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Decomposition of value added in Bangladesh's gross exports to India: a bilateral and sectoral perspective

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Abstract

The trade partnership between Bangladesh and India has strengthened significantly over the past decade, with growing integration into global value chains (GVCs). This study explores the value-added components of Bangladesh's exports to India from 2012 to 2022, categorizing them into five groups: domestic value added (DVA) directly absorbed, re-exported DVA, DVA returning home, foreign value added (FVA), and double-counted trade. Using the global value chain framework and input–output analysis, the research employs multiregional input–output (MRIO) tables from the Asian Development Bank, covering 62 economies and 35 sectors. This methodological approach provides a detailed examination of sectoral and bilateral trade dynamics, highlighting the shifts in value-added contributions over the decade. The results reveal an increasing trend of backward participation in GVCs for Bangladesh, particularly in the textile sector, where the contribution to India's GVC participation rose by 182%. Other sectors, including agriculture, food and beverages, leather, and telecommunications, also exhibited notable trends. The agriculture sector saw a modest rise in value-added exports of final (4%) and intermediate (3%) goods, while the food and beverage sector experienced a 56% increase in intermediate exports despite a decline in final goods. The textile sector achieved a 15% growth in intermediate exports and a 13% increase in FVA. These findings underscore the need for sectoral diversification and an enhanced focus on intermediate goods to strengthen Bangladesh's trade position. By providing a decade-long, sector-specific analysis, this study offers valuable insights for policymakers and stakeholders aiming to optimize GVC integration.

Keywords Gross exports, Value-added decomposition, DVA, FVA, GVC, Input–output analysis, MRIO

1 Introduction

Bangladesh is a prominent emerging market economy, recognized as the second-largest in South Asia. On a global scale, it ranks as the 33rd largest economy in terms of nominal GDP and holds the 25th position based on purchasing power parity (PPP). The nation predominantly relies on exports, primarily comprising manufactured goods,

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notably garments. Given the labor-intensive nature of these goods, Bangladesh's competitive advantage lies in its low-wage environment, which is appealing to foreign direct investment.

Despite its growing economic strength, Bangladesh consistently runs a negative trade balance. This paper makes a unique contribution by moving beyond overall trade figures to analyze the value-added structure of Bangladesh's exports in a bilateral context with India. Unlike previous studies that mainly focus on aggregate trade flows or focus only on the garment industry, this research provides a sector-by-sector and bilateral breakdown of value added using the Asian Development Bank's multiregional input–output (ADB MRIO) database. By applying the Borin & Mancini (2019) framework, the paper shows how domestic, foreign, and re-exported value-added components develop across key sectors such as textiles, agriculture, food and beverages, and telecommunications. This dual focus, bilateral and sectoral, introduces an innovative perspective that has not yet been systematically used to analyze Bangladesh's trade with India. Moreover, the findings offer policy-relevant insights for diversifying Bangladesh's export base and boosting its integration into regional value chains.

2 The current status of Bangladesh–India trade

Bangladesh's economy is heavily trade-dependent, with exports dominated by garments. The export-led growth model has positioned the country strongly in global markets, yet trade imbalances persist. Figure 1 shows Bangladesh's exports, imports to GDP ratio in %.[1]

India stands as the largest neighboring country and the fourth-largest trading partner of Bangladesh (Fig. 2). Over the past decade, bilateral trade between Bangladesh and India has surged, reaching a milestone of $16 billion. While both exports and imports have witnessed growth, there has also been a significant rise in the trade deficit. Data from the Bangladesh Bank (BB) and Export Promotion Bureau (EPB) reveal that bilateral trade between the two countries escalated from $5.3 billion in FY2012-13 to $15.93 billion in FY2021-22, reflecting a remarkable 200% increase.

It is worth noting that Bangladesh is currently the second-largest importer of Indian goods, right after China. Additionally, the country has experienced a significant increase

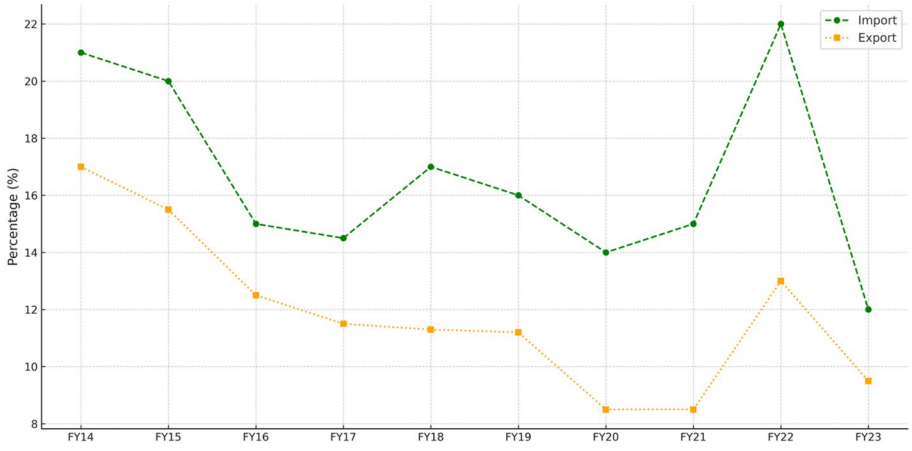


Fig. 1 Bangladesh's exports, imports to GDP ratio in %. Source: Bangladesh Economic Review 2023

[1] Source: Bangladesh Economic Review 2023.

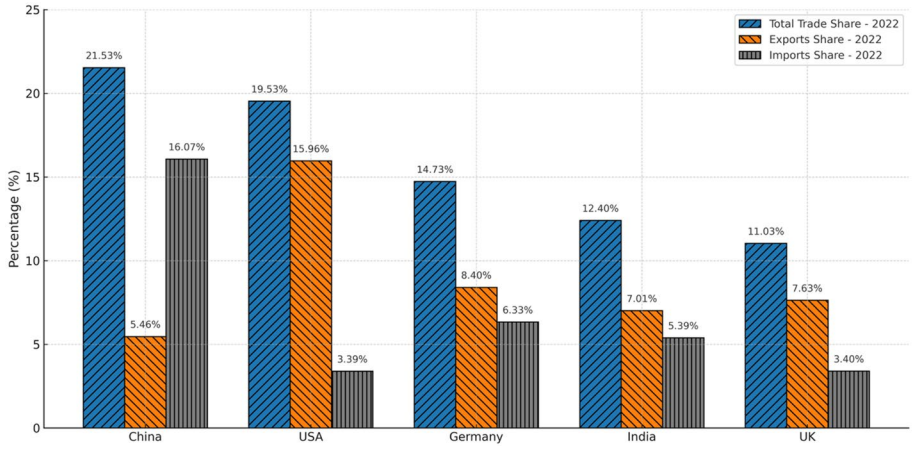


Fig. 2 Bangladesh's top five trading partners in 2022 and their trade share. Data source: (Bangladesh Bank 2022a, b) (The World Bank 2024)

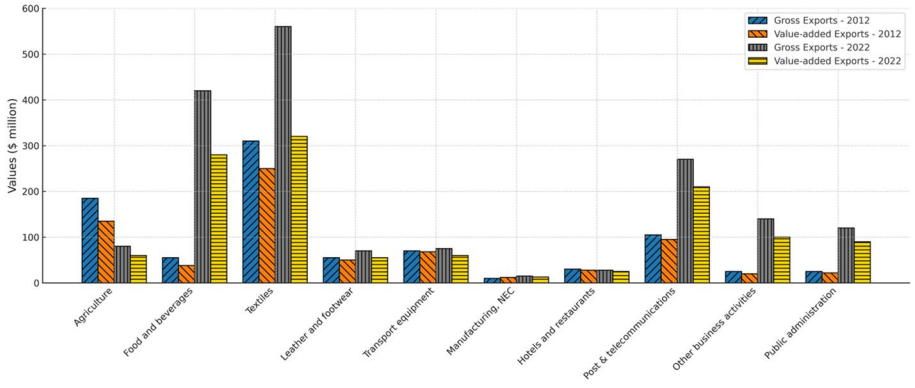


Fig. 3 Sectoral gross exports and value-added exports ($ million). Author's calculations based on the Asian Development Bank MRIO database

in its exports to India in recent years, resulting in a substantial rise in export revenue over the past few years.

Over the past decade, Bangladesh has experienced an increase in both its gross exports and value-added exports to India. This trend is visible in Fig. 3 above. The top contributing sectors to both types of exports are agriculture, food and beverage, post and telecommunications, and textiles. The positive direction of both gross and value-added exports indicates a strengthening economic partnership between Bangladesh and India.

This paper explores Bangladesh's gross exports, considering both bilateral and sectoral perspectives. This analysis is useful for assessing how much of Bangladesh's GDP is included in its overall exports, known as 'domestic value-added,' or in the exports of Bangladesh as a whole, termed 'foreign value added.' The study focuses on value-added indicators measured at bilateral and sectoral levels, which can be incorporated into Bangladesh's total exported GDP. Consequently, the research delves into the decomposition of value-added components within disaggregated trade flows, as these components collectively contribute to Bangladesh's total exports. Figure 4 provides a clear understanding of the VA components of gross exports and related GVC trade flows (Fig. 5).

In Fig. 4, the various components contributing to the value of gross exports are depicted. The inclined blue line represents the domestically sourced value added, which

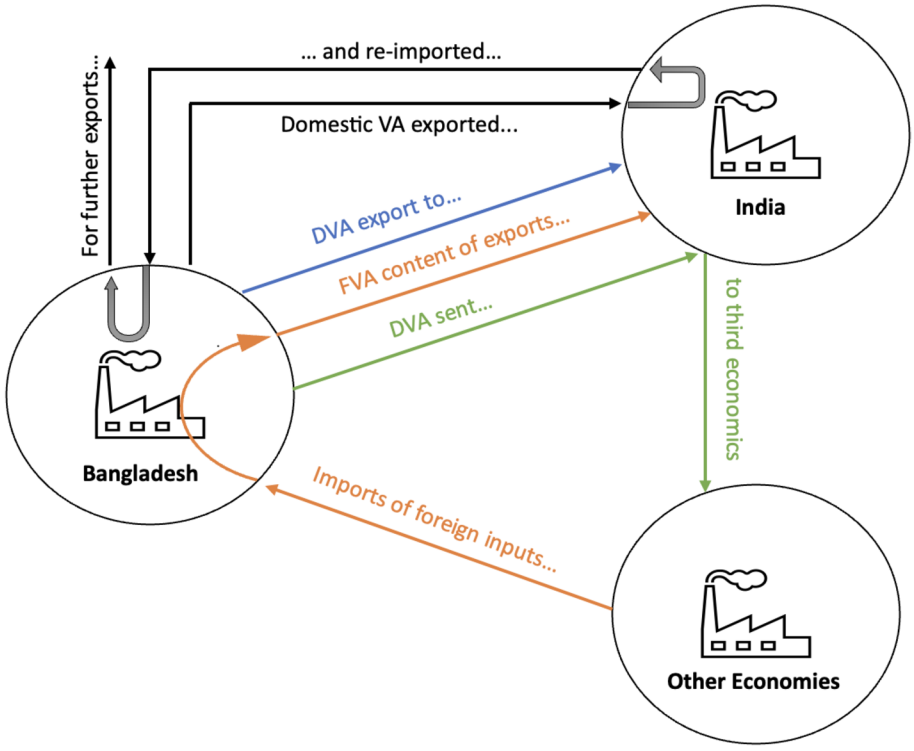


Fig. 4 The VA components of gross exports and related GVC trade flows. Modified form OECD-WTO trade in value-added (TiVA) database

		Bangladesh	India	Rest of the World	Bangladesh	India	Rest of the World	Total Output
		Intermediate Use			Final Use			
		c1 .. c35	c1 .. c35	c1 .. c35	F1 .. F5	F1 .. F5	F1 .. F5	
Bangladesh	c1 : c35	Z			Y			x
India	c1 : c35							
Rest of the World	c1 : c35							
Value-added		Va						
Total Output		X						

Fig. 5 The structure of the ADB multiregional input–output table. Source: Asian Development Bank MRIO database

is indirectly exported to other economies, indicating Bangladesh's involvement in the forward global value chain (GVC). Conversely, the orange arrow pointing from Bangladesh to India symbolizes the foreign value-added (FVA) segment of Bangladesh's exports to India, indicating the value originating from a third economy. This arrow illustrates Bangladesh's participation in the Backward GVC.

Our approach is to decompose gross bilateral and sectoral trade flows using (Borin & Mancini 2019) by identifying the following actors:

I. What share of the value in goods, Bangladesh exports to India originates from Bangladesh (DAVAX)?

II. What value-added is embedded in Bangladesh's exports to India ultimately ends up in final goods consumed in other countries ("rest of the world") through India's processing and re-exports (REX)?
III. To what extent does India process and re-export Bangladesh's exports back to Bangladesh itself, impacting the domestic value-added share (REF)?
IV. How much additional value from foreign sources (materials, services) is incorporated into Bangladesh's exports to India before the final sale (FVA)?
V. How much of the reported value in Bangladesh's exports to India is double-counted due to both countries accounting for the same processing steps (PDC)?

The comprehensive sector-specific analysis aims to provide policymakers, economists, and stakeholders with an in-depth understanding of the complexities present in the trade dynamics between Bangladesh and India. By delving into this examination, this paper intends to reveal the various levels of value addition and the fundamental forces that are forming this vital economic relationship.

The article first provides a comprehensive review of relevant literature in the field. Following this, we discuss the sources and structure of the data utilized in our analysis. Subsequently, this paper outlines the methodology employed to analyze the data before presenting our findings. Finally, it concludes by synthesizing our results and discussing their implications in the Sect. 6.

3 Literature review

The fragmentation of production and trade within GVCs has prompted researchers to develop a method for breaking down total exports in intercountry input–output tables (ICIO). This approach helps quantify the value added by each country in the production chain. A huge range of studies (Daudin et al. 2011; Johnson & Noguera 2012) have been conducted to refine trade measures to avoid the issue of 'double counting' present in gross exports. 'Double counting' occurs when intermediate goods, which contain value added from previous production stages, are counted multiple times in the output calculations. This concept is significant in the input–output analysis because it inflates the value of intermediate inputs beyond their actual contribution to the final output.

Gross exports represent the portion of a country's output purchased by overseas customers, and within this, there is an issue of double-counting, particularly with intermediate goods. This problem can be mitigated by examining net trade or by assessing value-added trade based on final consumption (Trefler & Zhu 2010; Johnson & Noguera 2012). However, the situation gets more complex when the calculation of gross exports includes double-counted elements since intermediate products are counted as both export items and as foreign inputs in their manufacture. Furthermore, 'foreign value added' (FVA)—a key factor in understanding international production networks—raises additional double-counting dilemmas. When analyzing the exports of all nations, any FVA gets double-counted as it represents the 'domestic value added' (DVA) of other nations. Thus, what researchers aim to identify as double-counting goes beyond just the repeated counting of intermediate goods in the total output; it also encompasses a portion of value added that is accounted for multiple times from the viewpoint of the exporting country, which is included in the FVA, a term occasionally described as 'pure double-counting'.

Additional research deepens the understanding of the distinctions between various analytical breakdowns in economics. (Los & Timmer 2018) put forward an integrated model that identifies export value addition, known as VAX-D, and the value addition consumed internationally, or VAX-C, a concept originally developed by Johnson & Noguera (2012). They also introduced a new indicator, VAX-P, which signifies the value-added used internationally in the ultimate production phase. VAX-D, the focus of this paper, is unique in that it measures trade in value-added terms, reflective of total gross exports. This metric, unlike VAX-C and VAX-P, which do not have issues of redundancy in the standard IO model, aims to provide a clearer picture of trade flows. (Los & Timmer 2018) work builds upon the methodology of (Los et al. 2016) to calculate VAX-D, though it does not extend to other decompositions or address the role of FVA in exports. They offer a novel insight into VAX-D, noting that the double-counting present in gross exports varies based on whether the analysis focuses on aggregate or bilateral exports. They reveal an overcounting issue when summing domestic value-added across bilateral relationships, highlighting a discrepancy with the aggregate DVA in total exports. Expanding on the work of Borin et al. (2017a) and Los & Timmer (2018) can help differentiate between global and national perspectives in export measurement, as well as the specifics of bilateral trade. Their methodological approach could be seen as a broadening of (Koopman et al. 2014), which itself was based on gross export data to derive various definitions of FVA and FDC, each with its economic interpretation.

Breaking down gross exports into various value-added components eliminates the double counting of intermediate inputs and offers a clearer understanding of the structure of global value chains (Miroudot & Ye 2022). Numerous studies have introduced statistical tools and analytical methods to illustrate supply and demand connections between economies. These include breaking down a country's total gross exports based on the origin and final destination of the embedded value added. (Borin et al. 2017b). Here, we will employ the gross export decomposition framework developed by Borin & Mancini (2019), which methodically breaks down gross exports into a sum of ten distinct terms, organized into five key categories. These categories are DAVAX, REX, REF, FVA, and PDC. This structured approach allows for a nuanced analysis of the complex trade flows and value additions in GVC. Enhancing Bangladesh's integration into the global production network, strengthening backward linkages, easing regulatory constraints, and fostering a business-friendly environment for foreign investors can significantly transform its role in international trade and global value chains (Md. S. Hossain & Baars 2022). (ADB & IsDB 2022) and (ADB 2023) extensively analyzed Bangladesh's integration into global value chains (GVCs) as a critical driver of economic progress. This integration has not only elevated Bangladesh's position in the global economy but has also exposed vulnerabilities, particularly evident during shocks like the COVID-19 pandemic, and emphasizes the need for strategic diversification away from heavy reliance on the RMG sector to sustain long-term growth and resilience. Overall, the paper focuses on analyzing import dependence and identifying new export destinations for specific commodities in Bangladesh, with particular emphasis on the RMG sector. However, the extent of decomposition in value chains is limited at the bilateral and sectoral levels.

4 Data source and methods

4.1 Data source

This study uses the ADB multiregional input–output (MRIO) database, an advanced extension of the WIOD framework. The database provides extensive resources, including data on national accounts, balance of payments, and benchmark input–output statistics. Launched in 2014, the ADB MRIO project created a detailed database by combining statistics from Asian and Pacific partner nations. Covering 62 economies along with a residual "rest of the world" category, the database is structured across 35 sectors, adhering to the International Standard Industrial Classification (ISIC) system. An annual update is carried out by a dedicated team using the most recent published data, making it one of the most current ICIO databases available. The ADB MRIO Database is particularly noted for its extensive coverage of developing Asia. To conduct our research, we extracted data from the ADB MRIO database for Bangladesh, India, and the Rest of the World across 35 sectors (ADB)[2] for the years 2012 and 2022.

4.2 Methods

This paper employs a rigorous methodology rooted in input–output (IO) analysis, as articulated by Miller & Blair (2009), to delve into the intricate dynamics of global value chains (GVCs). Focusing on the bilateral trade relationship between Bangladesh (s) and India (r), we dissect the composition of value added in gross exports (E_{sr}) at both the bilateral and sectoral levels.

Gross exports, while offering a broad perspective, often mask the various forms of trade, each with unique characteristics. Primarily, there is direct trade, where value-added (VA) crosses a single border to reach its final destination. Indirect trade takes various forms, adding complexity to international trade dynamics. One example involves imported inputs, where the value-added (VA) from one economy is embedded within another economy's exports. Another type is re-exports (REX), where the VA originating from one economy is redirected to a destination other than the initial importer. Lastly, there is pure double-counting (PDC), where VA crosses the same border multiple times, resulting in duplicated records in trade data.

Figure 6 provides a detailed breakdown of gross exports following the framework proposed by Borin and Mancini (2019), which builds on the work of Koopman et al. (2014). In this framework, exports from country 's' to country 'r' are initially divided into three main components: domestic value-added (DVA), foreign value-added (FVA), and pure double-counting (PDC). The DVA portion is further classified into exports consumed directly by the importing country and those re-exported by the importer. Re-exported DVA is subsequently analyzed based on its final destination—remaining within the country 'r', returning to the country 's', or reaching a third-party economy. These classifications can also be further refined to include the source of foreign value-added or identify third-party economies involved in receiving re-exports.

To derive all these mathematically,[3] begin with the following decomposition of gross exports:

[2] The details of the sectors are provided in the appendix.

[3] Borin & Mancini (2019) provide a comprehensive breakdown of the methodology, including its full mathematical details.

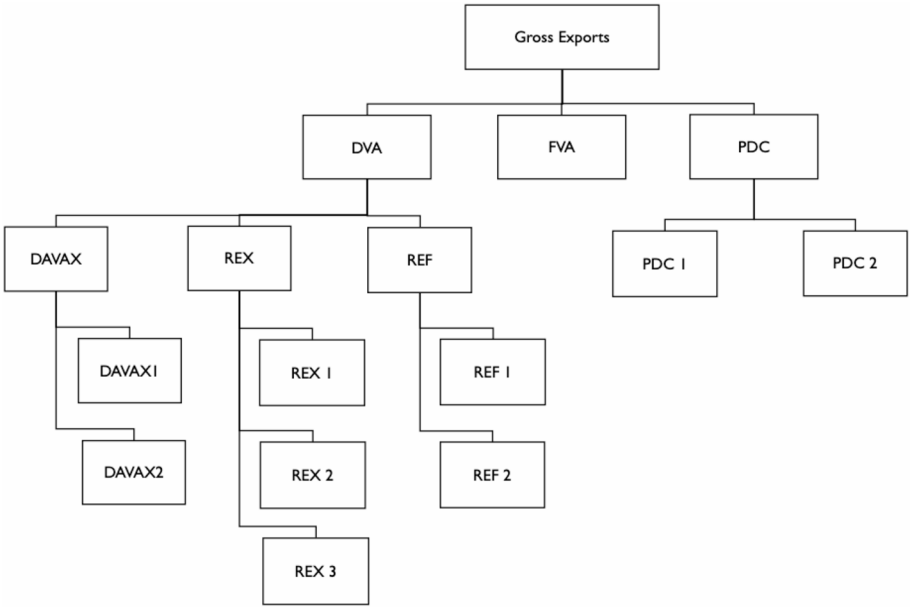


Fig. 6 Schematic illustration of the (Borin & Mancini 2019) decomposition framework

$$E_{sr} = \underbrace{\mathrm{v}_s \mathrm{B}^{\$}_{ss} \mathrm{e}_{sr}}_{DVA_{sr}} + \underbrace{\sum_{t \neq s} \mathrm{v}_t \mathrm{B}^{\$}_{ts} \mathrm{e}_{sr}}_{FVA_{sr}} + \underbrace{\sum_{t} \mathrm{v}_t \mathrm{B}^{\$}_{ts} \sum_{s \neq u} \mathrm{A}_{su} \mathrm{B}_{us} \mathrm{e}_{sr}}_{PDC_{sr}} \tag{1}$$

This approach differentiates the value-added origins of exports from s to r, represented as Esr, into domestic (s) and foreign (t ≠ s) sources. It establishes that all exports to rare either final goods consumed within r or intermediate goods utilized by r. These intermediates may subsequently be absorbed within r or re-exported and consumed in other destinations. Expanding DVAsr based on this framework yields the following:

$$DVA_{sr} = v_s B^{\$}_{ss} \left[y_{sr} + A_{sr} B^{d}_{rr} y_{rr} + A_{sr} B^{d}_{rr} e_r \right] \tag{2}$$

The first two terms represent exports to r that are consumed within r without crossing additional borders. These are referred to as "directly absorbed value-added exports" (DAVAX). Re-exports from the economy r, denoted as, $A_{sr} B^{d}_{rr} e_r$ can be divided into two categories: those that eventually return to the originating economy s, known as REF, and those redirected to other destinations, referred to as REX. Within the REX category, it is also important to identify the portion ultimately absorbed by the direct importer r.

$$\begin{aligned} DVA_{sr} = & \underbrace{\mathrm{v}_s \mathrm{B}^{\$}_{ss} \left[\mathrm{y}_{sr} + \mathrm{A}_{sr} \mathrm{B}^{d}_{rr} \mathrm{y}_{rr} \right]}_{DAVAX_{sr}} \\ & + \underbrace{\mathrm{v}_s \mathrm{B}^{\$}_{ss} \mathrm{A}_{sr} \mathrm{B}^{d}_{rr} \left[\sum_{u \neq r,s} \mathrm{y}_{ru} + \sum_{u \neq r} \mathrm{A}_{ru} \left(\sum_{k} \sum_{\ell \neq s,r} \mathrm{B}_{uk} \mathrm{y}_{k\ell} + \sum_{k} \mathrm{B}_{uk} \mathrm{y}_{kr} \right) \right]}_{REX_{sr}} \\ & + \underbrace{\mathrm{v}_s \mathrm{B}^{\$}_{ss} \mathrm{A}_{sr} \mathrm{B}^{d}_{rr} \left[\mathrm{y}_{rs} + \sum_{u \neq r} \mathrm{A}_{ru} \sum_{k} \mathrm{B}_{uk} \mathrm{y}_{ks} \right]}_{REF_{sr}} \end{aligned} \tag{3}$$

Each term has two or more sub-terms, referred to sequentially as $DAVAX1, DAVAX2$, REX1, REX2, and so on. Equations (1) and (3) comprise the value-added trade accounting framework. Full descriptions of each term are provided in Table 1.

Global Value Chain Participation (GVC): The global value chain participation rate measures how much an economy participates in GVCs. According to Borin and Mancini (2019), GVC participations are expressed as follows.

$$GVCXbackward_{sr} = FAV_{sr} + PDC_{sr}$$

$$GVCXforward_{sr} = REX_{sr} + REF_{sr}$$

Total GVC exports are the sum of the two. The trade-based GVC participation rate is obtained by dividing these by gross exports.

$$GVCP_{sr}^{Trade} = \frac{GVCXbackward_{sr}}{E_{sr}} + \frac{GVCXforward_{sr}}{E_{sr}}$$

5 Results and discussion

Bangladesh mainly participates in backward GVCX-related trade with India. This means that Bangladesh uses foreign value-added (FVA) inputs for its exports to India. Sectors such as textiles, food & beverage, and post & telecommunications are typically involved in backward GVCX participation. In these sectors, most raw materials are imported from other economies, and Bangladesh primarily adds value through relatively low labor costs.

Table 1 Explanation of VA Classifications

Expression	Method	Narrative
DAVAX1	$v_s B_{ss}^{\$} y_{st}$	DVA in final goods is completed in Bangladesh and sent to India
DAVAX2	$v_s B_{ss}^{\$} A_{sr}$ $B_{rr}^{d} y_{rr}$	DVA in intermediate goods sent to, completed by, and absorbed in India
REX1	$v_s B_{ss}^{\$} A_{sr}$ $B_{rr}^{d} \sum_{u \neq r,s} y_{ru}$	DVA in intermediate goods is sent to and completed by India, then exported to the third economy
REX2	$v_s B_{ss}^{\$} A_{sr}$ $B_{rr}^{d} \sum_{u \neq r}$ $A_{ru} \sum_{k} \sum_{l \neq s,r} B_{uk} y_{kl}$	DVA in intermediate goods sent to and re-exported by India and eventually absorbed in the third economy
REX3	$v_s B_{ss}^{\$} A_{sr}$ $B_{rr}^{d} \sum_{u \neq r}$ $A_{ru} \sum_{k} B_{uk} y_{kr}$	DVA in intermediate goods sent to and re-exported by India and eventually absorbed in India
REF1	$v_s B_{ss}^{\$} A_{sr} B_{rr}^{d} y_{rs}$	DVA in intermediate goods sent to and completed by India, then exported to Bangladesh
REF2	$v_s B_{ss}^{\$} A_{sr} B_{rr}^{d} \sum_{u \neq r}$ $A_{ru} \sum_{k} B_{uk} y_{ks}$	DVA in intermediate goods sent to and re-exported by India and eventually absorbed in Bangladesh
FVA	$\sum_{t \neq s} v_t B_{ts}^{\$} e_{sr}$	Foreign value added in gross exports from Bangladesh to India
PDC1	$v_s B_{ss}^{\$} \sum_{s \neq u}$ $A_{su} B_{us} e_{sr}$	PDC of domestic origin
PDC2	$\sum_{t \neq s} v_t B_{ts}^{\$}$ $\sum_{s \neq u} A_{su} B_{us} e_{sr}$	PDC of foreign origin

Based on Borin and Mancini (2019) and ADB-global value chain

The textile sector is considered the most important industry for Bangladesh's exports, and it is the largest source of foreign currency earnings and job creation. The ready-made garment (RMG) industry alone accounts for more than 80% of Bangladesh's total export revenues, making it the backbone of the country's trade performance (Raihan 2024; Habib et al 2018). In terms of employment, the sector provides direct jobs to over four million workers, the majority of whom are women, and indirectly supports millions more through backward and forward linkages with transport, services, and raw material supply chains (Sultana 2025). Backward GVC participation from Bangladesh to India in the textiles sector increased by 182%, from USD 67 million in 2012 to USD 189 million in 2022 (Fig. 7). This growth reflects a strengthening role for textiles in the Bangladesh–India value chain integration. In contrast, the agriculture sector declined by 31%, from USD 31 million in 2012 to USD 21 million in 2022, while the post and telecommunications sector expanded from virtually zero to USD 5 million over the same period. These changes indicate a shift toward manufacturing-led backward linkages and a reduced role for agriculture in sourcing foreign value-added inputs.

Additionally, investments in technology and production facilities have boosted output efficiency, and favorable transportation systems, including new highways and railways, have facilitated easier and more cost-effective exports. The Bangladesh Textile Mills Association (BTMA) reports a 20% increase in machinery imports in 2022, which corresponded with a 5% rise in productivity and a 9% reduction in downtime (BTMA 2022). Moreover, growing consumer demand in India for diverse textile products has driven up imports from Bangladesh. Enhanced regional economic integration within South Asia has also played a role in strengthening trade relationships and increasing export volumes, contributing to the 182% rise in GVCX backward over the last decade.

The 31% decrease in the backward participation of GVCX from Bangladesh to India in the agriculture sector over the past decade can be attributed to several key factors. Improved domestic agricultural production capacity in India, supported by subsidies and government policies, has likely reduced the need for imported agricultural inputs from Bangladesh. Improved domestic agricultural production capacity in India is a central driver of this trend. According to the Food and Agriculture Organization (FAO 2022), India's total food grain output rose from 257 million metric tons in 2012 to 315 million metric tons in 2021, an increase of more than 22%, supported by extensive government

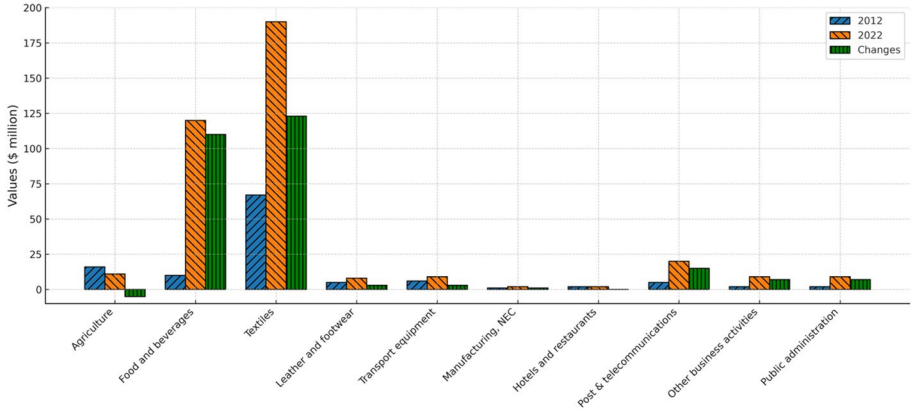


Fig. 7 $GVCX_{sr}$ backward ($ million). Please refer to Online Appendix Table 1 for further information regarding the details of the figure

subsidies, irrigation development, and mechanization initiatives. This sharp rise in self-sufficiency has reduced India's reliance on imported agricultural inputs from neighboring countries, including Bangladesh. Additionally, Bangladesh may have experienced a shift in comparative advantage, focusing more on lucrative sectors like manufacturing and services, thereby diverting resources away from agriculture. Changes in agricultural policies by India, such as export restrictions or increased tariffs, and the imposition of non-tariff barriers like stringent sanitary and phytosanitary measures, could have negatively impacted Bangladeshi agricultural exports.

Furthermore, adverse environmental conditions and climate change effects have measurably reduced agricultural productivity in Bangladesh. According to the World Bank (2021), nearly 25% of Bangladesh's cropland is affected annually by floods, cyclones, or droughts, while salinity intrusion in coastal districts has lowered rice yields by 10–15% over the past decade. Similarly, FAO (2022) reports that agricultural losses due to extreme weather events account for approximately USD 1 billion annually. These climate-related stresses have significantly constrained Bangladesh's agricultural export potential, contributing to the decline in exports to India. Furthermore, adverse environmental conditions or climate change effects may have reduced agricultural productivity in Bangladesh (Hossain et al. 2023; Habib et al 2024), contributing to the decline in exports to India.

The low participation of Bangladesh in the forward GVCX to India suggests that Bangladesh lacks a well-developed upstream industry and is not fully integrated into the value chains. The sharp decline of 81% in Bangladesh's agriculture sector's forward GVCX participation with India, from $42 million in 2012 to $8 million in 2022, can be attributed to several factors. One major reason is improved agricultural self-sufficiency in India, reducing its reliance on imported agricultural goods. One major reason is India's improved agricultural self-sufficiency, supported by a steady increase in food grain production, which rose from 259 million tons in 2012–13 to 315 million tons in 2021–22 (Government of India, Ministry of Agriculture and Farmers Welfare 2022). Additionally, stringent regulatory and non-tariff barriers, such as increased sanitary and phytosanitary standards, could have made it more difficult for Bangladeshi agricultural products to access the Indian market. Shifts in comparative advantage may have also played a role, with Bangladesh focusing more on industrial and manufacturing sectors rather than agriculture. Environmental challenges, such as climate change and adverse weather conditions, could have further impacted agricultural productivity and export capacity (Hamzi et al 2025). Finally, changes in trade policies, including export restrictions from Bangladesh, have contributed to the decline in agricultural exports.

Forward GVC participation from Bangladesh to India shows mixed trends across sectors (Fig. 8). Agriculture fell sharply by 81%, from USD 42 million in 2012 to USD 8 million in 2022, while textiles rose by USD 41 million, from USD 51 million to USD 92 million. Food and beverages increased by USD 29 million, from USD 8 million to USD 37 million, and post and telecommunications surged from almost zero to USD 33 million. These results suggest that while agriculture's upstream role in GVCs has contracted, manufacturing and service sectors have strengthened their forward linkages with India. In particular, the growth in food and beverage and textile exports reflects enhanced production capabilities and improved product quality, supported by the expansion of modern industrial facilities, evidenced by the increase in registered textile

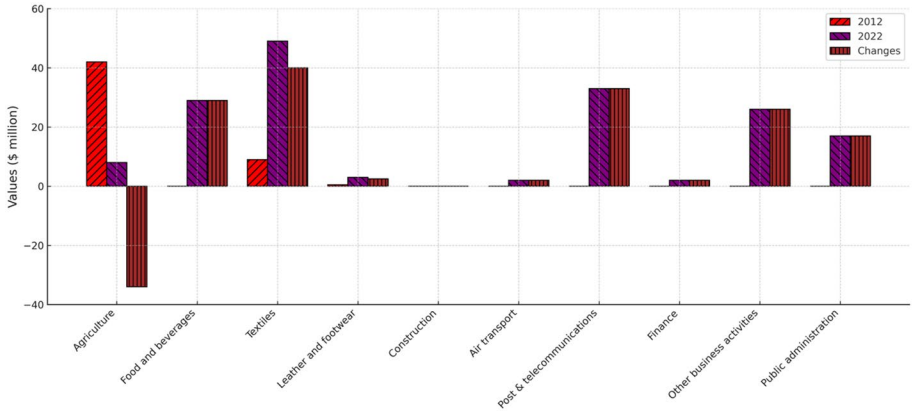


Fig. 8 $GVCX_{sf}$ forward ($ million). Please refer to Online Appendix Table 1 for further information regarding the details of the figure

and apparel factories from 5150 in 2010 to over 4,000 compliant RMG factories in 2022 (BGMEA 2022), as well as improved food processing capacity, with processed food exports from Bangladesh rising from USD 524 million in 2012 to USD 1.1 billion in 2021 (Export Promotion Bureau 2022). As India is the largest country in terms of population, growing consumer demand in India for food has also driven up imports from Bangladesh. Enhanced multiregional integration has strengthened trade relationships, further supporting the increase in GVCX participation in these sectors. The significant growth in the post and telecommunications sector, which contributed USD 33 million to Bangladesh's forward GVCX to India in 2022 from almost zero in 2012, can be attributed to rapid technological advancements and increased digital connectivity, evidenced by the rise in Bangladesh's international internet bandwidth capacity from 7.4 Gbps in 2008 to over 3600 Gbps in 2022 (BTRC 2022), alongside the expansion of fiber-optic connectivity that enabled bandwidth exports to India. Investments in telecommunication infrastructure and services in Bangladesh, such as the increase in mobile internet penetration from 31% in 2012 to 74% in 2022 (GSMA 2022), have also boosted the sector's capacity to engage in international value chains. The growing digital economy in India has increased demand for telecommunication services and products, creating new opportunities for Bangladeshi firms. Some favorable regulatory changes and trade policies have facilitated this growth, as evidenced by the reduction of India's tariffs on cross-border bandwidth and telecommunication equipment from an average of 15% in 2012 to 5% in 2021 (World Trade Organization 2022), and the introduction of the India–Bangladesh ICT Cooperation Agreement in 2016, which enabled simplified licensing and joint digital projects. Furthermore, the rise of e-commerce and digital services has expanded the market for telecommunication exports, contributing to the significant growth in forward GVCX participation.

Participating in global value chains (GVCs) can be crucial for the economic development of a developing country. It brings refinement to production, increases productivity, and diversifies exports (Kowalski et al. 2015). The GVC participation rate is a helpful measure to understand how an economy is engaging in GVCs and related trade. For Bangladesh, engaging with India's market has shown varying levels of success across different sectors.

The textile sector has been a cornerstone of Bangladesh's economy, accounting for over 80% of total export revenue and employing more than 4 million workers, the majority of whom are women (World Bank 2023; Raihan 2024; Habib et al 2025), and its GVC participation with India reflects this. Over a decade, the participation rate in GVCs for textiles increased by 79%, indicating stronger integration into India's value chains. The textile sector's robust performance is a positive indicator of Bangladesh's increasing integration into the global economy.

The food and beverage sector has exhibited a remarkable increase in GVC participation, with a rise of approximately 91% over ten years. This significant growth underscores the sector's dynamic evolution, likely driven by factors such as improved processing techniques, better supply chain management, and an expanding product range that meets the diverse tastes of the Indian market. Enhanced agricultural practices and investment in food processing infrastructure have also contributed to this surge. Bangladesh's processed food export value increased from USD 524 million in 2012 to USD 1.1 billion in 2021 (Export Promotion Bureau 2022), reflecting both improved agricultural output and upgraded processing facilities. Additionally, government-supported industrial parks and food processing zones have expanded by 35% over the last decade, providing modern facilities and logistics support for export-oriented food production.

Contrasting with the positive trends in textiles and food, and beverages, the agriculture sector's GVC participation rate has seen a decline of 23%. This downturn in one of Bangladesh's most critical sectors for GVC trade with India is concerning. There are several reasons for this decline, such as difficulties in meeting global standards**,** insufficient infrastructure, only 38% of rural roads are paved and less than 20% of farms have access to modern storage facilities, leading to post-harvest losses of approximately 15–20% annually (FAO 2022), and variable agricultural production caused by weather conditions, including floods, droughts, and salinity intrusion, which affect nearly 25% of cropland annually and reduce key crop yields by 10–15% (World Bank 2021). Moreover, restricted availability of advanced agricultural technologies and capital remains a key constraint: only 12% of farms in Bangladesh use modern mechanized equipment such as tractors and harvesters, and access to formal agricultural credit is limited to roughly 18% of farmers, hindering investment in high-yield seeds, irrigation, and processing technologies (Bangladesh Bank 2021). The different patterns in GVC involvement in these key sectors emphasize the importance of customized approaches to strengthen Bangladesh's connection to global markets. For the textile industry, it is crucial to continue investing in technology and skill development to sustain its growth momentum, as well as to reinforce backward linkages and promote innovation to maintain competitiveness. In the food and beverage sector, expanding market entry through trade agreements has proven effective, as seen in Bangladesh's exports under the South Asia Free Trade Agreement (SAFTA), which grew by 28% between 2012 and 2021, reaching USD 1.2 billion (EPB 2022). Improving quality standards can further stimulate growth, while incentivizing foreign direct investment (FDI) in food processing. FDI inflows increased from USD 145 million in 2012 to USD 310 million in 2021 (Bangladesh Bank 2022a, b). Tackling the decline in the agricultural sector requires a multifaceted strategy, including improving infrastructure, advocating for sustainable agricultural practices, and enhancing access to financial support for farmers. Moreover, investment in research and development (R&D) in agriculture has been shown to enhance productivity: total R&D spending in

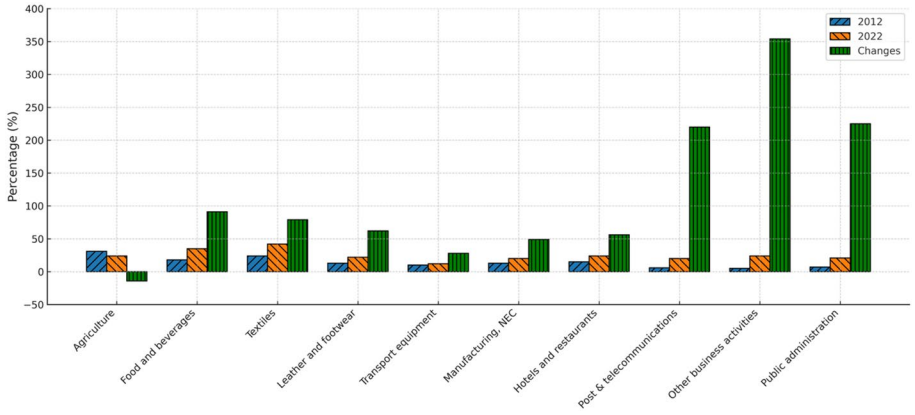


Fig. 9 $GVCP_{sr}^{Trade}$ participation rate. Please refer to Online Appendix Table 2 for further information regarding the details of the figure

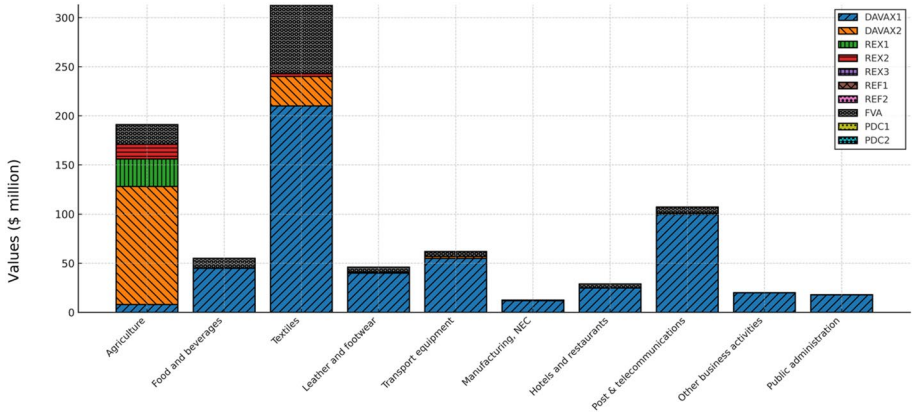


Fig. 10 Gross exports decomposition in 2012 ($ million). Please refer to Online Appendix Table 3 for further information regarding the details of the figure

Bangladesh's agriculture sector increased from USD 120 million in 2012 to USD 220 million in 2021, leading to the development of climate-resilient crop varieties and improved yields (Ministry of Agriculture, Bangladesh 2022). In summary, while Bangladesh has made significant progress in increasing its GVC involvement in certain sectors, challenges persist, particularly in agriculture. By implementing strategies tailored to each sector and creating a supportive policy environment, Bangladesh can enhance its GVC integration, which will drive further economic development and growth (Fig. 9).

Figure 10 delineates the gross export values from Bangladesh to India across various value-added terms in 2012. The agricultural sector exhibited notable growth in Bangladesh's exports to India, particularly in the domestic value-added in intermediate goods (DAVAX2), which surged from $6.79 million to $124.03 million. The notable surge suggests an increasing demand for agricultural goods from Bangladesh in India, possibly due to improved agricultural methods and enhanced trade ties between the two nations. The industry also demonstrates significant inputs from foreign value-added (FVA), suggesting a dependence on imported materials to elevate production standards. The considerable expansion and significance of value addition through intermediary products underscore the agricultural sector as a vital component of Bangladesh's export economy.

The food and beverage industry has demonstrated robust economic performance, particularly in the domestic value-added in final goods (DAVAX1), which stands at $45.18 million. However, the contributions in other value-added categories are less significant, suggesting limited processing or re-export activities in India. Despite this, the industry shows a notable foreign value-added (FVA) of about $10 million, indicating reliance on imported inputs. The strong performance in DAVAX1, coupled with significant FVA, highlights the industry's potential for growth by exploring further value addition and processing opportunities.

The textile sector remains a cornerstone of Bangladesh's export economy, with a high DAVAX1 of $206.54 million and a significant FVA of $66.48 million. These figures reflect consistent and substantial value addition in both final and intermediate goods. The sector also shows small values for PDC, with consecutive figures of $0.08 and $0.02 million, indicating minimal decomposition of production processes across borders. The textile sector's established economic prominence and consistent performance make it a key area for continued investment and growth.

The leather and footwear industry displays strong domestic value-added in final goods (DAVAX1) at $36.79 million, but contributions in other value-added categories are less significant. This suggests limited processing or re-export activities. However, the strong DAVAX1 figures indicate robust final goods production, making this sector a potential area for enhancing intermediate goods processing and exploring re-export opportunities. Focused investment could lead to increased value addition and export performance in this industry.

The transport equipment sector makes a notable contribution to Bangladesh's gross exports, with a DAVAX1 of $55.76 million and a significant FVA of $5.97 million. These figures highlight the sector's economic importance and growth potential in manufacturing and exporting transport equipment. The substantial contributions indicate a growing role in the export economy, suggesting that further investment in this sector could yield significant returns and enhance export values.

The post and telecommunications sector has emerged as a key player in the export market, with a noteworthy DAVAX1 of $99.51 million and an FVA of $6.66 million. The amounts represent the growing significance of the digital and communication aspects of the export industry in Bangladesh. The considerable increase in value and growing influence suggest significant potential for expansion, positioning this industry as a crucial opportunity for investment to take advantage of the increasing need for technology and communication services.

Based on the description of Fig. 11, which details the breakdown of gross exports from Bangladesh to India in 2022 across various sectors, the agricultural sector continued to show positive trends in Bangladesh's exports to India in 2022. The domestic value-added in final goods (DAVAX1) increased, reaching $56.21 million in DAVAX2. This growth indicates a significant potential for domestic value addition in final goods. Additionally, the foreign value added (FVA) for agricultural exports was $11.17 million, reflecting the importance of imported inputs in this sector's production processes. The positive trend in DAVAX2 highlights the sector's ability to produce intermediate goods that are further processed and absorbed in India.

The food and beverage industry demonstrated a robust economic performance in 2022. DAVAX1 rose from $39.78 million to an impressive $240.45 million in DAVAX2.

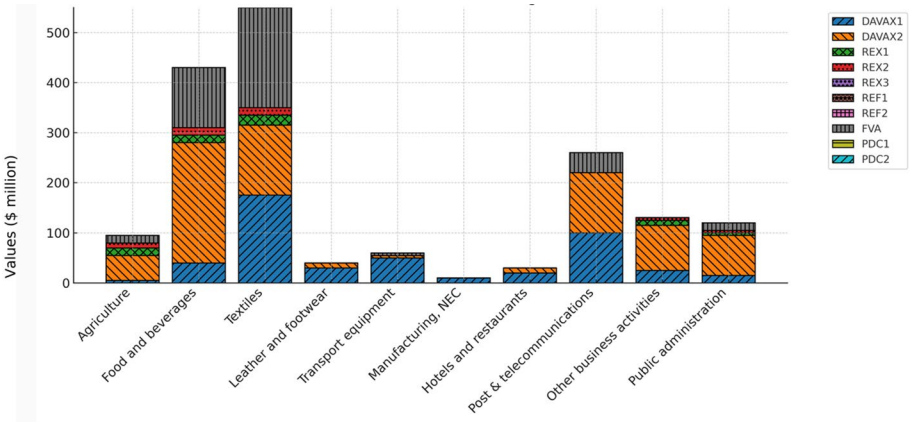


Fig. 11 Gross exports decomposition in 2022 ($ million). Please refer to Online Appendix Table 4 for further information regarding the details of the figure

This substantial increase suggests high consumer demand and the competitive performance of this sector. The industry also reported a significant FVA of approximately $119 million, indicating a strong reliance on imported inputs to enhance the production of exported goods. The remarkable growth in DAVAX2 underscores the sector's capability to produce intermediate goods with high-value additions.

The textile industry, a crucial component of Bangladesh's economy, had a DAVAX1 value of $173.49 million in 2022. However, this slightly decreased to $150.42 million in DAVAX2, indicating changes in market dynamics and possibly increased competition or shifts in demand. Other categories, such as REX, REF, and FVA, also showed significant value-added exports to India. Pure double counting (PDC) 1 and 2 had small export values of $0.05 million and $0.02 million, respectively. Despite the slight decrease in DAVAX2, the textile sector remains essential for the nation's exports, with continued strong performance across various value-added categories.

The leather and footwear sector began 2022 with a strong DAVAX1 of $35.19 million, but this decreased to $10.98 million in DAVAX2. This decline suggests potential challenges in maintaining intermediate goods' value addition or changes in market conditions affecting the sector. Despite the drop in DAVAX2, the initial strong performance in DAVAX1 highlights the sector's capacity for producing high-value final goods, suggesting areas for potential improvement and investment to enhance intermediate goods processing and export performance.

In the post and telecommunications sector, the DVAX2 was larger than DVAX1, indicating that Bangladesh exported more intermediate goods than final goods in this sector in 2022. This trend reflects the sector's increasing role in the digital and communication aspects of the export market. Additionally, the sector reported a significant Foreign Value Added (FVA) of $20.89 million, showing substantial value addition through imported inputs. The larger DVAX2 compared to DVAX1 emphasizes the sector's potential for further growth in intermediate goods exports.

In 2022, the analysis underscores several important trends and opportunities for Bangladesh's exports to India. The domestic value addition for intermediate goods in the agricultural sector exhibits strong growth potential. The food and beverage industry has shown impressive performance, propelled by robust consumer demand and competitive production capabilities. Despite a slight decrease in the value addition of intermediate

goods, the textile sector remains a pivotal component of the export economy. While the leather and footwear industry encountered challenges in the value addition of intermediate goods, it displayed promising initial performance in final goods. The post and telecommunications sector's substantial exports of intermediate and final goods indicate a growing influence on the digital and communication export market. Prioritizing these sectors and focusing on enhancing the processing and value addition of intermediate goods could result in significant growth in Bangladesh's exports to India.

Based on the description of Fig. 12, which outlines changes in the gross exports of Bangladesh to India between 2012 and 2022 across various sectors, the agriculture sector experienced a downturn. The DAVAX1 value decreased by $0.3877 million, and DAVAX2 plummeted by $67.8211 million. These significant declines indicate substantial challenges or changes in industry practices, due to adverse climatic conditions, reduced productivity, or shifts in market dynamics. To address these issues, policies aimed at improving agricultural productivity, such as investing in modern farming techniques, providing subsidies for high-quality seeds and fertilizers, and enhancing irrigation infrastructure, could help reverse the downturn. Additionally, establishing better storage and transportation facilities can minimize post-harvest losses and improve the sector's overall efficiency.

The food and beverage sector faced a decline of $5.4071 million in DAVAX1 but surged to $240.3291 million in DAVAX2. This sharp increase in DAVAX2 suggests successful strategic adaptation to market demands, possibly through diversification of products, improvement in processing techniques, and expansion into new markets. The FVA of this sector also increased by $109 million, highlighting a greater reliance on imported inputs. Policies to sustain this growth could include promoting food safety and quality standards, providing incentives for research and development in food processing, and facilitating access to international markets through trade agreements. Supporting small and medium-sized enterprises (SMEs) in the food sector with financing and technical assistance can also drive further growth.

The textile sector underwent a significant contraction in DAVAX1, declining by $33.0509 million. However, DAVAX2 increased to $113.0718 million, and the FVA also

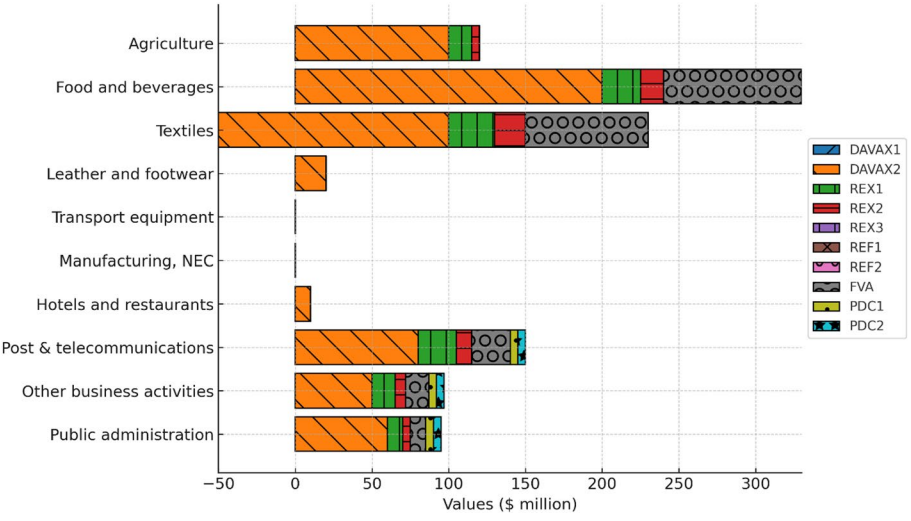


Fig. 12 Changes in gross exports decomposition over a decade ($ million). Please refer to Online Appendix Table 5 for further information regarding the details of the figure

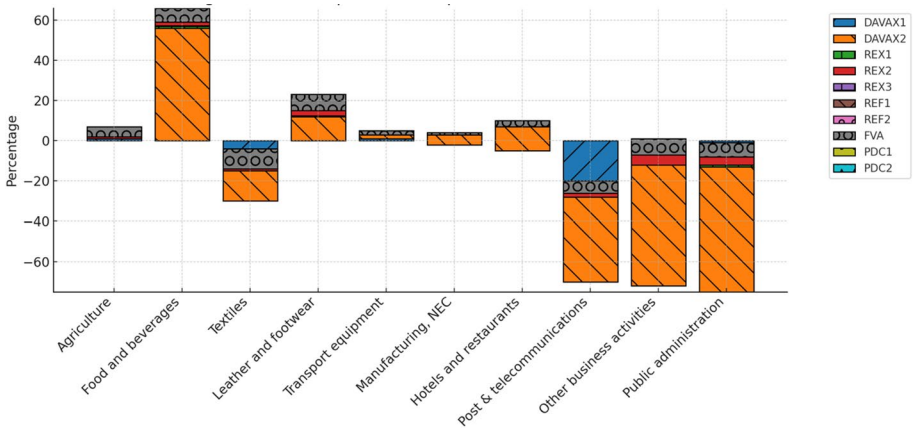


Fig. 13 Changes in gross exports decomposition over a decade (%). Please refer to Online Appendix Table 6 for further information regarding the details of the figure

increased by $121.95 million. This indicates a change in the industry's attention towards manufacturing more middle goods rather than finished products, perhaps because of shifts in global supply chain dynamics or increased competition in the market for finished products. To support the textile industry, strategies could concentrate on improving the competitiveness of Bangladeshi textiles by updating machinery, implementing training programs for workers, and offering tax benefits for innovation and improving quality. Improving trade relations and lowering tariffs on raw materials can also boost the sector's global competitiveness.

The post and telecommunications sector saw a significant drop in DAVAX1 by $1.7444 million but a notable rise in DAVAX2 to $113.2147 million. This indicates an expansion and increased contribution to gross exports, likely driven by the growing demand for digital and communication services. The sector also shows a significant increase in FVA, indicating heavy reliance on foreign inputs. To support this growth, policies should focus on improving digital infrastructure, promoting investment in telecommunications technology, and fostering innovation in digital services. Additionally, regulatory frameworks that ensure fair competition and protect consumer interests can help sustain the sector's growth.

During the decade from 2012 to 2022, Bangladesh experienced significant changes in its export decomposition in Fig. 13, as indicated by shifts in DAVAX, REX, FVA, and other categories. The agricultural sector had a moderate increase in its final goods export share (DAVAX1), which rose by 4%. Its DAVAX2 also increased by 3%, indicating a greater focus on adding value to the sector's products. However, there was a consecutive 8% and 4% decrease in REX1 and REX2, respectively. On the other hand, FVA for this sectoral export showed a 5% increase. In contrast, the mining sector moved from a significant deficit in DVAX1 share to a remarkable 66% in DAVAX2, which suggests a shift towards higher value-added exports.

The food and beverage industry experienced a decline in its export share for DVAX1, but it showed strong growth in its DVAX2 value, which climbed to 56% in DAVAX2. This growth reflects a strategic focus on exporting intermediate products. Textiles, which are crucial to the country's largest export economy, showed resilience despite a decline in DAVAX1. Instead, there was an increase in DAVAX2 to 15%, indicating a

sustained increase in the value chain and a strategic shift towards exporting higher-value textile products. Over a decade, the FVA also increased by 13%.

Service-oriented sectors, such as post telecommunications and finance, demonstrated an increase in DAVAX2, indicating diversification of the export economy into the service domain. This trend reflects the global shift towards digitalization and financial integration. Between 2012 and 2022, Bangladesh's exports to India underwent dynamic changes as the country adapted its strategies to foster value-added growth across its export sectors.

6 Conclusion

This study offers a detailed examination of the economic partnership between Bangladesh and India, with a focus on the value-added components in Bangladesh's exports to India over the past decade. The bilateral trade has grown significantly, reaching $16 billion, underscoring their deepening economic interdependence. The analysis reveals a strong trend of backward participation in the global value chain exports (GVCX), with the textile sector emerging as a key contributor. Textiles recorded an impressive 182% growth in value-added contributions, showcasing the industry's resilience and competitiveness. Other significant sectors, including food and beverages, leather, and telecommunications, demonstrated notable contributions in domestic value-added Absorbed (DAVAX), Re-exported domestic value-added (REX), and foreign value-added (FVA).

While the agricultural sector faced challenges, it achieved modest growth, highlighting its importance in bilateral trade. The food and beverage industry adapted to changing demands, with a shift from DAVAX1 to stronger growth in DAVAX2 exports. Similarly, the textiles sector exhibited adaptability, maintaining robust DAVAX2 growth despite a decline in DAVAX1. The study identified a 13% rise in Foreign Value-Added, indicating increasing reliance on foreign inputs in Bangladesh's exports to India. This underscores the need for policy measures to build domestic input industries, diversify supply sources, and enhance local value addition to ensure sustainable growth.

The findings highlight value-added decomposition as a critical tool for understanding trade dynamics and guiding policy. They provide actionable insights for policymakers and stakeholders to strengthen Bangladesh's global value chain integration and promote resilient economic growth.

Supplementary Information

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Supplementary Material 1

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Author contributions
Ahsan Habib (AH) was responsible for conceptualization and drafting the manuscript. Mohammad Sayedur RAHMAN (MSR) was responsible for conceptualization, data curation, methodology, and drafting the manuscript. Md Masum (MM) is responsible for formal analysis and investigation. All authors reviewed and approved the final manuscript.

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Data availability
The authors confirm that the data supporting the findings of this study are available within the article.

Declarations

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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