therapeutic Devices, and IVD (In Vitro Diagnostics) demonstrate a lower value of RCA. In case of surgical instruments, the RCA increased modestly from 0.22 to 0.30, therapeutic devices improved from 0.05 to 0.20 between 2009 to 2024. IVD shows a similar trajectory, peaking modestly in recent years. The low value of RCA for these segments suggest that India has very weak comparative advantage in these segments. We observed a decline in RCA value in majority of the segment in the recent year, possibly due to regulatory changes or post-pandemic shifts in demand.

Figure 3: Revealed Comparative Advantage by device functional classification



Source: Estimated using data from WITS; for pharma export, HS-30 was considered

5.2. Trade Competitiveness (TC) or Trade Specialisation (TS) Index

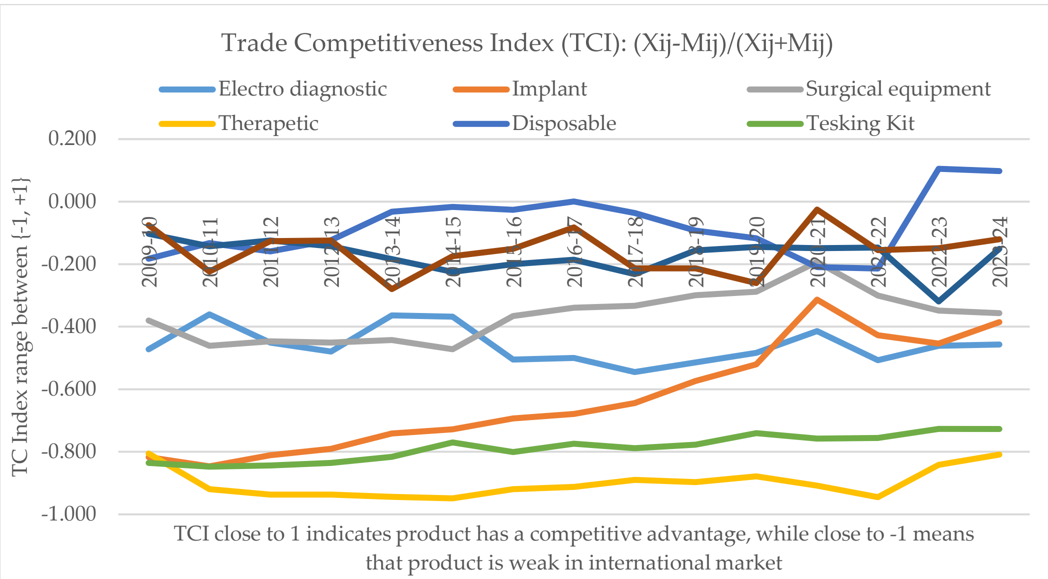
The Trade Competitiveness Index (TCI) analysis reveals a gradual but limited improvement in trade competitiveness. The TCI values consistently in the negative range across most product categories. In case of electro diagnostic equipment, TCI fluctuates between -0.36 to -0.55. Persistent trade deficit, indicating imports exceed exports significantly, suggesting limited improvements in competitiveness over 15 years (Table 1 and Figure 4). Disposable products have shown the most significant improvement, transitioning from negative values to positive TCI in recent years. This indicates a shift to net exports and growing global competitiveness of this segment, but TCI value remained slightly more then zero. Implants and surgical equipment have made consistent gains, with their TCI values moving closer to zero. However, both categories are still in a net import position. Therapeutic devices and testing kits remain highly import-reliant, with TCI values below -0.7 throughout the period. The testing kit segment shows a very low competitiveness. Optical lenses and hospital furniture show relatively unstable trade balance with minor signs of improvement in TCI. However, we see an upward movement in the overall TCI from -0.469 to -0.372, suggesting some strengthening in domestic production capabilities and a modest increase in exports.

Table 1: Trade Competitiveness/Specialisation Index

	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Electro diagnostic	-0.473	-0.360	-0.451	-0.479	-0.364	-0.368	-0.505	-0.500	-0.545	-0.514	-0.483	-0.414	-0.507	-0.461	-0.457
Implant	-0.817	-0.846	-0.811	-0.791	-0.742	-0.728	-0.694	-0.679	-0.644	-0.573	-0.521	-0.313	-0.427	-0.454	-0.385
Surgical equipment	-0.380	-0.460	-0.447	-0.451	-0.443	-0.472	-0.366	-0.340	-0.333	-0.299	-0.288	-0.193	-0.300	-0.349	-0.357
Therapeutic	-0.805	-0.919	-0.937	-0.937	-0.945	-0.949	-0.919	-0.912	-0.890	-0.897	-0.878	-0.908	-0.945	-0.842	-0.809
Disposable	-0.183	-0.132	-0.159	-0.123	-0.032	-0.017	-0.026	0.000	-0.036	-0.092	-0.117	-0.209	-0.214	0.105	0.098
Testing Kit	-0.836	-0.847	-0.844	-0.835	-0.816	-0.770	-0.801	-0.774	-0.789	-0.777	-0.741	-0.758	-0.756	-0.727	-0.727
Optical Lens	-0.103	-0.143	-0.124	-0.143	-0.184	-0.225	-0.200	-0.185	-0.231	-0.156	-0.145	-0.149	-0.147	-0.319	-0.151
Hospital Furniture	-0.075	-0.223	-0.126	-0.124	-0.280	-0.174	-0.151	-0.082	-0.214	-0.213	-0.261	-0.025	-0.155	-0.149	-0.121
Total	-0.469	-0.445	-0.468	-0.465	-0.411	-0.406	-0.421	-0.405	-0.420	-0.416	-0.402	-0.392	-0.467	-0.386	-0.372

Source: Author's estimates using data from DGCI&S

Figure 4: Trade Competitiveness/Specialisation Index

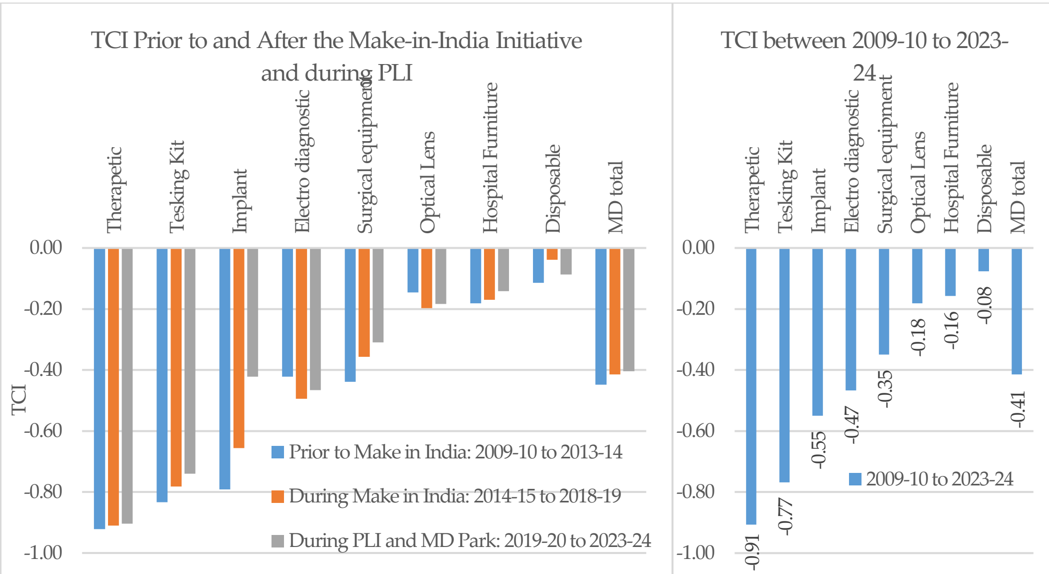


Source: Author's estimates using data from DGCI&S

There is a gradual improvement in trade competitiveness, though with slow reduction in import dependency. Most product categories show an improvement in TCI values, particularly from the Make in India phase onward. The largest gains are seen during the

PLI and Medical Device Parks phase, especially in categories like implants and surgical equipment, suggesting these policies are beginning to yield results (Figure 5). However, several categories remain deeply import-dependent like the therapeutic and testing kits. This suggests that while government policies have led to some positive momentum in trade competitiveness, the improvement is modest and uneven. Continued focus on scaling up domestic production, innovation, and export capacity will be critical for achieving long-term trade competitiveness in the sector.

Figure 5: Impact of MII and PLI on Trade Competitiveness/Specialisation

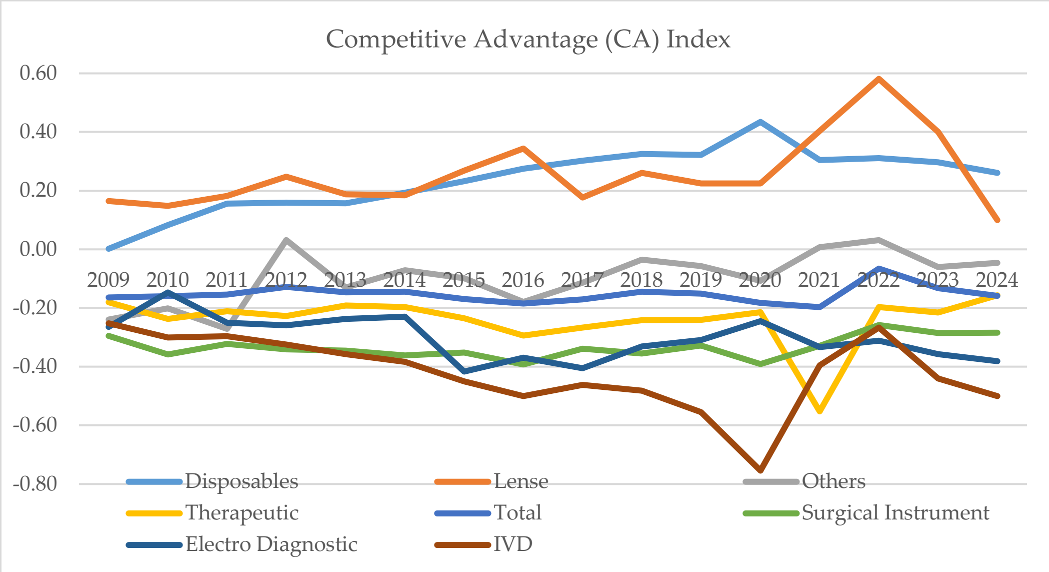


Source: Author's estimates using data from DGCI&S

5.3. Competitive Advantage (CA) Index

The estimated value of CA index for the medical device product remain consistently negative throughout 2009-2024 ranging between -0.20 and -0.07, which is less than zero (Figure 6). This indicates the country lacks a competitive advantage in this product during the entire period. There was a slight improvement in 2022, but overall competitive advantage remains weak. The value of CA found to be less than zero across different functional classification, except for disposable and lenses. CA for these two categories remained closer to zero. This indicates that country imports more medical device product and does not export enough to offset these imports.

Figure 6: Competitive Advantage Index



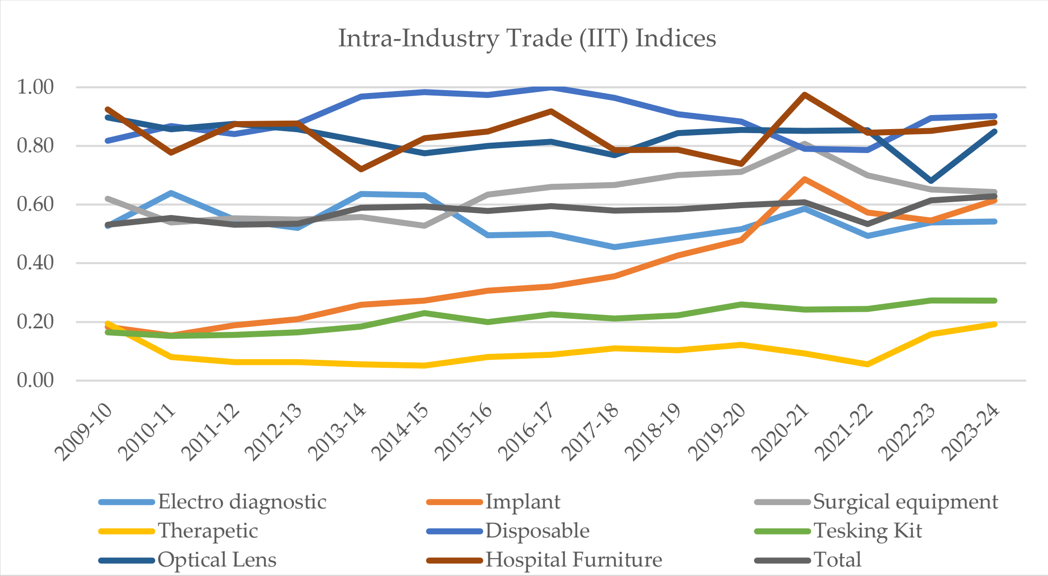
Source: Author's estimates using data from DGCI&S

6. Analysis of Intra-Industry Trade

6.1. The Grubel-Lloyd (GL) Index

The Grubel-Lloyd (GL) index measures the degree of intra-industry trade, with values ranging from 0 (only exports or only imports) to 1 (equal exports and imports). As discussed, a higher values of GL indicate a greater balance of exports and imports within a product category, reflecting more intense intra-industry trade. The analysis shows that for electro diagnostic, the IIT ranges between 0.46 and 0.64 (Figure 7). For implants, IIT shows a consistent rise. The surgical equipment maintained relatively high IIT levels (0.53-0.81), showing consistently strong intra-industry trade. Therapeutic products show low IIT values throughout, indicating predominance of imports rather than balanced trade. In case of disposable products, we observed a very high IIT ranges 0.8 to 1.0, indicating a very intense intra-industry trade. The testing kits show low IIT with a slight increases over time. For optical lens, we see a very high IIT values, reflecting strong intra-industry trade. The hospital furniture also show a high IIT levels, ranges between 0.72 and 0.97 though with some fluctuation, indicating intense balanced trade. The overall IIT index ranges between 0.53 and 0.63 over the years, suggesting a moderate level of intra-industry trade across the entire medical device sector, with a slight upward trend towards more balanced trade in recent years.

Figure 7: Intra-Industry Trade (IIT) Indices



Source: Author's estimates using data from DGCI&S

The GL index values from 2009 to 2024 reveal a mixed picture of India's IIT patterns in medical devices (MD) across different regions and key MD trading partners (Table 2). With South Asia, it experienced a sharp decline in IIT, falling from 0.70 in 2016 to a low of 0.12 in 2024, indicating a clear shift toward inter-industry trade, possibly due to reduced specialization or increasing dependence on imports of dissimilar MD products. Similarly, Sub-Saharan Africa continues to reflect low IIT levels, consistently below 0.20, suggesting limited overlap in the nature of products traded.

In contrast, regions like East Asia–Pacific and Latin America–Caribbean show a strengthening IIT trend. The latter, in particular, recorded a significant rise from 0.45 in 2009 to 0.88 in 2024, pointing toward a maturing trade relationship characterized by increased specialization and two-way trade in similar products. North America, OECD, and High-income countries maintained slightly improved IIT levels, staying within the moderate IIT range, while Europe–Central Asia and Middle East–North Africa showed gradual progress, though still at the lower end of the spectrum (Figure 8).

Among India's key MD trading partners, the Netherlands, France, and Singapore stand out for sustaining high levels of IIT, reflecting deeper integration and similarity in traded medical technologies. The GL with Netherlands reached a striking 0.93 by 2024, indicating an overwhelmingly intra-industry trade pattern. On the other hand, key economies like China and Japan exhibited declining IIT trends, moving towards more inter-industry-dominated trade, which may suggest rising asymmetry in product types or trade imbalance.

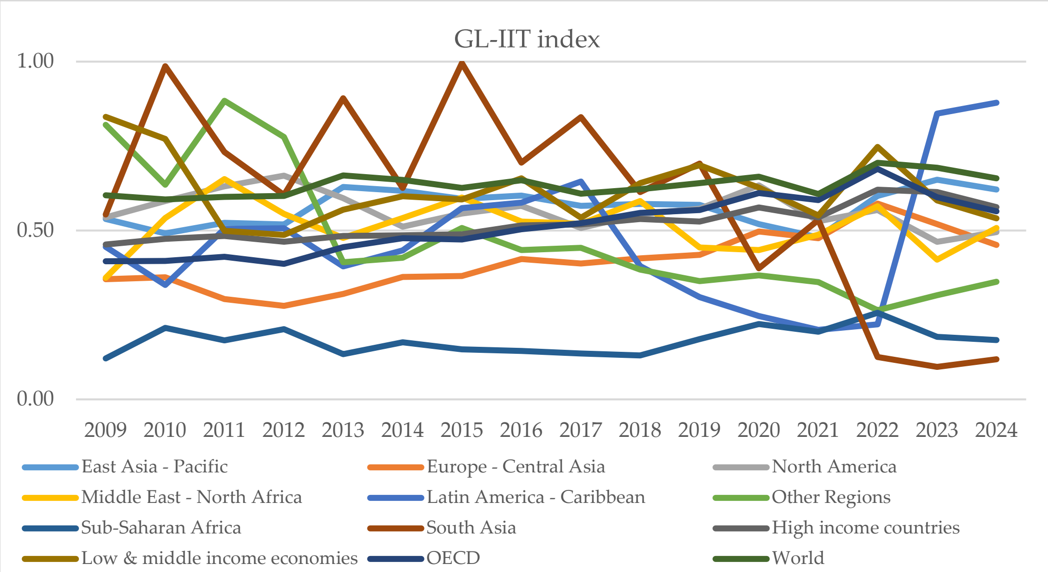
Overall, the data highlights that India's medical device trade has grown more integrated with certain high-income and developed partners, suggesting increased competitiveness and specialization. However, it also reveals a divergence with other regions and partners where trade remains predominantly inter-industry in nature, indicating potential areas for diversification or targeted policy support to deepen industrial alignment.

Table 2: Intra-Industry Trade (IIT): The GL Indices Values

GL -IIT index	*2009*	*2016*	*2024*
South Asia	0.55	0.70	0.12
Sub-Saharan Africa	0.12	0.14	0.18
Other Regions	0.81	0.44	0.35
Europe - Central Asia	0.36	0.42	0.46
North America	0.54	0.57	0.50
Middle East - North Africa	0.36	0.53	0.51
East Asia - Pacific	0.53	0.60	0.62
Latin America - Caribbean	0.45	0.58	0.88
Low & middle income economies	0.84	0.65	0.54
OECD	0.41	0.50	0.56
High income countries	0.46	0.51	0.57
India's key MD trading partners			
United States	0.43	0.53	0.60
Germany	0.30	0.39	0.42
France	0.52	0.98	0.89
China	0.59	0.37	0.20
Singapore	0.73	0.75	0.72
United Kingdom	0.63	0.57	0.71
Netherlands	0.41	0.78	0.93
Italy	0.47	0.46	0.78
Belgium	0.98	0.55	0.61
Japan	0.38	0.18	0.16
Malaysia	0.41	0.60	0.29
Above-11	0.46	0.51	0.51
Next top10	0.57	0.61	0.63
Rest of the World	0.67	0.63	0.69

Source: Author's estimates using data from WITS

Figure 8: Trends in GL-IIT Index across different Regions for the World



Source: Author's estimates using data from WITS

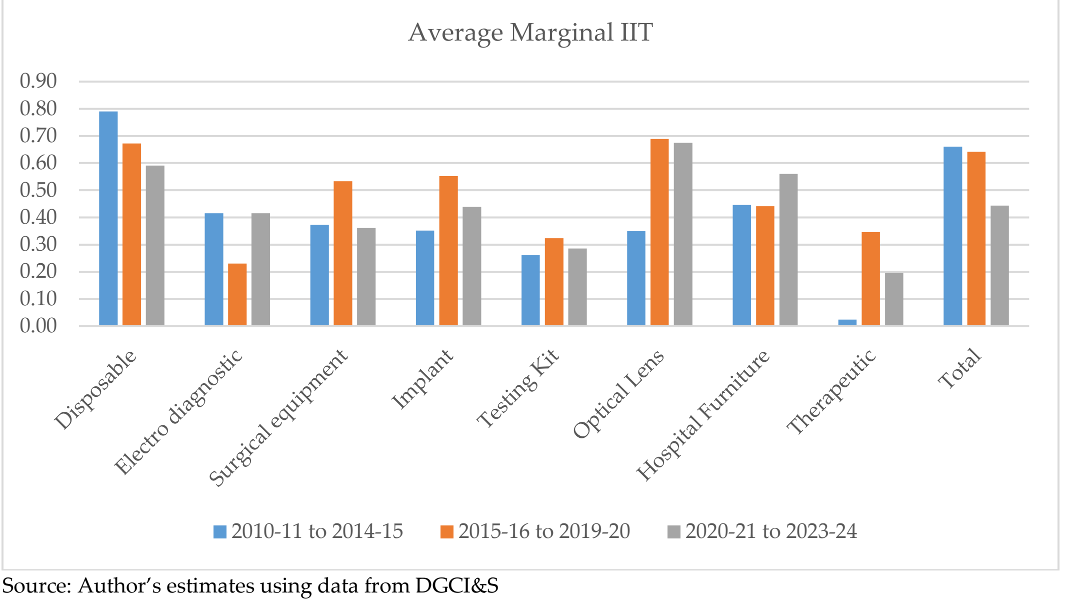
6.2. The Marginal Intra-Industry Trade Index

The marginal intra-industry trade (MIIT) data from 2010–11 to 2023–24 shows evolving trade dynamics across various medical device categories (Figure 9). Overall, the total MIIT index declined from 0.66 in the first period (2010–11 to 2014–15) to 0.44 in the most recent period (2020–21 to 2023–24), indicating a shift away from intra-industry trade in MD products. This suggests that changes in India's MD trade during recent years have increasingly involved products that are not similar in nature, pointing to growing asymmetry between exports and imports. Among product segments, disposable medical devices had the highest MIIT values in all three periods, though it declined from 0.79 to 0.59 over time, indicating a weakening of MIIT in recent years. Optical lenses also showed a increase from 0.35 in the first period to 0.69 in the second, maintaining a relatively high level (0.67), thereafter, it is signalling a maturing and balanced trade structure in this category. In contrast, electro diagnostic equipment and surgical equipment presented more volatile MIIT trends. Electro diagnostic devices MIIT dropped to a low of 0.23 during 2015–20 before recovering to 0.42, indicating an inconsistent pattern of trade adjustment. Surgical equipment experienced a spike in MIIT during 2015–20 (0.53) but declined again in the most recent period (0.36), reflecting fluctuating trade dynamics possibly driven by technological shifts or regulatory changes or shift in demand due to Covid-19.

Segments like implants, testing kits, and therapeutic devices remained in the low MIIT range, with values well below 0.5 across all periods. This points to trade changes in these categories being predominantly inter-industry in nature, suggesting that India either imports or exports entirely different types of products in these areas rather than engaging in two-way trade of similar items. Notably, therapeutic devices had extremely low MIIT in the first period (0.02), rising somewhat in 2015-2020 but declined thereafter, indicating limited and inconsistent intra-industry trade integration.

Overall, while some medical device categories, like disposables and optical lenses, are increasingly embedded in intra-industry trade, the broader trend suggests weakening MIIT, especially in the post-Covid period. This reflects a shift in India's MD trade towards more inter-industry dynamics, possibly driven by newer product types, evolving comparative advantages, or structural trade changes during the pandemic and post-pandemic periods.

Figure 9: Marginal Intra-Industry Trade (MIIT)



Source: Author's estimates using data from DGCI&S

7. Conclusion and Discussion

India's medical device sector has experienced gradual improvements in its global competitiveness, though challenges persist. The Revealed Comparative Advantage (RCA) index, which measures a country's relative strength in exporting specific products, shows that India's competitiveness in medical devices has remained low, with RCA values consistently below 1 from 2009 to 2024. Although the RCA index increased from 0.27 in 2009 to 0.43 in 2023, signalling towards some improvement, it still falls short of the threshold indicating a strong comparative advantage. This suggests that India's medical device industry is still in its nascent stages and is gradually gaining ground in the global market. However, India's relative weakness in this sector underscores the country's reliance on foreign imports, particularly in high-tech segments.

The Trade Specialization (TS) and Competitive Advantage (CA) indices reinforce this finding. The TS index, which measures the degree to which a country specializes in particular products, remained negative throughout the study period, indicating that India continues to experience a trade deficit in medical devices. The TS index values fluctuated between -0.47 and -0.37, showing only modest improvements, while the CA index remained consistently negative, further emphasizing India’s limited competitive edge in medical devices. These results confirm that India's medical device exports have not achieved a robust position in global markets, despite recent efforts to foster domestic growth and export performance. However, it is worth noting that the modest improvements in both indices suggest that the competitiveness of Indian medical devices has been gradually improving, particularly after the implementation of initiatives like Make-in-India and Production Linked Incentives (PLI) for medical devices.

The Grubel-Lloyd (GL) index, which measures intra-industry trade (IIT), reveals that India’s trade in medical devices has a moderate level of balance between exports and imports. The GL index consistently remained above 0.5, suggesting that India is involved in moderate intra-industry trade in the medical device sector. This implies that there is a substantial degree of specialization in the types of medical devices that India both imports and exports. However, not all medical device categories exhibit the same trend. Products like disposable medical devices and optical lenses saw strong intra-industry trade, with GL values reaching up to 0.87 in some years, signalling a more balanced trade structure. Conversely, categories such as therapeutic devices and testing kits displayed lower levels of intra-industry trade, implying that these segments remain highly dependent on imports, likely due to technological gaps and a lack of domestic production capacity.

The Marginal Intra-Industry Trade (MIIT) index, which tracks incremental changes in intra-industry trade, presents a more dynamic view of India’s trade in medical devices. The MIIT index for disposable devices, for example, was high at 0.79 in 2010-11 but has declined to 0.59 in the most recent period (2020-24), indicating a trend toward inter-industry trade, particularly in high-tech medical products. The MIIT values for electro diagnostic equipment and surgical equipment have also shown fluctuations, with the MIIT dropping sharply for electro diagnostic devices during 2015-2020 and recovering thereafter. These fluctuations reflect the changing trade dynamics, likely due to shifts in technological demand, regulatory changes, and the impact of the Covid-19 pandemic. The results highlight that while India has made strides in increasing its exports of certain medical devices, the overall trend shows that the country is still dependent on imports for a significant portion of its high-tech medical devices.

Despite the gradual improvement in trade competitiveness, the Trade Competitiveness Index (TCI) for India’s medical device sector suggests continued challenges. While there were improvements in certain categories, particularly disposable products and implants, product categories including testing kits and therapeutic devices, remain highly import-dependent. The TCI index showed a modest increase from -0.469 in 2009 to -0.372 in 2023, indicating some strengthening in export capabilities, but the sector is still far from achieving a balanced trade position. Surgical equipment and hospital furniture, for example, have shown slight improvements in their TCI values, but they are still in a net import position, highlighting that India continues to face significant challenges in becoming globally competitive in high-tech medical devices.

The theoretical framework for understanding India's medical device trade dynamics is rooted in traditional international trade theories, particularly the Heckscher-Ohlin (H-O) theory and Ricardo's theory of comparative advantage. The H-O theory suggests that countries will export products that utilize their abundant resources and import those that rely on scarce resources. For India, this translates into exports of low-tech medical devices (which are labour-intensive and resource-abundant) and imports of high-tech devices (which are capital- and technology-intensive). This is consistent with India's RCA, TS, and CA indices, which show that the country is competitive in low-tech products but lacks competitiveness in high-tech medical devices. A similar type of connotation is also presented in Ghosh (2022).

While the H-O theory explains India's reliance on imports for high-tech devices, Ricardo's theory helps to contextualize India's growing participation in the global medical device industry. According to Ricardo's theory, even developing countries like India can benefit from international trade by focusing on industries where they have a comparative advantage. In India's case, this advantage lies in low-tech medical devices, particularly disposables, where the country has shown competitive improvement. However, for higher-tech segments like diagnostic equipment, surgical tools, and therapeutic devices, India remains dependent on imports from technologically advanced countries. The government's initiatives, including Make-in-India, Medical Device Parks, and PLI schemes, are designed to shift the country's medical device sector from being reliant on imports to focusing more on domestic production and innovation.

Overall, while India's medical device sector is gradually improving its global competitiveness, it remains dependent on imports, particularly in high-tech products. The moderate improvements observed in indices like RCA, TS, and MIIT reflect the potential for future growth, but they also underscore the sector's dependence on continued policy support, technological innovation, and domestic capacity-building. The application of international trade theories highlights India's current position as a growing player in low-tech medical devices, while emphasizing the challenges faced in the high-tech medical device market. The continued focus on scaling up domestic production, improving innovation, and expanding export capabilities will be crucial for India to achieve long-term trade competitiveness in the global medical device sector.

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An institution of Indian Council of Social Science Research (Ministry of Education)
Policy Research to Foster India's Industrial Transformation
4 Vasant Kunj Institutional Area, New Delhi - 110070, India
Phone: +91 11 3510 4511 | E-mail: info@isid.org.in | Website: https://isid.org.in