Evidence from India's Sectoral Performance in Integrating Technological Exports with Global Value Chains

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Abstract

This paper captures India’s sectoral performance of two very important manufacturing sectors, namely- Textile & Clothing (T&C) and Electronics & Hardware (E&H), possessing varying technological capabilities and competitive trade performance. By considering advanced time-series analysis from 1991 to 2017, a comparative performance in terms of the linkages between trade and technology is elaborated. For T&C, the process of cointegration reveals that there exists significantly positive long-run association between GFCF, extensive margin and RCA with gross exports. There is also evidence of bi-directional granger causality between gross exports and RCA, as well as one-way causation from gross exports to intensive and extensive margins. The dynamic performance of the variables is further investigated using the impulse response function. The impact of technology on involvement in global value chains (GVCs) in terms of increasing exports is not immediately apparent. However, the association is established through indirect causation routes. However, for E&H only short-run relationship exists between intensive margin, production value and lagged gross export value with gross exports. There exists no long-run relationship, but a silver lining in the form of various sectoral policies targeting GVC participation and thus increasing export share need to be boosted. Hence, this paper provides a direction to the policy-makers in the form of aiming well-timed and informed policies for these two sectors.

Keywords: ARDL Cointegration, GVC Linkages, FDI, Trade Margins, R&D Expenditure, Revealed Comparative Advantage

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1. Introduction

A successful industrialization process considers creation of new industries linked with greater value-addition and technological sophistication leading to shifts from one stage of development to another (Akyuz, 2009). Although, path-dependent, countries aim for structural transformation from low-technology and productive sectors to high performing technology-intensive sectors (Rodrik, 2008). However, in the present world, the dynamic growth prospects are surrounded with market imperfections and uncertainties which can be overcome by exploiting economies of scale, technical efficiencies and strengthening the country's existing technological capabilities by adopting and absorbing sophisticated technology required for a focussed, step-by-step sectoral development process.

India's pattern of technological catch-up by considering the available and possible openings from increased trade with developed markets recognises the linkages between trade and technology in the context of developing countries as being different from that of developed countries. For developed countries, innovation and diffusion of new technologies within a country act as a basis for market power which leads to international trade flows. In contrast, for developing countries, the evolution of trade leads to the development of national technological capabilities as discussed in Kim and Dahlman, 1992. The key issue is the ability of a country to learn how to utilize technology to strengthen its export competitiveness. Countries like Japan and South Korea chose the activities like heavy industries (steel, power), automobile industry, and electronic industry and made a determined effort to build up technological capability. The change in the composition of the export basket from low-tech, low-value items (textiles) to high-tech, low-value items (steel) requiring skill of complex project management, to high-tech, high-value final products like automobiles and electronics & hardware involving complex manufacturing process was a well-planned strategy.

For India, this kind of development strategy focuses on (i) low-technology, labour-intensive sectors namely, textiles and clothing including man-made fibres, and (ii) higher integration in global value chains (GVCs) (Veeramani & Aerath, 2020). Historically, developing countries have used success in apparel production as a first step towards industrialization and a gateway to globalized manufacturing exports– as illustrated in Kaname Akamatsu's "flying geese model" of 1962. For entire Asia, the comparative advantage has largely been dependent on the production of labour-intensive, low-skilled and low-paid industry which has been garment production. In fact, Asia being called the clothing factory for the world, accounts for 60% of global exports of garments, textiles and footwear and is a great manufacturing employer (World Bank, 2016). In Asia, textile production has been divided on the basis of important differences in source materials, product lines and end markets. South Asian countries are dominated by the production of cotton-based garments while South-East Asian countries produce more of man-made fibres (MMF).

Apparel production being a quintessential global value chain in itself, the different stages of production involving transformation of raw materials into retail products are performed in different countries. Because of the complex and fast-changing buyer demands, the competition among the garment manufacturers results into introduction of new processes and organisation of work with technology that can respond to such demands. However, China being the dominant player in apparel production is slowly vacating this position as it is either moving-up the value chain into higher-value goods (and out of apparel) or is going ahead with production shifts in response to its higher wages. This presents India with huge opportunity to improve building capabilities across the value chain segments, to be aided by competitive incentive framework in the form of horizontal industrial and sectoral-specific policies and to gain benefits in terms of increased trade, value-addition and greater number of employment opportunities.

Secondly, with the emergence of network products[1] (Athukorala, 2014, Veeramani & Dhir, 2017), India could become a major destination for assembly in a range of final products. The GVCs in these products are led by producer driven lead firms which are global enterprises such as Samsung, Apple, Sony, etc. As these network products cater to electronics and hardware sector, the opportunity of India lies in specialising in low-skilled and labour-intensive stages of production involving assembly, testing and packaging (ATP). However, with rising income levels, import of electronic products in the form of semiconductors, integrated circuit chips, mobile phones, products for defence electronics etc, have captured around 10-15% of total imports bill. This necessitates further increase in domestic production leading to increase in exports (Tewari and Veeramani, 2016). However, to reduce import dependence, government promoted local production and local procurement schemes. Telecom manufacturers like Cisco has already started making some high-level components in Pune, Nokia has a big facility in India, Huawei has facilities in India. Thus, large telecom manufacturers are helping to develop larger scale of local manufacturing and thus, making the core infrastructure stronger.

This paper develops and examines the linkages between trade competitiveness and technological capabilities of two sectors, textile and clothing (low technology-intensive) and electronics and hardware (high technology-intensive). These two sectors being the most significant for development and progress of Asia in general and India in particular manifest contrasting and important cases of export success with varying levels of technological dimensions. Also, in the case of India, very few studies have examined sectoral analysis focussing on the GVC participation and its spill overs on trade competitiveness and technological capabilities.

The analysis considered in this paper utilizes advanced time-series modelling from 1991 to 2017 which is constructed in the form of auto-regressive distributed lag (ARDL) model. This analysis will enable in testing the long-term relationship between export performance and technological capabilities and hence, through causality analysis, this relationship will further provide policy solutions to the policy-makers in increasing and upgrading the value-addition in these two important sectors of India. We also examine the dynamic effects of the shocks on the endogenous variables using impulse response functions. This method captures the evolution of dynamic behaviour of the variables over time (Zhang et al., 2017). By constructing a Vector Error Correction (VEC) model, the advantage of explicitly allowing for feedback effects from gross exports to explanatory variables is considered which could not be addressed through single-equation approach. Also, it can illustrate how the response of gross export varies according to the nature of shocks provided by trade and technology variables.

[1] These are the products which enable in the final assembly and thus, are not completely produced in one country. Sequentially, with every country's specialisation, these products are made.

This kind of research in a comparative perspective has not been undertaken from an extensive longitudinal dimension. With this, section two presents the sectoral trends and patterns determined by the factors impacting export performance and innovation capabilities. Section three elaborates on the research methodology; section four provides data analysis and results. And finally, section five presents conclusion and policy implications.

1.1 Sectoral Trends and Patterns

1.1.1 GVC Participation

The stage at which a country's sector is performing and adding value determines the country's growth and competitiveness. Participating in the manufacturing process as a supplier of raw materials or semi-processed intermediates is a simpler way to profit from trade. In a globally dispersed business, integration helps rising countries, in particular, to join current supply chains rather than creating new ones (Baldwin, 2011). As for these countries, the stages of performing sophisticated R&D and designing are difficult especially if the industry itself is not present in the country. With greater specialisation in a segment of value chain, these countries with increased sophistication of goods, can participate without the need to gain comparative advantage in a broad range of production stages domestically. This kind of shift has been the result of ease in transportation and information technologies along with the declining trade barriers providing opportunities to unbundle production into tasks performed at different locations to take advantage of different factor costs (Feenstra and Hanson, 1997; Grossman and Rossi-Hansberg, 2008). Thus, a key role is played by GVCs in bolstering the competitiveness of existing exports and in industrial and economic development of a country.

Koopman et al. (2014) created the indicator to quantify GVC participation by combining foreign value addition (FVA) and indirect domestic value addition (DVX). Backward participation, or imported intermediate inputs used in exports, is measured by FVA. Forward participation, or the export of intermediate inputs utilised in exporting to a third country, is measured by DVX. The higher this ratio, the more interconnected those sector's GVCs are.

$$GVC_{Participation} = \frac{FVA+DVX}{Gross\ Exports}. \qquad (1)$$

The GVC position index, which gauges the relative position of that sector in the value chain, is another statistic employed at the same time. Koopman et al., 2014, consider both upstream and downstream activity to determine the sector's position.

$$GVC_{Position} = \ln\left(1 + \frac{DVX}{Gross\ Exports}\right) - \ln\left(1 + \frac{FVA}{Gross\ Exports}\right). \qquad (2)$$

The higher the ratio, the bigger the contribution or value-addition of that sector in that chain. Figure-1 shows both of these indicators, with GVC participation on the y-axis and GVC position on the x-axis. From 1991 to 2017, the combination of both of these indicators is analysed.

The textile and clothing (T&C) industry's worldwide value chain is buyer-driven, with brand owners and market merchants in charge of design (Arora & Siddiqui, 2020), trademarks, new technologies, and consumer demand. India, on the other hand, has the complete textile value chain covered, from raw materials through spinning, weaving, and knitting, as well as clothing manufacturing using skilled and low-cost labour. From 1991 to 2000, India was one of the first countries to outsource most manufacturing activity to the global network (in the figure). Increased learning and the establishment of a speciality market for cotton products such as men's bottoms, knit and woven tops, skirts, and embroidered and embellished clothes helped India become more competitive. As a result, the company was able to advance up the value chain. As a result, from 2010 to 2017, India's textile sector showed an increase in GVC participation.

GVC participation of Indian textile and clothing has not been challenging due to a domestic value addition rate of more than 80% (Gupta, 2015). This is owing to India's gradual shift away from cotton and toward other types of fibre, such as man-made fibre (MMF), as well as high levels of contamination and low quality of fibre, both in the case of length and quality. Furthermore, China and Bangladesh, as key buyers of Indian cotton yarn, add value to the yarn before selling it to India at a reduced price. This emphasises the need to enhance and expand the supply of cotton yarn in order to make higher-value textiles and apparel[2]. Although India has performed well in the lower stages of CMT (Cut-Make-Trim), demand for Indian exports is anticipated to drop in the near future as developed nations invest in higher-tech such as robotics, 3D printing, and artificial intelligence (AI). As a result, India must rely on regional value chains (RVCs) rather than the majority of industrialised countries (Sengupta, 2018).

Because of the high adaptability of the production process, GVCs have a significant presence in the electronics sector. If a country imports/exports a substantial percentage of subassembly items and components, as well as a large share of finished electronics exports/imports, it is positioned higher or lower in the value chain. Between 1991 and 2017, GVC participation and position in the Indian electronics and hardware (E&H) sector expanded. From 1991 to 2010, however, the reliance on backward connections was enormous, owing to decreasing GVC participation. Although India has overtaken China as the world's second largest producer of mobile phones, the value added is minimal because just the assembly takes place in India.

The requirement to expand the manufacture of electronic components and subassembly products in India can help to increase and upgrade value addition in the electronics industry. The development of electronics system design hardware and manufacturing (ESDM) for both local and international markets has been the main emphasis of both Make in India and Digital India projects, with a target market size of US$ 251 billion by 2023.

As a result of the government's sectoral strategies, domestic manufacturing is gradually surpassing the rise of electronic industry imports. Semiconductors and integrated circuits make up the majority of the imported goods. There is still a long way to go in terms of domestic manufacturing of these products because India lacks the necessary ecosystem and technological know-how. However, due to shifting global supply chains following the pandemic, India has the opportunity to seize the worldwide market.

[2] https://niti.gov.in/weaving-way-indian-textile-industry

1.1.2 Revealed Comparative Advantage Ratio

The revealed comparative advantage is used to determine the competitiveness of a sector's exports (RCA). Many research studies employ the RCA indicator to assess the competitiveness of an ex-post export situation. RCA for the textile and apparel sector was investigated utilising Balassa's formulas in studies such as (Veeramani, 2012, Kathuria, 2013, 2018; Dhiman and Sharma, 2017; Kannan, 2018). The RCA has been employed in research in the electronics and other sectors, (Veeramani, 2012, Mukherjee & Mukherjee, 2012, Kathuria et al., 2008, Singh & Siddiqui, 2021).

The RCA calculated is as follows:

$$RCA = \Sigma(Xj/Xc) / \Sigma(Xnj/Xnc), \qquad (3)$$

where X= India's sectoral exports,
j=specific commodity sector,
c=set of all commodity exports,
n=set of all other countries (world).

Exports of a commodity from a certain industry are compared to total exports and exports from all countries across the world. When the RCA is more than or equal to one ($RCA \geq 1$). There is a comparative advantage that has been discovered. From 1991 to 2019, Figure-2 displays the RCA trend for the two industries. Because it gives a full image and direction for exporting, as well as a clear trade specialisation pattern, RCA is one of the most essential markers of export performance. As can be seen, the RCA for the textile industry is higher than the RCA for the electronics industry. T&C is an internationally competitive industry, as evidenced by this. Although, when compared to 1991, its RCA values have reduced in 2017. The Indian electronics industry has yet to mature into a global force.

1.1.3 Trade Margins

Diversifying the export base reduces export earnings volatility, diversifies export channels and hence revenues, improves the value-adding process, and, ultimately, boosts growth. Export specialisation or diversification can be seen in both extensive and intensive margins. From a comparative approach, these margins have been examined (Besedes & Prusa, 2007). Regardless, they have become well-known as a result of the implementation and diffusion of new technology (Comin et al., 2006, Battisti et al., 2009).

The relevance of technology in trade is highlighted by the impact of extensive margin in expanding trade volumes (Hummels & Klenow, 2005), as well as the effect of corporate R&D in raising exports (Castillejo, et al., 2011). A huge margin's importance has also been emphasised (Besedes & Prusa, 2007; Bernard et al., 2009; Helpman et al., 2008; Brenton & Newfarmer, 2007). The extensive export margin represents the export of current product variants to new markets, whereas the intensive export margin represents the export of new product variants to existing or new markets (Hummels & Klenow, 2005). The calculation of intensive and extensive margins is depicted in equation (4) and (5)

$$IM = \sum X_{ij} / \sum X_{wj}, \quad (4)$$

$$EM = \sum X_{ij} / \sum X_{w}, \quad (5)$$

where, x=exports,
i= exporting country,
j= sector of interest,
w=the world,

The intensive margin is depicted on the x-axis, while the extensive margin is indicated on the y-axis. The figure shows how important the T&C industry is to India, as both of these margins are quite substantial when compared to the E&H industry. The extensive margin in the T&C business declined between 1991 and 2017, while the intensive margin climbed, showing fierce competition among manufacturers for export markets. According to reports from the International Labour Organization (ILO), NASSCOM-FICCI-EY, 2017, and UNCTAD, 2017, it's time to diversify and explore regional markets for garment products to reduce reliance on western markets, particularly as these countries increase textile production through robotics technology, and to diversify exports in terms of new products.

From 1991 to 2017, both margins in the electronics industry increased, although the intensive margin declined somewhat from 2010 to 2017. Many countries, including Japan, South Korea, and the United States, are eyeing India's market as a potential replacement for China's manufacturing supply chains, with trade wars in the rear-view mirror, rising labour costs in China, and other pull factors such as potential domestic demand and government policies to boost electronics exports. In addition to computers, cell phones, and other electronic devices, there are channels in accessories and components where MNCs can develop India's technological capabilities while receiving incentivised regulatory backing from the government. This will allow telecom imports to migrate away from fully built equipment and toward intermediate suppliers, resulting in an increase in electronics exports, including consumer items. As a result, India's current large net electronic imports will decrease.

1.1.4 Sector-wise R&D Expenditure

R&D costs cover the costs of developing new products and processes, as well as refining existing technologies used in a company's manufacturing, services, and marketing. The relationship between technological capability development and R&D spending is depicted in figure-4. By summing the R&D spending at the firm level, the total R&D expenditure at the sectoral level is computed. Firms are at the centre of innovation systems because of their unique abilities to combine numerous types of information in order to bring new technology, goods, and services to market (Metcalfe & Ramlogan, 2008). Learning-by-doing, learning-by-exporting, and interacting with users, clients, and suppliers all play essential roles in diverse scenarios. Figure-4 depicts how the share of R&D investment in both industries has varied between highs and lows, but has been slowly increasing since 2014.

Due to the innovation ecosystem provided by private firms, government initiatives, and FDI, the electronics sector's R&D expenditure has expanded. Value can be added to final products outside of the production process since the electronics value chain is modular. Research, product and process development, design (the most profitable activity, but held by lead firms), marketing, and after-sales services are among the tasks carried out (these activities along with final assembly are outsourced to developing countries). Manufacturing capabilities must be nurtured and incentivised through sectoral policies such as Digital India and the National Policy on Electronics (NPE) 2019, the Phased Manufacturing Programme (PMP), the Electronics Development Fund (EDF), Preferential Market Access (PMA), and the Modified Special Incentive Package Scheme (MSIPS) to meet the country's needs and serve the international market.

Technical textiles are the most up-to-date textile materials and products, with a focus on technical performance and utility rather than aesthetic and decorative qualities. Agriculture, medical, infrastructure, automotive, aerospace, sports, defence, and packaging are just a few industries that make use of them. Because of its cost-effectiveness, durability, and adaptability, India is likely to be a key emerging market for technological textiles. The technical textile industry is driven by the healthcare and infrastructure sectors. Technical textiles has the potential to create a huge number of jobs as it is an R&D-driven industry. To help potential investors into the technical textiles business, the ministry has established Focus Incubation Centres (FIC) and a Technology Mission on Technical Textiles (TMTT).

1.1.5 Sector-wise FDI

Foreign direct investment (FDI) was touted as a means of increasing exports by introducing additional cash, as well as the benefits of technology, management know-how, and marketing skill, as well as access to global, regional, and developing home country markets (UNCTAD, 2002). Inflows of foreign direct investment have been important to the developing world's outward-oriented development strategy's success. It allows for the entrance of fresh (risk-sharing, debt-free) capital, foreign exchange, easy access to global markets and sourcing, and technological transfers (Chia and Plummer, 2015; Prasad et al., 2006). The percentage of FDI inflows into the textile and electronics sectors in India's total FDI inflows is shown in (Figure-5).

India received a total of US$ 469 billion in FDI from April 2000 to March 2020, the majority of which came from Mauritius, Singapore, and Japan (DPIIT). The electronics industry drew FDI worth US$ 2.8 billion in the same year, accounting for 0.6% of total FDI. Furthermore, the FDI cap in the telecom sector has been raised to 100% from 74%; of the 100%, 49% will be done through the automatic route, and the remaining will be done through the FIPB approval route, where FDI of up to 100% is permitted for infrastructure providers offering dark fibre, electronic mail, and voice mail.

The textile and garment sector got $3.45 billion in FDI over the same time, representing for 0.73% of total FDI received. The computerised system has approved up to 100% FDI, accelerating the growth of the textile industry. The textiles sector has received Rs 27,000 crore (US$ 4.19 billion) in investment since June 2017. In India's textile business, there has been a considerable surge in partnerships between global giants and domestic enterprises. Several multinational apparel behemoths have already established operations in India, including Gap, H&M, Zara, Marks and Spencer, and Diesel.

The relationship between export data and FDI inflows shows that the electronics industry has attempted to match FDI inflows in the textile industry, but its exports have not increased as a result. In the literature, there is an inconclusive association between FDI and exports (complementing or substituting each other). Therefore, even in the high-tech business, FDI's capacity to accelerate exports is impeded if it is mainly influenced by acquisition of resources and capturing of domestic market (Arora & Siddiqui, 2020). One of the major factors limiting India's manufacturing sector's growth is a lack of technological depth. The majority of Indian manufacturing companies appear to be trapped at a basic or intermediate technology level. Imports of sophisticated goods (whether capital or intermediate items) and inward foreign direct investment flows that result in technical spill overs/dissemination have benefitted India's industrial sectors through influencing R&D activity (Arora & Siddiqui, 2020).

2. Research Methodology

The variables for this study were acquired from a variety of sources between 1991 and 2017. According to the value-added variable last visited, data from the UNCTAD-EORA Global Value Chain Database is accessible until 2017. In 1991, India's access to the global market improved as a result of policies aimed at globalisation, liberalisation, and privatisation. This resulted in an improvement in industrial performance, primarily in terms of international trade. As a result, the study takes into account the true image for reliable outcomes by commencing in 1991.

2.1 Dependent Variable

Gross Exports is taken as the dependent variable. Firms perform exports to become more competitive and earn greater revenues. This results in making firm more efficient due to knowledge spill overs (Wagner 2007). The gross exports as a proportion of total exports to world has been taken for both the sectors. Export data is accessed from UNCOMTRADE database.

2.2 Explanatory Variables

All the above variables taken as determinants of exports for these two sectors are considered as explanatory variables. However, sector-specific variables, output and gross fixed capital formation are also taken as the control variables. Gross Fixed Capital Formation (GFCF) and Production output- The GFCF for each sector is derived from the CMIE's industry outlook database, which spans the years 1991 to 2017. This variable accounts for inventory changes as well as dynamic net valuables acquisitions. In the same way, output production has a direct impact on exports. This variable comes from the CMIE's industry outlook database, which spans the years 1991 to 2017. The effects of these variables are summed up. Both of these variables are expressed as a percentage of total industrial output and total industrial GFCF, respectively.

3. Data Analysis & Results

The stationarity of the variables used in the time-series analysis is tested first. The ADF and Phillips-Peron (1988) tests are being considered. The ARDL/bound-testing is then performed using Pesaran & Shin (1999) and Pesaran et al. (2001), with the assumption that all variables have either I(0) or I(1) order of integration, or both I(0) and I(1) order of integration (1). We must ensure that bound-testing variables for ARDL are not I (2).

3.1 Unit roots Tests

The stationarity tests reveal that for T&C sector, few variables are both I(0) and I(1). And for E&H sector all variables are non-stationary at level. In order to avoid spurious regression and thus results and inferences from it, the series needs to be stationary. In general, if a series requires to be differenced ‘d’ times in order to reach the stationarity, such a series is said to be integrated of order ‘d’ and denoted as I(d). We use Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1979) and Phillips-Perron (PP) (Phillips and Perron, 1988) tests to check the stationarity of the variables. The ADF Test can be represented by equation (6)

Consider the equation

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta yt - 1 + \varepsilon_t, \quad (6)$$

where Y_t is our variable of interest, Δ is the differencing operator, t is the time trend and ε is the white noise residual of zero mean and constant variance. $\{\beta_1, \beta_2, \delta, \alpha_1, \ldots, \alpha_m\}$ is a set of parameters to be estimated.
Both of the null and alternative hypotheses in unit root tests are:
H0: $\delta = 0$ (yt is non-stationary / a unit root process)
H1: $\delta \neq 0$ (yt is stationary)
The unit root hypothesis of the Dickey-Fuller can be rejected if the t-test statistic from these tests is negatively less than the critical value tabulated. In other words, by the Augmented Dickey Fuller (ADF) test, a unit root exists in the series (implies nonstationary) if the null hypothesis of δ equals zero is not rejected.

3.2 Cointegration Bounds tests

The ARDL cointegration technique is considered to analyse the long and short-run dynamic interactions among variables. If the sample size is modest (as in this study), long and short-run components are estimated simultaneously, autocorrelation and omitted variables are removed, and there is a distinction between explanatory and dependent factors, the resulting estimates are unbiased and efficient. The technique of cointegration considers ARDL (p, q1, q2......qk) model as:

$$\Delta X_t = \delta_{0i} + \sum_{i=1}^{k} a_{1,i} \Delta X_{t-1} + \sum_{i=1}^{k} a_{2,i} \Delta Y_{t-1} + \delta_1 X_{t-1} + \delta_2 Y_{t-1} + v_{1t}, \quad (7)$$

$$\Delta Y_t = \delta_{0i} + \sum_{i=1}^{k} a_{1,i} \Delta Y_{t-1} + \sum_{i=1}^{k} a_{2,i} \Delta X_{t-1} + \delta_1 Y_{t-1} + \delta_2 X_{t-1} + v_{1t}. \quad (8)$$

The maximum lag order is k, which is determined by the user. The F-statistic is used to test the null hypothesis that the coefficients of the lagged variables (δ1X□−1 δ1Y□−1 or δ1Y□−1 δ1X□−1) are both zero. The long-run relationship is represented by (δ1, δ2), whereas the model's short-run dynamics are represented by (α1, α2). The hypothesis that the coefficients of the lag level variables are zero is to be tested. The null of non-existence of the long-run relationship is defined by; Ho: δ1 = δ2= 0 (null, i.e. the long run relationship does not exist) H1: δ1 ≠ δ2 ≠ 0 (Alternative, i.e. the long run relationship exists)

The critical values of the F statistics for various numbers of variables (K) are provided by Pesaran & Pesaran (1996a) and Pesaran et al. (2000), as well as whether the ARDL model contains an intercept and/or trend (2001). They provide two different sets of crucial values. One set assumes that all the variables in the ARDL model are I(0) (i.e. lower critical bound which assumes that all the variables are I(0), meaning that there is no cointegration among the underlying variables) and the other assumes that all the variables are I(1) (i.e. upper critical bound which assumes that all the variables are I(1), meaning that there is cointegration among the underlying variables). There is a band for each application that covers all potential classifications of variables into I(0) and I(1).

A conclusive judgement can be made if the applicable computed F-statistic for the joint significance of the level variables in each of the equations, 1, and 2, falls outside this band. The Ho is rejected when the computed F statistic is greater than the upper bound critical value (the variables are cointegrated). The Ho cannot be rejected if the F-statistic is less than the lower bound critical value (there is no cointegration among the variables). However, if the computed statistic falls within (between the lower and upper bound) the critical value band, the result of the inference is inconclusive and depends on whether the underlying variables are I(0) or I(1).

The small data span guides this strategy. Using the Akaike information criterion (AIC)., the conditional ARDL vector error correction is provided a maximum lag order of 1. The F-statistics for the two sectors are shown in Table 2. Because the F-statistic (12.33) is larger than the upper bound critical value (3.3) at the 5% level for the textile industry, it is obvious that there is a long run relationship between the variables with gross exports as the dependent variable. In equations 7 and 8, the null hypothesis of no cointegration is rejected, implying that the null hypothesis of no cointegration is rejected. This ensures a short-term repair process, avoiding errors from becoming larger in the long run. In the electronics industry, however, the null hypothesis of no cointegration is accepted.

3.3 Long Run and Short Run Dynamics of ARDL Approach

Once cointegration is established, the conditional ARDL (p, q1, q2, q3,..,qn) long-run model for (GE_t) can be estimated as:

$$GE_t = a_0 + \sum_{i=1}^{p} a_{1i}GE_{t-1} + \sum_{i=1}^{q1} a_{2i}Bpar_{t-1} + \sum_{i=1}^{q2} a_{3i}Fpar_{t-1}\, i + \sum_{i=1}^{q3} a_{4i}RnD_{t-1} + \sum_{i=1}^{q4} a_{5i}FDI_{t-1} + \sum_{i=1}^{q5} a_{6i}Extmar_{t-1} + \sum_{i=1}^{q6} a_{7i}Intmar_{t-1} + \sum_{i=1}^{q7} a_{8i}RCA_{t-1} + \sum_{i=1}^{q8} a_{9i}GFCF_{t-1} + \sum_{i=1}^{q9} a_{10i}Prod_{t-1} + \varepsilon t. \quad (9)$$

Here, gross exports is GE, backward participation is Bpar, forward participation is Fpar, research & development expenditure is R&D, foreign direct investment flows is FDI, intensive margin is Intmar, extensive margin is Extmar, revealed comparative advantage is RCA, output value is Prod and gross fixed capital formation is GFCF.

The ARDL model ordering (p, q1, q2, q3, q4, q5, q6, q7, q8, q9) is taken through AIC specification of the ten variables. Equation (10) is calculated using the ARDL (1, 0, 0, 1, 0, 1, 0, 1, 1, 1, 1) textile sector specification. The long-run model's results are shown in Table-3. However, there is no long-term link in the electronics and hardware sector when gross export is the dependent variable.

At the 1% and 5% level of significance, the calculated coefficients of the long-run association that are positively significant are extensive margin, GFCF, and RCA, whereas the coefficients that have a negative long-run relationship with gross exports are FDI and intense margin. This explains why, in the long run, establishing new markets with new products largely funded by the GFCF will boost gross exports for this low-tech sector. And, with continuous RCA in textile items over the years covered, the report shows that the sector's products' global competitiveness will increase by an average of 4%, boosting global exports. Technology import variables such as GVC engagement and R&D expenditure are unimportant in this business.

The equation (10) is estimated for the electronics industry using the ARDL (1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1) short run causal relationship estimation. Table-4 indicates that the one-year lagged value of gross exports, intensive margin, and output are all positively significant at the 1% and 5% levels. Hence, the present large short run estimates of extensive margin and RCA have a positive influence on gross exports, whereas the current significant short run estimate of intensive margin has a negative impact. This emphasises the need of globally competitive electronics products that capture a broad range of markets and result in greater short-term exports. On the other hand, the lagged estimate of intensity margin has a significant positive impact on gross exports.

As a result, in the near run, the electronics sector's forward involvement reflected by DVX and its own R&D expenditure do not lead to a positive causal relationship with exports. The current short-run significant estimates of investment variables such as FDI and GFCF have a negative impact on gross exports. FDI has a negative impact, while GFCF has a favourable impact[3] (at a 10% level of significance).

The dynamic parameters of the short-run model linked to long-run estimations are generated using error correction modelling (ECM) (Narayan and Smyth, 2008). ECM determines the pace of adjustment or correction from a short-run shock to the long-run equilibrium. The F-statistic and the lagged error-correction term imply that there is Granger-causality in at least one direction, based on the long-run relationship between the variables. To derive the short-run dynamic parameters, we estimate an error correction model linked with the long-run estimates, ARDL, in the third phase (p, q). The following is what is observed:

$$\Delta Y_t = \delta_0 i + \sum_{i=1}^{p} \beta_1 \Delta Y_{t-1} + \sum_{i=1}^{q} \beta_2 \Delta X(1)_{t-1} + \sum_{i=1}^{r} \beta_3 \Delta X(2)_{t-1} + \sum_{i=1}^{s} \beta_4 \Delta X(4)_{t-1} + \lambda ECM_{t-1} + v_t. \quad (10)$$

The short-run dynamic coefficients of the model are presented by β1 and β2, β3 and β4. The error-correction term ECMt-1 defines a long-run equilibrium connection and represents the speed with which a short-run shock is adjusted to the equilibrium level. The ECMt-1 has a negative sign, indicating that a portion of the disequilibrium will be addressed in the next period. Short-term and long-term behaviour can be reconciled with ECM.

The ARDL-ECM equation in Table-5 presents both short-run and long-run relationship dynamic coefficients. The ECT coefficient is substantial at a 1% level, with an estimated value of -0.67, indicating that the rate of adjustment to equilibrium after a shock is reasonable. As a result, in the current year, around 67 percent of the disequilibrium caused by the previous year's shock converges to the long-run equilibrium. The ECM is as follows, using GE as a dependent variable:

[3] In many studies questions have been raised if FDI is included in GFCF. In this study a point is to be noted that as this is an industry-level analysis, the domestic firms having foreign ownership can undertake FDI to finance fixed capital formation also. Nonetheless, we would consider FDI as a source of technological inputs and would not digress from this issue.

ECM = GE - 0.0124*DVX - 111.122*Extmar + 1.572*FDI + 0.255*FVA - 0.192*GFCF + 4.242*Intmar + 0.265*R&D - 0.041*RCA + 0.078*Output.

According to the ECM model, the coefficients of GFCF and RCA are positively associated with gross exports and are significant at even 1%. The value of output is positively related with GE even at a 10% significance level. In the near run, however, FDI and R&D coefficients have a negative connection with gross exports and are statistically significant at the 1% level. When compared to FDI, GFCF has a considerable positive impact on gross exports over time. The error-correction term implies interaction causality from RCA, output, R&D, FDI and GFCF to gross export. Since a result, technology considerations have a negative impact on GE in the short term, as technology adoption and integration into existing production takes time to improve production efficiency and consequently exports. In the short run, importing technology represents a sunk cost for textile producers. However, in the short run, these two variables have a positive impact on gross exports due to increasing production and exports becoming more globally competitive.

3.4 Diagnostics and Stability

The ARDL equation (7) has fitted well but also needs to pass the diagnostic tests. The tests considered are against heteroscedasticity and serial correlation. The results are presented in Table-6. Also, the cumulative sum of recursive residuals of square (CUSUMSQ) test is applied to assess the parameter stability (Pesaran, 1997) of the long-run coefficient tested by the short-run dynamics. The CUSUMSQ statistic plots between the critical bands of the parameter stability 5 percent confidence interval, suggesting that the coefficients are not unstable.

3.4.1 Granger Causality Tests

The presence of a long-run equilibrium relationship determines the likelihood of causality in at least one direction. When there is no cointegration between the variables, they have no effect on each other and are hence independent. Granger (1969) created a causality test method to determine the pattern of such a relationship. It is claimed that X 'Granger causes' Y if current and lagged values of X improve the prediction of the future value of Y.

The multivariate pth order for the vector error correction model (VECM) is demonstrated by:

$$\Delta X_t = \varphi + \sum_{i=1}^{n} \Theta i X_{t-i} + \lambda ECM_{t-1} + \varepsilon_t.$$

Here, vector of the variables is denoted by Xt, φ vector of constant terms, ϴi includes the interaction coefficients of the variables involved. λ is the vector of coefficients for each of the error correction terms, and Ɛt is the vector of disturbance terms.

The Granger causality results for short run pair-wise are shown in Table-7. F-statistics show a bi-directional granger causality between RCA and gross exports, as well as a unidirectional granger causality from gross exports to wide and intense margins and textile sector production, at the 5% level of significance. Evidence of bi-directional granger causality can also be found between large and intensive margins. In the short run, the more the global competitiveness of Indian textile products, the greater the gross export to the world, and vice versa.

Thus, for low-technology sectors such as textiles and clothing, the interplay of technology in terms of involvement in global value chains in boosting exports is not readily obvious. Table-7, on the other hand, shows that the indirect impact of technological skills in determining textile export competitiveness is established, albeit in the short run, as a result of forward participation unidirectionally granger causing FDI, GFCF, RCA, and production. Backward participation granger and DVX are two examples of backward participation granger, which results in large and intense margins. When RCA grangers increase export competitiveness, they produce an extensive margin, which makes sense since as items get more competitive, their market capturing reach grows and diversifies. Extensive margin captures the enabling function of technology in exporting novel things to many markets, bringing the point of learning by exporting, when RCA granger causes extensive and intense margins.

3.4.2 Impulse Response Function

Our next step is to quantify the shocks' dynamic effects on the endogenous variables. Following that, the impulse response functions based on the VEC model are provided. If the variables are non-stationary and there is a cointegration relationship, the error correction component must be included to the Vector Autoregressive (VAR) model in order to construct a VEC model. The VEC model is a cointegration-constrained VAR model that is used to simulate non-stationary series with cointegration relationships (Zhang et al., 2017). Because our variables are nonstationary and cointegrated, we utilise a VEC model with cointegration relations included into the specification, which limits the endogenous variables' long-run behaviour to converge to their cointegrating relationships while still allowing for short-run dynamics. According to the Representation Theorem of Engle and Granger (1987), a VEC model has the following representation (Naka and Tufte, 1997):

$$\Delta Y_t = \mu + \delta T + \alpha\beta Y_{t-1} + \sum_{s=1}^{p-1}\{G_s \Delta Y_{t-s}\} + \varepsilon_t,$$

where Δ is the first difference operator, "Y" is an (n x 1) vector of variables, "□; δ" are (n x 1) vectors of deterministic components, "T" is a time trend, "p" is the maximum lag length, "Gs" are (n x n) matrices, that indicate short term adjustments among variables and "εt" is an (n x 1) vector of residual.

Figure-6 shows the impulse responses of gross exports to a unit standard deviation shock in the long-run (30 year). The responses of GE to a unit standard deviation of DVX, extensive margin and FVA result in only positive direction. However, the response of GE to FDI, RCA and value of output result in a positive trend after witnessing a declining trend. For the shock provided by R&D expenditure and intensive margin, the response of GE has been similar. Thus, with the impulse response functions, the future direction of the variables following a shock represents the dynamic nature which becomes very important to be gauged.

4. Conclusion and Policy Implications

Two critical industries for India's development are discussed in this article. Textiles and clothes are low-tech and labour-intensive industries, whereas electronics and hardware are high-tech industries. Both are notable examples of India's inventive and competitive export performance. While there is cointegration among the variables in the textile business, there is none in the electronics industry, according to sophisticated time series modelling. Thus, factors such as export diversification (extensive margin) and RCA have a positive and significant impact on textile exports in the long run. Additionally, increased GFCF investments in this area have a significant impact on exports. Textile production demands a considerable amount of capital and well-developed infrastructure, in addition to being energy-intensive. This seems to be the path of the new textile strategy 2020, which promises to increase domestic output, promote organic cotton farming, processing, and branding, and leverage FDI to establish machinery manufacturing centres. According to the policy, major textile centres would be developed across the country. These centres would undoubtedly help India become a worldwide contender by providing end-to-end production, from raw materials to final product export. This also highlights the successful collaborative measures that have been demonstrated to be effective in scaling up solutions (e.g. policy, training, capacity building, and so on). Scaling-up can also benefit SMEs with limited resources that are initially hesitant to invest in pilots. Moreover, rather than being a cotton-driven industry, this programme aims to turn India into a man-made fibre (MMF) hub. To move towards MMF and boost the handcart and handloom sectors, the production linked incentive (PLI) plan with a five-year gestation period was implemented. The Technology Upgradation Funds Scheme (TUFS) is a capital investment assistance programme for textile manufacturing modernization. In India, however, MMFs have yet to be implemented, which means that garment exports are centred on the spring/summer season, with factories open for only 6.5 months. In this environment, government-supported textile research associations around the country may play a critical role in cultivating an ecosystem among private firms, colleges, and research institutes that will tremendously benefit Indian textile research and innovation. All of this is crucial for the textile industry's workforce development and growth.

Asia, which accounts for 60% of global garment, textile, and footwear exports and is known as the world's clothing sector, is experiencing growing manufacturing costs in China, where China is the dominant player (ILO, 2017). As a result, India should recapture the export market share that China has lost in recent years. The FTAs with the EU and the UK might result in the creation of 1,08,029 additional direct jobs in the garment sector each year, according to the Economic Survey 2016-17. Export potentialities are a major driver of job creation in the textile industry. As a result, if exports increase as a result of expanding into new markets, more jobs will be created.

According to pair-wise granger causality, the stronger the global competitiveness of Indian textile items, the higher the gross export to the globe, and vice versa. Technology's role in promoting exports through involvement in global value chains is sometimes overlooked. On the other hand, the impact of technological capabilities on textile export competitiveness is becoming evident. As a result, the government's role in providing domestic enterprises with preferential access to capital in order to support indigenous R&D and the acquisition of foreign technology, allowing them to improve their overall global competitiveness, has been restored. Both the granger causality and impulse response functions imply a greater link between commerce and technological linkages as a result of membership in GVCs.

Textile producers should concentrate on regional and local markets as well. The relevance of sectoral policies and strategies for industrial growth cannot be overstated. Firms are urged to spend more money on back-end services like logistics and front-end activities like design in order to stay current. India's key weaving and fabric processing industries will need to expand as a result. This weak link permits the export of yarn (raw material) and the import of fabric (final product). Customers all across the world favour OEM-capable enterprises because they can outsource not only assembly but also supply chain management (ILO, 2017). As a result, better regional trade integration among emerging countries may help them maintain market share in these countries. This could be one approach to diversify existing exports and generate new FTAs, especially since many of them are with countries in the region.

According to the short-run causal connection estimate for the electronics sector, the current values of extensive margin, RCA, and output have a favourable and considerable impact on gross exports. FDI and high margin values, on the other hand, have a major negative influence on gross exports. This indicates that internationally competitive gross exports might diversify even further in terms of newer items, markets, or both. Furthermore, FDI in this industry has focused on developing domestic markets rather than increasing exports in the short term. This also emphasises how difficult it is for domestic producers to profit from their participation in the value chain. On the other side, the high margin and low gross export values have a significant and positive impact on gross exports. This demonstrates how path-dependent things are in the globally competitive electronics business. Even though India is a vast market, authorities must focus on increasing demand. Meeting the quality criteria of the importing country will encourage the development of local manufacturing, resulting in more exports and the promotion of learning-by-exporting.

Despite the fact that India has overtaken China as the world's second largest producer of mobile phones, the value added is low because only assembly takes place in the country. The lagged value of foreign value addition, which has a positive but tiny impact on gross exports, exemplifies this. Several companies have been forced to construct printed circuit board assembly (PCBA) units as a result of this innovation. In addition, by 2025, the PLI plan aims to manufacture $133 billion in smartphones and components.

Many electronics MNCs have increased their focus on the development of semiconductors, which are the enabling hardware for all modern electronic devices. Its applications include computers, smartphones, and televisions, and its production process is separated into various modules, including research and development (R&D), design, manufacturing, and assembly, testing, and packaging (ATP). The division of components in the production process allows GVCs to grow. To take advantage of lower labour costs and a large market, lead firms process semiconductor production in close proximity to such markets. The complex manufacturing method used in semiconductors, on the other hand, leads in increased cost pressure. This pushes India's next electronics policy in this direction by providing a competitive incentive structure for current players. With 100% FDI in this sector, a strong manufacturing base may be built by encouraging international businesses to set up R&D centres and design workshops, paving the way for the creation of a state-of-the-art semiconductor manufacturing facility in the near future. Finally, while GVC integration necessitates behind-the-border logistics support to ensure superior quality and on-time delivery, the duty structure should favour finished electronics over electronic components and subassembly items, and domestic manufacturing over imports. China's example can be seen in an export-intensive strategy that exempted raw and other intermediate imported products.

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Figures and Tables

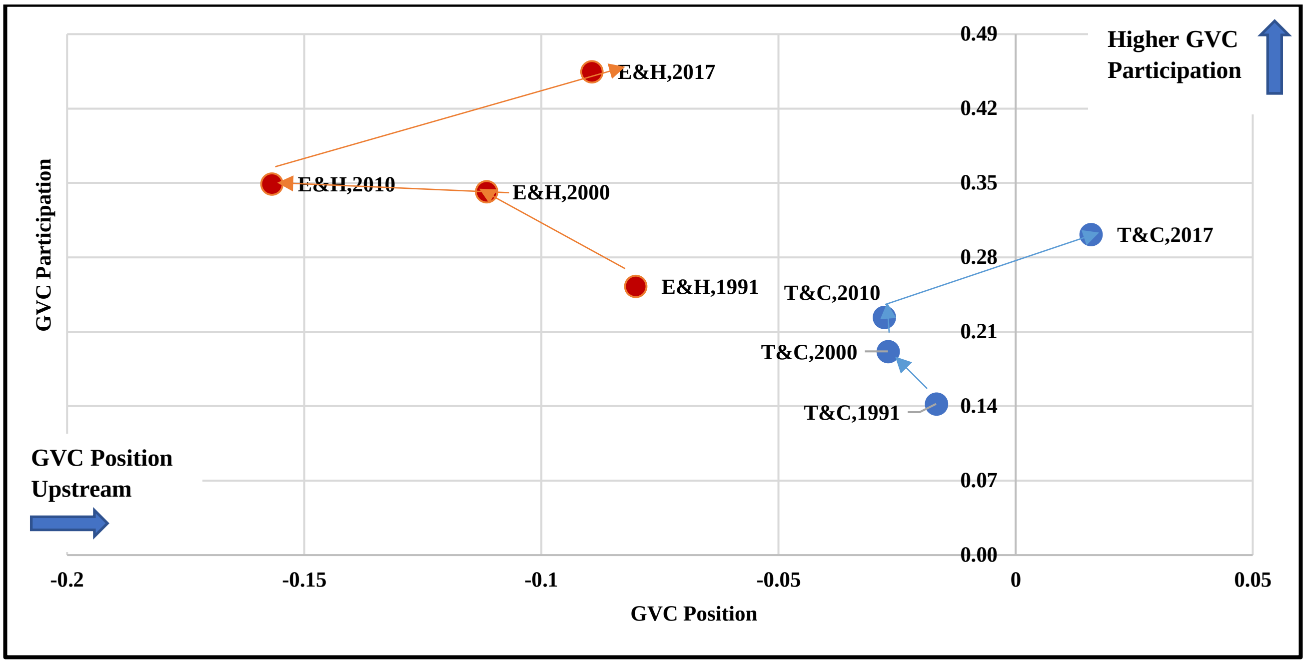


Figure-1 GVC Participation & Position

Source: Authors' calculations using EORA database.

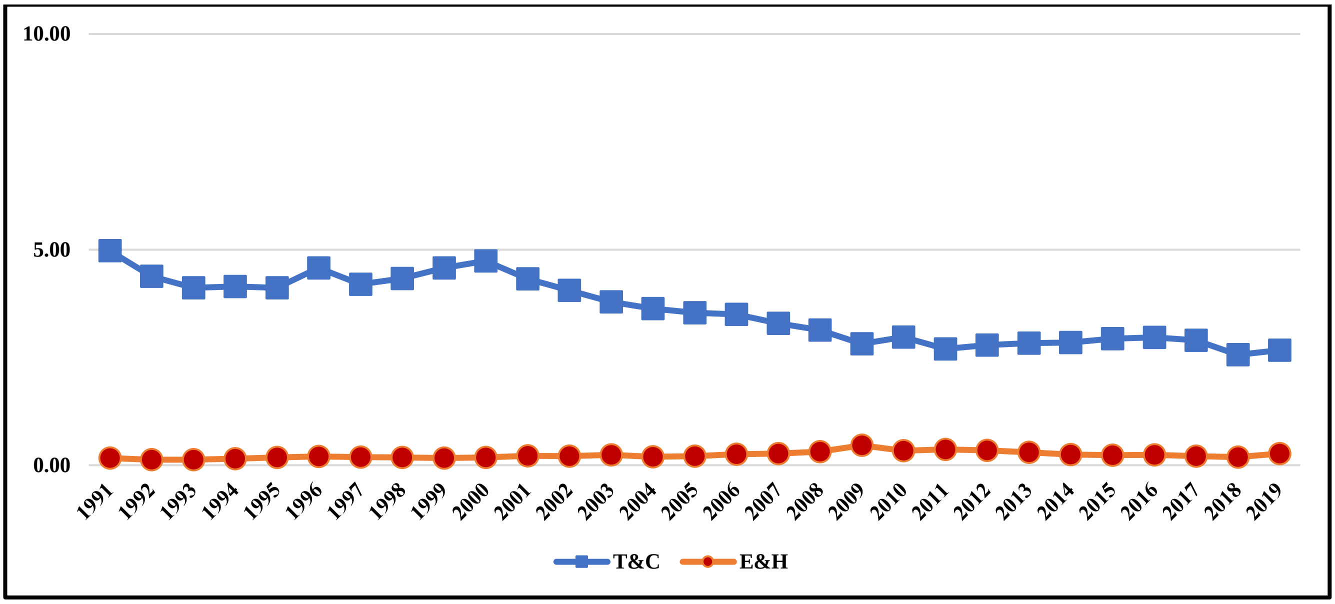


Figure-2 RCA ratio

Source: Authors' calculation using UN-COMTRADE.

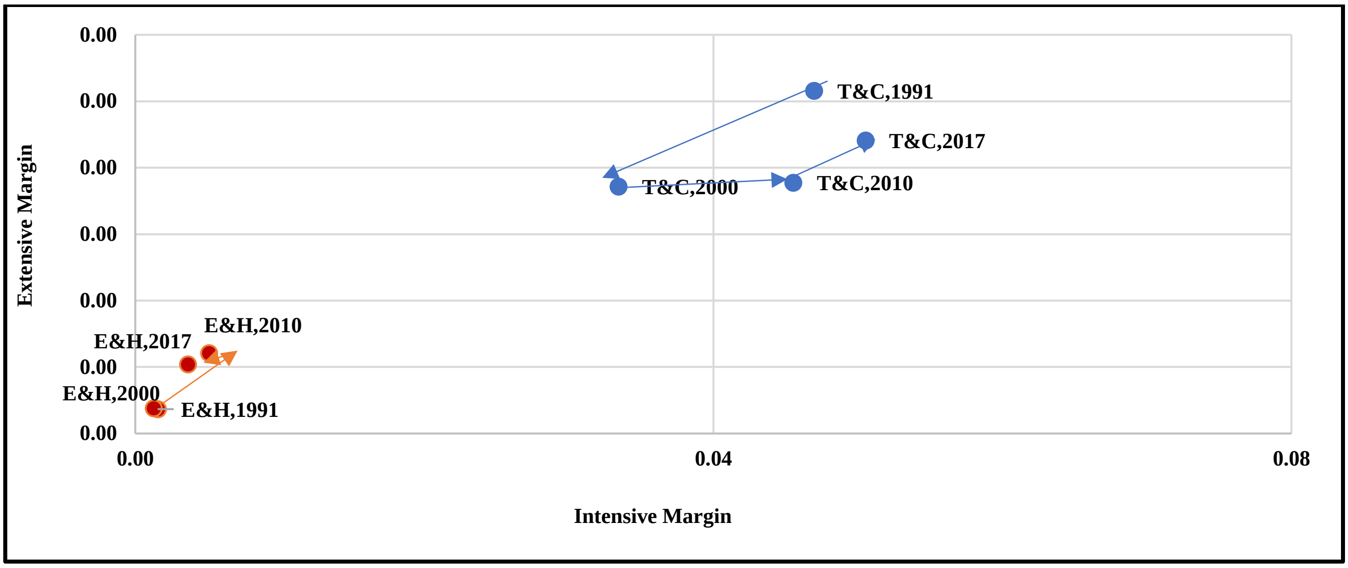


Figure-3 Intensive & Extensive margins

Source- Authors' calculation using WITS UN-COMTRADE.

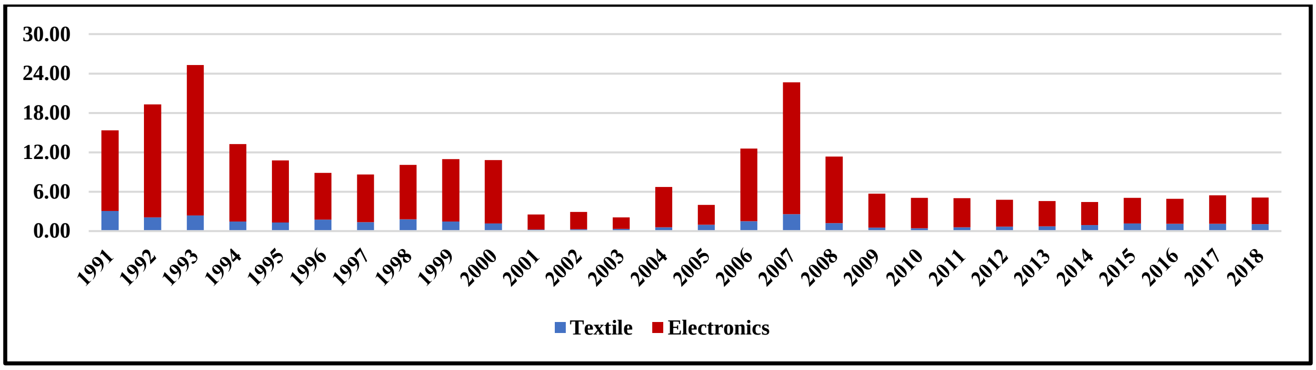


Figure-4 Sector-wise Share of R&D in total manufacturing R&D Expenditure (in %)

Source- Authors' calculations based on CMIE, Prowess Database.

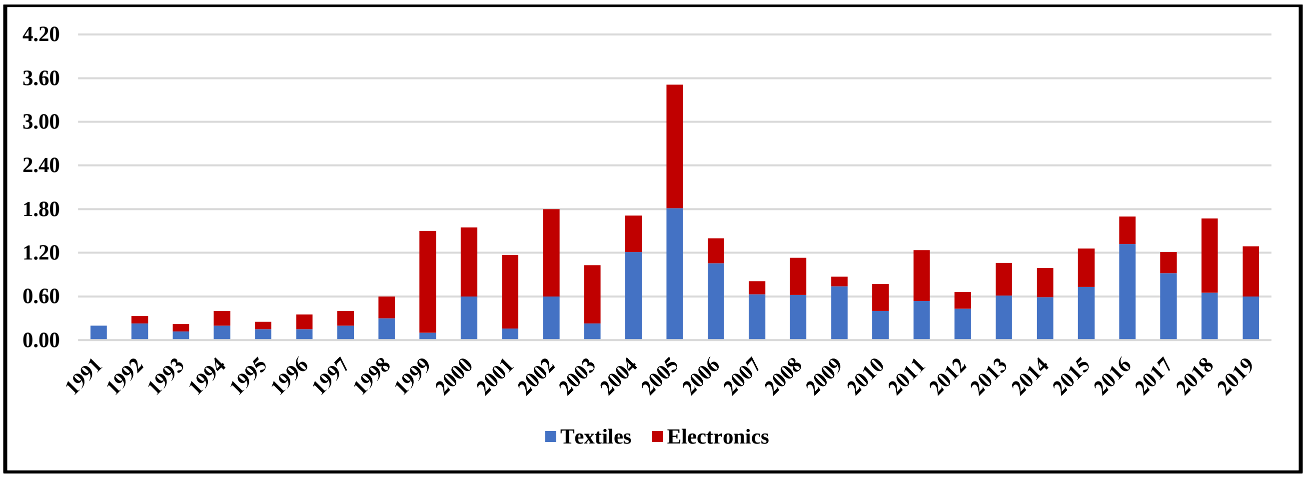


Figure-5 Sector-wise share of FDI in total India's FDI inflows (in %)

Source: Authors' calculation based on FDI Newsletters and Statistics, DPIIT.

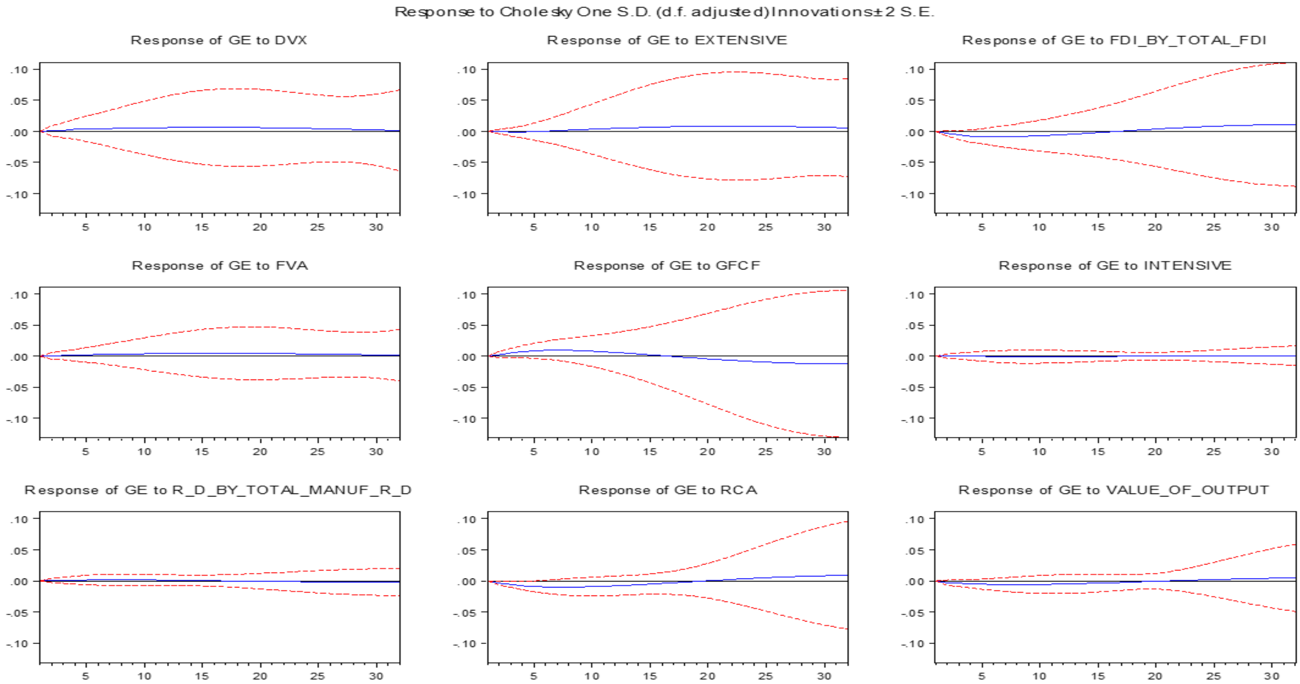


Figure-6 Impulse responses of gross exports (GE) in the long-run

Table-1 Results of the Unit Root Tests**

Variables	Textile and Clothing				Electronics and hardware			
	ADF		PP		ADF		PP	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
DVX (Indirect Value Addition)	0.68	0.04*	0.61	0.04*	0.167	0*	0.175	0*
Extensive (Extensive margin)	0.24	0*	0.24	0*	0.28	0*	0.27	0*
FDI (Foreign Direct Investment)	0.135	0*	0.13	0*	0.089	0*	0.082	0*
FVA (Foreign Value Addition)	0.006*	0*	0.006*	0*	0.063	0*	0.065	0*
GE (Gross Exports)	0.01*	0.01*	0.8	0*	0.36	0*	0.38	0*
GFCF (Gross Fixed Capital Formation)	0.014*	0*	0.014*	0*	0.214	0*	0.269	0*
Intensive (Intensive Margin)	0*	0*	0*	0*	0.596	0*	0.556	0*
R&D (Research & Development Expenditure)	0.169	0*	0.169	0*	0.207	0*	0.18	0*
RCA (Revealed Comparative Advantage)	0.614	0*	0.47	0*	0.719	0*	0.69	0*
Value of output	0.17	0*	0.17	0*	0.0876	0*	0.17	0*

Notes: ** The null hypothesis is that the series is non-stationary, or contains a unit root. The rejection of null hypothesis for both ADF and PP tests are based on the MacKinnon critical values. * Indicates the rejection of the null hypothesis of non-stationary at 5% significance level.

Table-2 Bound-test result

	F-Statistic	t-Statistic	Result
Dependant Variable (Gross Export)			
Textile and Clothing	12.33	-5.54 (significant)	Cointegration
Electronics and Hardware	2.77	0.20 (insignificant)	Inconclusive
Lower bound at 5%	2.14		
Upper Bound at 5%	3.3		

Notes: From Pesaran et al. (2001) and Narayan (2005), the critical values F-statistics are obtained.

Using ARDL approach (unrestricted constant and no trend) the estimated long-run coefficients.

Table-3 Textile and Clothing sector

Variable	Coefficient	t-Statistic	Prob.
DVX	0.012	0.125	0.903
Extmar	111.122	8.101	0.000*
FDI	-1.572	-2.960	0.014**
FVA	-0.255	-1.167	0.270
GFCF	0.192	2.434	0.035**
Intmar	-4.243	-5.439	0.000*
R&D	-0.265	-0.990	0.346
RCA	0.041	4.141	0.002*
Prod	-0.079	-0.178	0.862

Notes: * and ** signify statistically significant at 1% and 5% level respectively.

Using ARDL approach the estimated short-run coefficients.

Table-4 Electronics and Hardware sector

Variable	Coefficient	t-Statistic	Prob.
GE(-1)	1.05	3.95	0.01*
DVX	-0.02	-2.47	0.05**
DVX(-1)	-0.02	-2.59	0.04**
Extmar	50.27	4.89	0.00*
Extmar(-1)	-59.48	-2.66	0.04**
FDI	-0.14	-3.08	0.02**
FDI(-1)	0.14	1.91	0.10
FVA	-0.01	-0.86	0.42
FVA(-1)	0.01	1.31	0.24
Intmar	-5.29	-4.58	0.00*
Intmar(-1)	6.26	2.27	0.05**
GFCF	0.07	2.06	0.08
GFCF(-1)	-0.10	-1.97	0.10
R&D	-0.003	-0.57	0.59
R&D(-1)	-0.004	-0.73	0.49
RCA	0.10	8.40	0.00*
RCA(-1)	-0.11	-3.22	0.02**
Output	0.03	0.41	0.70
Output(-1)	0.18	2.61	0.04**
C	0.00	0.88	0.41

Notes: * and ** signify statistically significant at 1% and 5% level respectively.

Error correction representation: GE as endogenous variable.

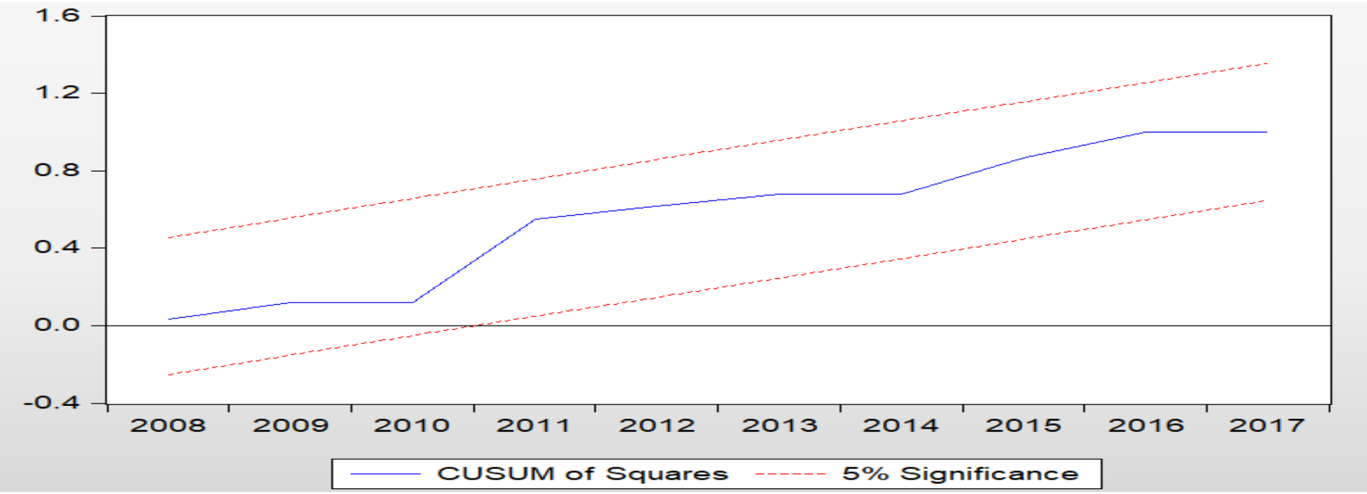
Table-5 Textile and clothing sector model ARDL (1, 0, 0, 1, 0, 1, 0, 1, 1, 1)

Variable	Coefficient	t-Statistic	Prob.
C	0.013	10.661	0.000*
D(FDI)	-0.637	-4.381	0.001*
D(GFCF)	0.048	4.462	0.001*
D(R&D)	-0.377	-3.240	0.009*
D(RCA)	0.039	12.765	0.000*
D(Output)	0.152	1.813	0.100
ECM(-1)*	-0.671	-15.305	0.000*
ECM = GE - 0.0124*DVX - 111.1223*Extmar + 1.5718*FDI + 0.2546*FVA - 0.1924*GFCF + 4.2425*Intmar + 0.2651*R&D - 0.0408*RCA + 0.0785*Output	R-squared=0.962 Adjusted R-squared = 0.95	S.E. of regression=0.003 Durbin-Watson stat = 2.855	F-statistic = 79.45 (000)

Notes: * and ** signify statistically significant at 1% and 5% level respectively.

Table-6 Diagnostic Tests

Tests	F-statistic	Prob
Breusch-Godfrey Serial Correlation LM Test:	2.703	0.127
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.523	0.875



Graph-1 Plot of CUSUMSQ Test for equation

Table-7 Results of short run Granger causality

Variables	GE	Extmar	DVX	FDI	FVA	GFCF	Intmar	R&D	RCA	Output
GE	_	0.65	0.67	0.16	0.87	1.00	0.65	0.73	**0.02**	0.16
Extmar	**0.06**	_	0.20	0.94	**0.02**	**0.06**	**0.04**	0.45	**0.03**	**0.06**
DVX	0.83	0.20	_	0.07	**0.07**	0.78	0.16	0.92	0.77	0.84
FDI	0.40	0.99	**0.02**	_	0.34	0.62	0.89	0.24	0.58	0.26
FVA	0.11	0.47	0.14	0.96	_	0.18	0.54	0.12	0.14	0.18
GFCF	0.13	0.90	**0.04**	0.88	0.22	_	0.22	0.96	0.12	0.28
Intmar	**0.01**	**0.01**	0.14	0.89	**0.01**	0.28	_	0.51	**0.00**	**0.01**
R&D	0.87	0.49	0.12	0.35	0.90	0.12	0.38	_	0.72	0.21
RCA	**0.00**	0.89	**0.05**	0.44	0.54	0.60	0.57	0.81	_	0.18
Output	**0.00**	0.70	**0.01**	0.19	0.63	0.72	0.68	0.67	0.24	_

Notes: (Bold) denote statistical significance at the 5% levels respectively.