

Software and services export, IT investment and GDP nexus in India

Evidence from VECM framework

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Received 5 February 2019
Revised 11 May 2019
Accepted 21 May 2019

Abstract

Purpose – The purpose of this paper is to investigate both long-run and short-run dynamics among the software and services export, investment in information technology (IT) and GDP in India and to investigate the direction of the relationship among the given three macro-economic variables.

Design/methodology/approach – The time series data have been taken to investigate the long-run relationship exists among the variables. Annual data were collected from the NASSCOM Annual Reports, Planning Commission of India and Reserve Bank of India during the period 1980–2016. Cointegration and vector error correction model have been used for analyzing the causal relationship among investment in IT, software exports and GDP in India.

Findings – Cointegration results confirm that software and services export, investment in IT and GDP are cointegrated, implying that there exists the long-run equilibrium relationship among the given three macro-economic variables. Similarly, vector error correction mechanism Granger causality results hold that there is uni-directional long-run causality running from software and services export and investment in IT to GDP, implying that software and services export is an important determinant of economic growth in India.

Research limitations/implications – The limitations of the paper are generalization of the results and proxy variable for IT investments.

Practical implications – The paper has implications for the expansion of market concentration, diversification of software and service exports, and investments in R&D for increasing competitiveness of the industry in the global market.

Originality/value – This paper focuses on originality in the analysis of the relationship among the given variables software exports, investment in the IT sector and GDP in India. All the work has been done in original by the authors and the work used have been acknowledged properly.

Keywords Cointegration analysis, Vector error correction model (VECM), Software and services export, Economic growth

Paper type Research paper

1. Introduction

Information technology (IT) is diffusing rapidly into all sectors of the production and is now seen as one of the most crucial technologies affecting economic growth in developing countries (Bhatnagar, 1992). Software production is nowadays essential for the growth of the economies of developing countries. The launching of programs to promote strong and indigenous software industries is a priority task (Fialkowski, 1990). Software production is also seen as the best entry point for developing countries in the IT production complex. For instance, compared with hardware production, software production has much lower entry barriers, being more labor-intensive and with a lower rate of obsolescence. All of these factors assist developing

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The authors would like to thank two anonymous referees for their invaluable suggestions and comments.



countries, and the software's labor intensity production offers a clear opportunity for them compared with many other production processes. Hence, it is not surprising that in developing countries interest in both the production and the use of the software is becoming more intense and the actual production is also increasing (Schware, 1990).

The computer software and services industry is a key example of knowledge production, as the value of what a software firm produces is almost entirely knowledge embodied in its products and services. It is a fast-growing industry producing high-value services for its customer. Although it is dominated by firms based in major industrialized countries of the world, it continues to offer great prospects for economic growth and industrial development within developing economies. Indeed, the software industry has become a leading source of employment creation and economic growth in the world (Sen, 1995). In addition, the software has become a key in facilitating technology, making it a major strategic technology for growth and development. Software and computer services centrally underpin the actual creation, besides the efficient utilization of core aspects of modern manufacturing and the physical products that are produced (Alic, 1994).

The emergence of the country as a center for outsourcing a highly knowledge-intensive service, such as software is helping to change the public perception about India and is focusing attention on the potential of the country in knowledge-based industries. Perhaps as a development, a significant number of multinational enterprises in other knowledge-based industries have set-up global or regional research and development (R&D) centers in India to benefit from the expertise and software houses available in the country. The software industry's development has also facilitated capital flows to the economy. These include foreign institutional investments in the stocks of software companies in India, foreign direct investment (FDI) by multinational corporations (MNC) and joint ventures in India.

India has now been recognized as the emerging leader of the global IT industry, especially in business processing management (BPM). Over 1.1m employees in BPM offering to outsource in 35 languages to firms in more than 80 countries. BPM exports in FY 2017 has reached around \$26bn. According to NASSCOM India's IT-BPM sector accounted for 56 percent of the world market in 2016. The BPM accounted for total revenue of \$28bn during FY 2016, with a 25 percent share of the total IT[1] exports. Software development and IT-enabled services, software engineering R&D services and product development have emerged as the most dynamic and vibrant sectors in India's economy. It is the single largest contributor to services exports. As per Global Services Location Index (2017), India ranked top and remains the chief destination for off-shore services, BPM and voice services. India's competitiveness and effectiveness are well known by USA and European countries, the major export destinations of India. Policy makers are having a lot of hope on the ability of the IT industry in overcoming the retarded economic growth.

Given the rising importance and unprecedented growth rate of software and services export especially after the period when India adopted full systematic liberalization process in the 1990s, it is important to find out dynamics of software and services export and country's Gross Domestic Product (GDP). The rest of the paper is organized as follows: Section 2 provides a comprehensive summary of existing literature. Evolution and importance of IT industry in the economic development of India are provided in Section 3. Section 4 is devoted to the variable description and estimation of the econometric method. Results are presented in Section 5 and Section 6 concludes the paper.

2. Review of literature

A number of scholars have studied the role of software and services exports and India's overall development particularly after the success of the Indian IT sector in the 1980s. Bhatnagar and Jain (1991) examined India's software export potential by analyzing the structure of the global software market and its implications for the Indian software industry

for the period 1986–1990. All segments of the global software market were taken into account to assess separately their impacts on the Indian software industry. The study found that Indian software exports were confined largely to one segment of coding of a customized application. Growth prospects of different types of companies were quite different for the 500 companies. There were 20 companies which accounted for almost 80 percent of all software exports. Companies with MNCs collaborations had a capital market. The capacity of these companies to attract manpower was high. Majority of the small companies were engaged in “body shopping,” as a result of the American policy of allowing liberal entry of software programmers in order to overcome the shortage of manpower in this area. Lakha (1994) examined the growth of the Indian software sector in terms of the New International Division of Labour (NIDL) during 1984–1987. It confirmed some of the propositions of NIDL theorists by arguing that the strategy of expanding the Indian software industry through exports is promoting its integration into the global division of labor. He found that with the release of the new computer policy, computer production rose by 100 percent in physical terms and 65 percent in monetary value. The international software market and Indian software industry were constrained by the lack of specialization in packaged software. He identified three factors for that: first, its unfamiliarity with the most recent market trends and the environment in the USA and Europe. Second, the difference in computer systems also presented impediments. Finally, severe competition in the software industry with high costs in marketing and promotion made it difficult to compete effectively. He felt that an important measure of expanding technological links between USA and India was the growth in the value of commercial licenses for the export of high-technology goods to India. The varied links between India and USA had served to integrate the Indian software into the NIDL. Based on the Department of Electronics Government of India, data for the period of 1987–1993, Sen (1995) examined the nature of growth in software exports, through the comparison of linear and exponential growth rates. He made comparisons of Section 80-HHC of Income Tax Act, Section 80-HHE to software exporters, Section 10-A and Section 10-B of Income Tax Act, for studying the software exports from India. The time path of software exports in Rupees and US dollar were taken into account to estimate the growth in software exports. He found that linear trend in software growth was more superior to the exponential because production was human capital in nature and the growth does not come only by investing in tools and equipment, as entrepreneurs do in the case of physical products. The extension of tax exemption on export profits through Section 80-HHC to Section 80-HHE led to constant uncertainty regarding the renewal of this section, which in turn affected all software contracts. Using Data Quest data for the period of 1980–1998, Heeks (1998) analyzed the various reasons behind the success of high growth rates in India over the decade 1987–1997, particularly the growth in off-shore working. He also analyzed the Indian software exports by destination, uneven locational divisions, and uneven skill divisions, to study the nature of the Indian software industry. He found that there were huge variations in software exports of the Indian software industry. The trend showed that individuals and firms were attracted more toward off-shore and more highly-skilled work. Large changes in the locational division of labor brought much more jobs into India. The real benefit to the industry came through exports that were carried out on-site, because these exports did not require various costs, like the cost of hardware or software technology by the Indian companies. The exports relied on coding skills, which required the least skill as compared to other stages of software production. He felt India’s abundant labor supply, which requires only contact overseas, got utilized by service exports. Arora and Asundi (1999) explored the quality certification in India, ISO9001 of the International Standards Organization (ISO) in articulating the different ways in which ISO certification can affect firm profits. They used the national association of software service companies (NASSCOM) directory of Indian software companies and primary survey for the period of 1994–1997. They found that the

benefits of ISO certification arose significantly because it allowed firms to signal to potential customers. The ISO certification also enhanced revenue for a given size, suggesting that firms were receiving a higher price per unit of output. Besides, it also increased the quality of output. Carmel (2003) analyzed the success factors of new software exporting nations, including India, using “Oval model” that incorporates factors that lead software industries to export success. She found eight factors that led to the success of new software exporting nations, namely, first, government vision and policies, including funding and tax benefits. Many new software exporting nations succeeded because their government took active steps to encourage the high-tech sector in general or the software industry in particular; second, human capital, including national orientation and traditions, quantity, composition, language skills, and managerial skills; third, quality of life-talented professionals tended to concentrate in desirable locations; fourth, wages – the differences in wage rates were striking and very tempting for managers who were under cost pressures; fifth linkages, which emerged between individuals, work groups, firms, and nations due to geographic, cultural, linguistic or ethnic connections; sixth, technological infrastructure – software firms require abundant, reliable and cheap telephone and broadband data communication connections. In cases where infrastructure was absent on a national basis, “cluster-centered infrastructure” were preferred alternatives for software firms; seventh, capital sources for software firms could be any combination of domestic and foreign; and, eighth, industry characteristics, including clustering effects, the number of firms, their size, the associations which organize the industry’s firms, the industry’s degree of common vision and branding and the standards that the firms aspire. Carmel (2003) studied the role of software export sector of new software exporting nations on the broader national economies. She analyzed the economic and social impacts, like impact on labor, new organizational forms, stimulation of infrastructure and other industries. She felt that the growth of software export industry had directly benefited labor within that sector. Through job creation, wages of the software professionals increased over-time, the owners of software equity increased their wealth and high-tech millionaires were created in many nations. The growth of software export industry had directly or indirectly benefited the organizational forms and structures of the software firms. Over time the software export industry adopted the international business norms, like international quality standards typified by the capability maturity model or international ISO9000. Software exporting industry improved national trade balance and contributed to GDP growth. It also enlarged middle-class people, who were more likely to support democratic and pro-market policies. The growth of the software export industry stimulated other national entities through externalities. Software demand spurred investment in communications infrastructure-related industries, such as IT-enabled services. The demand for software skills spurred investments in higher education and specialized training institutes. Jain and Agrawal (2007) analyzed the status of the ICT industry as well as of ICT education and training (E&T) system. They examined the deficiencies of system like insufficient investment by the concerned stakeholders, shortage of competent core faculty, little collaboration between academics and user-industries, infrequent up-graduation of course-curriculum, focus on mass higher education with less considerations to quality, liberal evaluation of the academic institutions for quality accreditations and lack of initiatives on the part of the Indian corporate and institutional climate dominated by the dependency motive. They used data collected from Data Quest, Economic Survey of India, Statistical Yearbook and Reports of NASSCOM for the period of 1990–2005. They found that government’s strong will to make a huge investment in ICT-based education were prerequisite for ICT-based development in India, as well as for bridging India’s digital divide between rural and urban, and between developed to less developed States. ICT E&T market would grow proportionately, as Indian ICT firms maintain the existing talent on one hand and expand the workforce base on the other, in

order to ensure their operational effectiveness and competitive edge over its rivals. Hutchinson and Ilavarasan (2008) studied the developments in the geographic distribution of India IT and IT-enabled services (IT-ITES) industry, using NASSCOM data for the period 1998–2006. The study examined the economic activity clusters, and why they move from one place to another. They examined the role of sub-national governments and policy options open to them. They found that geographical distribution of the software sector showed the dominance of five clusters, namely, Bangalore, Chennai, Mumbai, Hyderabad and Delhi. Existing clusters were not able to sustain the exploding growth with limited infrastructure, rising labor and land costs. Given negative externalities in establishing industry centers, the firms explored second-tier cities as alternatives. They suggested that the government could play a vital role in creating an environment in boosting clusters by addressing collective action issues and market failures. Martijn (2010) analyzed the characteristics of a successful marketing strategy for Indian software companies for entering the Western–European market, using data from conversations with the Chief Executive Officer, Employees and Partners for the period from September 11, 2007 to August 11, 2010. He found that there were seven characteristics of a successful marketing strategy for Indian software companies to enter the Western–European market. Those seven characteristics were: lower psychological distance, developing relationships, creating knowledge of the market, determining the asset investments and risks, developing and maintaining relationships, using first non-equity modes and reducing the price level. He felt that the importance of the internet in the daily business of Indian software companies and the use of native workers by Indian software companies to contact partners in the Western–European market. Based on primary data collected from e-mails, interviews and schedules for the period 2011–2012, Bhatt and Sarangdevot (2013) examined the impact of ICT and its potential toward the Indian software sector. They also explored the role of information on communication technologies with respect to the information on the company's framed policies and procedures. They found that there was a positive impact of ICT in globalization with Indian IT software companies. They found 87.5 percent of the Indian IT companies had a partnership with the global IT leaders. Indian IT entrepreneurs were successful in providing excellent work culture satisfaction based on their policies and procedures. The share of respondents as a software engineer was the highest in conceptualization and support stages. The share of respondents as a programmer was the highest in coding level, lesser in requirement analysis. The share of team members was the highest and equal in requirements analyses and low-level design share. The share of team leaders was the highest and equal in conceptualization and high-level design. Based on the Annual Reports of NASSCOM, Sundharan and Kumar (2013) examined the structure, growth and performance of Indian IT business processing outsourcing (IT-BPO) industry, besides examining government intervention in the industry and delineating its future sustainability during 2008–2012. They found that production, growth and export of Indian software and ITES, including BPO, rose significantly during the last decade, making her leading exporter of IT-BPO services since the last decade. IT services and BPO contributed significantly to the export basket of the IT-BPO sector, whereas hardware and computer components comprised the main contributor in the domestic market. Both the central and state governments had played a significant role in the steady growth and performance of the IT industry, by formulating vibrant policies. A large number of MNCs opened business tie-ups and subsidiaries in India, due to the investment-friendly environment created by the government. The internal labor markets were highly competitive and the industry was expanding to the second-tier cities in search of cheap labor. However, International competition from countries like Vietnam, China, and Mauritius was likely to aggravate the problem of sustainability for India. Erumban and Das (2015) studied the sources of economic growth since 1980 in India with special focus on the role of ICT. The impact of ICT

on economic growth was analyzed in two ways. First, direct contribution of ICT investment to aggregate and manufacturing growth. Second, indirect impact of ICT on total factor productivity growth in ICT using and ICT producing sectors. They adopted direct aggregation method given by Jorgensen *et al.* for constructing aggregate estimates of productivity growth in three case of three industries, classified as ICT producing, ICT using and non-ICT industries. They found that the role of ICT investments was limited to the service sector and was successful in raising the overall growth in India but it could not spread the ICT spillover effects across the country. Whereas the ICT using and ICT producing industries has played an increasing role in driving the aggregate productivity growth in the Indian economy after the late 1990s.

It has been observed that there are enormous research studies on software and service exports and India's overall growth. Existing studies have mostly used cross-section and firm level data in their analysis. Important studies on role of software and services export on Indian economy are from the authors like Bhatnagar and Jain (1991), Lakha (1994), Sen (1995), Heeks (1998), Chandana and Jayachandran (2001), Carmel (2003), Contractor and Mudambi (2008), Jain and Agrawal (2007), Hutchinson and Ilavarasan (2008), Bhatt and Sarangdevot (2013), Sundharan and Kumar (2013) and Erumban and Das (2015). However, none of the studies have examined both short-run and long-run dynamics of software and services export in India during the period 1980–2016. Therefore, the present paper is an attempt to analyze both short-run and long-run dynamics between software and services export, investment in IT industry and GDP by taking a large span of sample and times series econometrics approach.

3. Evolution and importance of IT industry in the economic development of India

India's technology was started by many notable scientists and scholars from the British period, such as Satyendra Nath Bose, Sir C.V. Raman, J.C. Bose, Homi Bhabha, and S. Ramanujan. The IT started in the 1960s has grown rapidly and is still growing dynamically. IT has emerged as an enabler of sustained growth and national competitiveness, as well as a powerful driver of change and modernization in the Indian economy. Beyond encouraging economic growth, the IT industry is also helping to achieve social sustainability by improving the way the government provides education, health care and services to citizens. The industry is changing the way of people's interaction with one another, creating long-term and largely positive change in a variety of areas (Kumar, 2010).

IT industry in India was first set up by Tata Consultancy Group in 1986. Tata Consultancy Services (TCS), Mumbai, first joined with the US' Borroughs, a mainframe manufacturer, to supply programmers. It was first denied by the India government, as there were no rules and regulations for software at that time. During the time, IT was not an industry for the Government of India to grant any kind of business and for developing the program. In the 1970s, the state government, controlling the country's economy was not willing to promote IT, as the hardware and software rates were very huge to export from other nations. In 1984, the late Prime Minister of India Mr Rajiv Gandhi launched a New Computer Policy, which reduced the price rate of exporting industry resources from foreign nations and opened the gateway to the IT industry (Kumar, 2001).

The Indian IT sector has evolved in three phases: up to 1984, 1984–1990 and post-1990. In the first phase, apart from trying to establish its own technological trajectories, the state had attempted to run the industry, which resulted in the absence of a commercial sector. During this phase, there was not great differentiation between software and hardware. In the second, the national government realized that software was a great opportunity to avail for income generation and technological capability enhancement. In the third phase, the software export industry blossomed, strongly promoted by national and sub-national governments.

Consequently, the export-driven growth model ignored the hardware sector and domestic markets, despite their huge potential. Though the IT sector has been growing in all domains, it is predominantly driven by export-oriented software services. Until then, the Indian economy was typically run under state control and there was less incentive to invest in R&D by the private industry. The science and technology system in the country was mostly driven by the state-run research institutes and laboratories, without any pressure of competing with international standards. A sea change occurred after the liberalization of the economy in the 1990s. Domestic players faced global competition in the home turf from the MNCs, and the need to invest in R&D was tremendous. State-run research institutes and laboratories were asked to generate their share of revenues through commercialization and showcase their capabilities through patents as well (Simon, 2011).

According to NASSCOM, “timely government policies and increased private-public participation have played a key role in creating an extended business environment for the Indian IT sector. The government attention on education has helped in developing the abundant skilled people, from where the industry meets its labor requirements. The government’s proactive approach toward the IT industry was further highlighted in 2008 through actions such as the IT Act amendment, extension of tax incentives by a year, removal of the Special Economic Zones (SEZ) Act anomalies, and the introduction of progressive telecom policies that focus on work from home” (NASSCOM, 2012/2013).

The first Software Export Zone Santacruz Electronics Export Processing Zone (SEEPZ) was created as a major economic zone in India at Mumbai in 1973. The Department of Information Technology (DIT) under the Ministry of Communications and IT totally imparts the IT education, research, development, e-commerce, rules, regulations and systems of internet policies. DIT also undertakes the functions of National Informatics Centre (NIC), Electronics Export and Computer Software Promotion Council, promoting electronics and IT-enabled services, caring and managing IT-related laws, such as promoting IT education, standardizing and certifying IT products and interacting with international IT governing organizations. The Indian Government enterprises in IT are SEZs, Electronics Hardware Technology Parks (EHTPs), Software Technology Parks (STPs) and Export-Oriented Units (EOUs) (Kumar, 2001).

The private business of IT sector exists in the areas of software development; satellite-based communication wireless, IT-enabled education, communications, IT-BPO and IT-enabled services. The topmost Indian IT Companies are TCS Ltd, Wipro and Infosys. The IT hubs are prominently located in six major clusters, namely, Bangalore (Karnataka), Mumbai and Pune (Maharashtra), Chennai (Tamil Nadu), Hyderabad (Andhra Pradesh) and the National Capital Region, which consists of New Delhi (Delhi), Noida (Uttar Pradesh) and Gurgaon (Haryana). Almost 97 percent of the revenues come from these regions in exports. All these regions show a strong presence of MNCs. A comparison of the major IT clusters shows that Bangalore cluster presents a more mature eco-system for the IT industry, as compared to the others. Due to its historical advantages, it has a deep labor market, a healthy mix of large domestic firm’s proximity of reputed research institutes, government research labs, presence of venture capital, multinationals and other supplementary firms. Both central and state governments have been trying to expand the presence of the Indian IT sector beyond the established six clusters. An array of tools was used to stimulate exports, among others the SEZs, EOUs within Export Processing Zones (EPZs), EHTPs and STPs (OECD, 2010).

The success of the IT sector particularly after the 1980s has changed the Indian economy enormously as a source to economic growth, employment, and standard of living of people. It has increased its contribution to GDP from 1.2 percent in financial year (FY) 1998 to 7.7 percent in FY 2017 (Statista, 2017). IT sector continues to be one of the largest private sector employers in the country, directly employing 3.7m professionals in 2017. The indirect

employment created by the sector has reached around 10m in 2017. Software and service exports dominate the industry and were a sole contributor toward the dominant position of India, constitute about 77 percent of the total industry revenue. The country has continuously maintained a leadership position in global sourcing business with compound annual growth rate of 43.6 percent in the FY 2017, accounting for almost 55 percent of the global sourcing market size in the same year as compared to 52 percent in FY 2012. The industry's share in total Indian exports increased from less than 4.0 percent in FY 1998 to about 27 percent in FY 2017. The domestic market also witnessed a year on year growth of 14 percent, taking domestic revenue to 1,560bn Rupees in FY 2017. Its growth in FY 2017 continued to remain at 13 percent (NASSCOM, 2016-17). Further, India enjoys plenty of advantages in the IT sector. It has the world's largest IT firms, comprising more than 5,000 companies with the maturity of more than 25 years. Indian IT companies have set-up more than 1,000 delivery centers in 80 countries and are engaged in providing services with the presence in over 200 cities. According to the Department of Industrial Policy and Promotion, foreign investors are attracted to the Indian IT sector. The cumulative FDI inflows reached around \$30bn in December 2017. Indian top IT sector companies such as TCS, Infosys, Wipro and Mahindra Tech are leveraging their business operations in block-chains, Artificial Intelligence (AI) and R&D. India is 60–70 percent cost-effective in IT and ITES services than any other source countries, and 15–20 percent lower than the next lowest off-shore destinations. The economic transformation led by the industry in diverse economic activities is remarkable. Strong eco-system, a large number of delivery centers, unique selling proposition (USP) in the global outsourcing market, mound in intellectual capital, training and certification are the major attraction of India in IT sector arena (NASSCOM, 2016–17).

4. Data and description of variables

In this study, the time series data have been taken to investigate the long-run and short-run dynamics among the given variables. Annual data have been collected from the NASSCOM Annual Reports, Planning Commission of India and Reserve Bank of India during the period 1980–2016. Cointegration and vector error correction model have been used for analyzing the causal relationship among investment in IT, software exports and GDP in India. Due to non-availability of consistent investment in IT data we have taken investment in Telecommunication sector as a proxy for investment in IT industry, it is because telecommunications infrastructure is a major factor for the growth of IT industry in India (Kumar, 2010). The specification and description of the variable are as follows:

- SE: software and services export from India in billion rupees;
- GDP: gross domestic product in billion rupees; and
- IIT: investment in IT in billion rupees.

5. Econometric procedure

5.1 Unit root tests

The test of the order of integration for each variable has been checked using the Augmented Dickey–Fuller (ADF) method:

$$\Delta Y_t = \alpha + \Phi Y_{t-1} + \sum_{i=0}^m \beta_i \Delta Y_{t-i} + e_t, \quad (1)$$

where ΔY_t is the first difference of Y_t ; ΔY_{t-1} is the first difference of Y_{t-1} and so on; m is the optimum lag length; α , Φ and β are the parameters and e_t is error term. The null hypothesis

tested is that there is the presence of unit root ($H_0: \beta = 0$) against the alternative hypothesis variables are stationary ($H_0: \beta < 0$). Confirmation of stationarity of given variables has also been checked using the Phillips–Perron (PP) test. Phillips and Perron (1988) provided a comprehensive theory of non-stationarity. They provided a modification in the ADF test, introduced t-statistic in the unit root coefficients. The test is non-parametric and corrects statistic for the presence of serial correction and heteroscedasticity in the error term. This renders robustness to the presence of serial correction and heteroscedasticity. Another benefit of this test over the ADF test is that there is no need to specify the number of lags. Both the tests have the same null hypothesis as stated earlier. The functional form of the PP test is given as:

$$Y_t = \alpha + \rho Y_{t-1} + \epsilon_t. \quad (2)$$

5.2 Cointegration tests

Time series analysis is likely to posture some issues since the variables in the analysis are commonly non-stationary and could result in spurious regression (Granger and Newbold, 1974). As time series data possess long-run memory and differencing it can lead to loss of long-run information, which in turn can make the model capable of clarifying short-run effects only. This is mainly because economic theory is typically defined for the levels of variables instead of differences. Therefore, the estimation of relationships among software and service export, IT investment and GDP should be based on econometric methods that take into consideration the non-stationary properties of the variables. The theory of cointegration is competent in handling the issue of non-stationarity of data in a proficient manner. The theory of cointegration states that if two or more variables are non-stationary in nature but their linear combination is stationary then the variables are said to be cointegration. Economically speaking, if the given variables are cointegrated then they have long-run equilibrium relationship among them. These variables may deviate in the short-run due to temporary random shocks, but equilibrium adjustments force these variables back to their equilibrium state in the long-run (Engle and Granger, 1987). Therefore, the utility of the cointegration method is its capability for investigating long-run equilibrium relationships among variables. After determining the order of integration of the given variables as I (1), maximum likelihood method by Johansen and Juselius (1990) are used to investigate the long-run relationship among the given variables. A Vector Autoregressive (VAR) model with p lags can be expressed by the following equation:

$$y_t = \Phi + \sum_{k=1}^m \Pi_k y_{t-k} + \epsilon_t \quad t = 1, 2, 3, \dots, t, \quad (3)$$

where y_t is vector of non-stationary variables of order I (1), ϵ_t is a Gaussian error with zero mean and constant variance, Φ is the vector of constants. Since y_t is assumed to be I (1). Equation (3) could be represented with first difference in a VECM framework as:

$$\Delta y_t = \Phi + \sum_{k=1}^{m-1} \psi_k \Delta y_{t-k} + \Pi y_{t-1} + \epsilon_t, \quad (4)$$

where $\psi_k = I - (\Pi_1 - \Pi_2, \dots, -\Pi_k)$ and $\Pi = I - (\Pi_1, \dots, \Pi_m)$. Since ϵ_t is I (0), the rank (r) of the long-run matrix (Π) reveal number of linear combination of y_t are stationary. For $0 < r < n$, there are r cointegrating vectors, implies that r stationary linear combinations of y_t . The matrix Π can be decomposed into two parts, written as $\Pi = \alpha\beta'$, where α and β' are $n \times r$ matrices, represents the speed of adjustment and matrix of long-run coefficients respectively.

Even though vector of the variables y_t is non-stationary, the cointegrating vector β' has the characteristic that $\beta'y_t$ is stationary. Both trace statistics and maximum eigenvalue tests are used to determine the number of cointegrating vectors. In Johansen's cointegration test, the null hypothesis (H_0) states no cointegrating vectors ($r=0$) against the alternative hypothesis ($H1$) that makes an indication of one or more cointegrating vectors ($r > 1$).

5.3 Vector error correction mechanism (VECM)

After evaluation of cointegration among the variables, the disequilibrium between short-run temporary deviations and long-run adjustment process can be established by the VECM. While cointegration states long-run equilibrium relationship, VECM can be utilized to know the short-run dynamics among variables. Hence, it is evident that in order to estimate a valid relationship among given three macro-economic variables, cointegration method is appropriate. Similarly, to know the link between short-run dynamics and long-run relationship among the given variables, we need to rely on VECM. Keeping these things into consideration the present study has utilized a VECM approach. The analysis is based on the system of equation considering given the macro-economic variables software and services exports, investment in IT and India's GDP, all expressed in log form. The VECM representation of Equation (4) can be expressed as:

$$\Delta LGDP_t = \alpha_0 + Z_1 EC1_{t-1} + \sum_{i=1}^p \alpha_{1i} \Delta LGDP_{t-i} + \sum_{i=1}^p \alpha_{2i} \Delta LSE_{t-i} + \sum_{i=1}^p \alpha_{3i} \Delta LIIT_{t-i} + \varepsilon_{1t}, \quad (5)$$

$$\Delta LSE_t = \beta_0 + Z_2 EC2_{t-1} + \sum_{i=1}^p \beta_{1i} \Delta LSE_{t-i} + \sum_{i=1}^p \beta_{2i} \Delta LGDP_{t-i} + \sum_{i=1}^p \beta_{3i} \Delta LIIT_{t-i} + \varepsilon_{2t}, \quad (6)$$

$$\Delta LIIT = \gamma_0 + Z_3 EC3_{t-1} + \sum_{i=1}^p \gamma_{1i} \Delta LIIT_{t-i} + \sum_{i=1}^p \gamma_{2i} \Delta LGDP_{t-i} + \sum_{i=1}^p \gamma_{3i} \Delta LSE_{t-i} + \varepsilon_{3t}, \quad (7)$$

where Z_1 , Z_2 and Z_3 are the coefficients of error correction terms in the Equations (5)–(7), respectively. These coefficients are expected to capture the long-run causality among the variables LGDP, LSE and LIIT. Moreover, $\Delta LGDP_{t-i}$, ΔLSE_{t-i} and $\Delta LIIT_{t-i}$ are expected to capture the short-run causality among the variables.

6. Empirical results

Before estimation of the econometric model, time series of given variables are plotted and descriptive statistics are estimated (see Appendix). Logarithmic graphs of three series show more stable variance than the change in the level form. The descriptive statistics of the variables shows that each series SE, IIT and GDP are normally distributed during the sample period. This is confirmed by the Jarque–Bera statistics, which does not reject the null hypothesis of normal distribution. The descriptive statistics reveal that the given three variables have some variations and would require identifying their stationarity properties.

Prior to the testing of Cointegration, the test of the order of integration for each variable using ADF and PP tests have been conducted, presented in the Table I. The results show that the null hypothesis that there is the presence of unit root is not rejected at the levels for all variables. However, the null hypothesis is rejected against the alternative hypothesis that there is a presence of unit root when the first difference of the variables was taken. Thus, the first difference of all variables is found to be stationary and hence all the series are

integrated of order one. The tests of unit root support the unit root hypothesis at the 1 percent level of significance for all variables.

Analysis based on VAR is required to deal with optimum lag selection. The lag selection for our analysis is carried out by following lag order selection criteria such as final prediction error criteria, Hannan–Quinn criterion (HQ), Akaike information criterion (AIC) and Schwarz information criterion. The lag order selection results are presented in Table II.

The above table reveals that FPE, LR, HQC, AIC and SIC is recommending optimum lag to be 2, the SIC criteria suggest lag 1 as optimum. Based on the majority of lag selection criteria, we have considered lag 2 for the analysis.

The existence of unit root for all the variables is confirmed, the next step being the Cointegration test. Both trace and eigenvalue tests were conducted to determine the number of cointegrating vectors. The null hypothesis (H_0) tested were the presence of no cointegrating vector against the alternative hypotheses ($H1$) that the presence of cointegrating vector. Results of both tests, presented in the Table III support the existence of one cointegrating equation implying that the three variables GDP, IIT and SE are cointegrated. Thus, the test is indicating that there exists a long-run equilibrium relationship among the variables or all the variables GDP, IIT and SE are moving together in the long-run.

Table I.
Unit root tests

| Variables | ADF levels | ADF first difference | PP levels | PP first difference |
|-----------|------------|----------------------|-----------|---------------------|
| LGDP | -3.939 | -4.213* | -1.270 | -4.215* |
| LSE | -4.960 | -3.131* | -4.960 | -2.976* |
| LIIT | -1.978 | -6.894* | -4.985 | -7.401* |

Note: *Significant at 1 percent level

Table II.
Optimum lag length

| Selection criteria | Lag selection | | |
|--------------------|---------------|--------|--------|
| | 0 | 1 | 2 |
| FPE | 1.13 | 1.40 | 1.20* |
| LR | - | 34.39 | 18.72* |
| HQC | 73.15 | 61.99 | 61.95* |
| AIC | 73.10 | 61.80 | 61.63* |
| SIC | 73.24 | 62.35* | 62.58 |

Note: *Indicates optimal lag order selected by the criteria

Table III.
Johanson multivariate
cointegration tests

| <i>Trace test</i> | | |
|--------------------------------|------------------------|---------------------|
| Null hypothesis | Alternative hypothesis | Trace statistic |
| $r = 0$ | $r > 0$ | (32.984)** |
| $r \leq 1$ | $r > 1$ | (13.815) |
| $r \leq 2$ | $r > 2$ | (1.432) |
| <i>Maximum eigenvalue test</i> | | |
| Null hypothesis | Alternative hypothesis | Max-Eigen statistic |
| $r = 0$ | $r = 1$ | (19.168)** |
| $r = 1$ | $r = 2$ | (12.383) |
| $r = 2$ | $r = 3$ | (1.432) |

Note: **Significant 5 percent level

According to Granger (1969), when time series X Granger-causes time series Y , past values of X can be used to forecast the future values of Y . Having confirmed the existence of long-run association among the variables, the next step is to find the causal relationship among the given variables. The presence of Cointegration allows using the Vector Error Correction Granger Causality, which manifests both short-run as well as long-run causality. Table IV presents the estimated results of VECM results.

It shows the error correction term for the cointegrating equation with LGDP, LIIT and LSE as dependent variables. In the table, the error correction term with LGDP is negative and significant. Therefore, results reveal that software exports and investment in IT does Granger cause GDP in the long-run, implying that software exports are an important determinant of economic growth in India. The long-run coefficient with LSE as the dependent variable is insignificant which suggest that no presence of long-run causality from IIT and LGDP to LSE. The long-run coefficient with LIIT as the dependent variable is also not significant which suggests that no presence of long-run causality from LGDP and LSE to LIIT. Moreover, the χ^2 and probability in brackets for Granger causality tests are presented in Table IV. It has been found that there is no short-run causality among the variables.

The efficiency of the model has been tested for the presence of serial correlation, heteroscedasticity and for the normality of residuals. We have used Breusch–Godfrey serial correlation test to verify the presence of serial correlation. The results are presented in the Table V.

The test shows evidence that there is no serial correlation in the model. The autoregressive conditional heteroscedasticity (ARCH) has been used to test the ARCH effect in the model. The test reveals that there is no presence of ARCH effect in the model. The normality of residuals has been confirmed by the Jarque–Bera statistic. The result holds that residuals are normality distributed.

7. Discussion and conclusion

A government of a nation every time executes its efforts to look and analyze different sectors of the economy that ensure the nation to become more competitive and to achieve sustainability in growth processes of different sectors of an economy. IT sector in India has been one, which continuously is gaining global market concentration amid cost arbitrage. It has made an enormous contribution toward the Indian economy in terms of increments in

| Dependent variable | Δ LGDP | Δ LSE | Δ LIIT | Error correction term |
|--------------------|---------------|---------------|---------------|-----------------------|
| Δ LGDP | – | 4.689 (0.266) | 0.096 (0.095) | –0.408 (0.004) |
| Δ LSE | 6.127 (0.460) | – | 0.846 (0.654) | –0.059 (0.094) |
| Δ LIIT | 0.361 (0.834) | 0.915 (0.632) | – | –0.229 (0.150) |

Note: Figures in the Parenthesis are p -value

Table IV.
VECM granger
causality results

| Dependent variable | LM test | ARCH test | Normality test |
|--------------------|---------------|---------------|----------------|
| Δ LGDP | 3.763 (0.152) | 0.188 (0.910) | 0.051 (0.974) |
| Δ LIIT | 0.723 (0.696) | 0.702 (0.703) | 8.533 (0.140) |
| Δ LSE | 5.576 (0.061) | 5.025 (0.081) | 6.937 (0.311) |

Notes: Estimated values under the column LM test are observed R^2 values and probability χ^2 values are in parenthesis. Estimated values under the column ARCH test are observed R^2 values and probability values are in parenthesis. Estimated values under the column Normality test are Jarque–Bera test and probability values are in parenthesis

Table V.
Residual diagnostic
check

macro-economic indicators, such as national income, the balance of payment and total employment. The success of the IT exports particularly post-globalization has changed the Indian economy enormously as a source of economic growth, total employment and standard of living of people. The transitions in economic activity led by the invention in IT are incredible. The availability of abundant skilled IT professionals, a large number of international standard organization certificate recipient and USPs in outsourcing business are the main strengths of the country (NASSCOM, 2017). The growth of software export industry had directly benefited labor through job creation, wages of the software professionals increased over-time, the owners of software equity increased their wealth and high-tech millionaires were created in many nations. Software exporting industry improved national trade balance and contributed to GDP growth. Software demand spurred investment in communications infrastructure-related industries, such as IT-enabled services. The demand for software skills spurred investments in higher education and specialized training institutes (Carmel, 2003). During 1984–1987, IT sector has grown at an annual compound growth rate of 60 percent. The large benefits came through exports because these exports did not require cost of hardware or software technology by the Indian companies. The exports relied on low-level skills like programming, which required the least skill as compared to other stages of production process. India's abundant labor supply, which requires only contact overseas, got utilized by service exports. The benefits of ISO certification came significantly, as Indian firms were receiving a higher price per unit of output (Chandana and Jayachandran, 2001). Both domestic and multilateral trading in ICT training services are fast. Indian ICT E&T system provided the most viable and preferable option in the matter of ICT E&T for individuals as well as for corporate of the nation (Jain and Agrawal, 2007). The Indian IT-BPO industry as found by Sundharan and Kumar (2013) has heterogeneous character, with a wide array of service lines. It was mainly engaged in IT services, followed by BPO and product development. Although Indian companies accounted for a larger share relative to foreign firms in India, R&D and software products sector was dominated by foreign firms. Production, growth and export of Indian software and ITES, including BPO, rose significantly during the last decade. ITES exports significantly increased total export basket. The IT sector emerged as one of the largest employment generating sectors in the Indian economy. Among the service lines, IT services and software exports remained the largest employment generating segments followed by the BPO segment of the IT sector. Moreover, the role of investments in IT sector was successful in raising the overall growth via its direct impacts on factor productivity and manufacturing growth (Erumban and Das, 2015).

In order to attain sustainable economic growth in the contemporary globalized world, it is necessary to identify and examine export sectors like IT sector, which can contribute toward the total export growth and also help in mitigating trade deficit of the balance of payment of highly trade-dependent Indian economy. This paper investigates both short-run and long-run dynamics between software and services export and economic growth in India. Multivariate cointegration analysis has been used to investigate the long-run relationship among the variables software and services export, investment in IT industry and GDP. Our cointegration tests result indicated that software and services export, investment in IT and GDP are cointegrated, implying that there is the co-movement/cointegrating relationship among the given variables. Similarly, VECM Granger causality results hold that there is uni-directional long-run causality running from software and services export and investment in IT to GDP, implying that software and services exports are an important determinant of economic growth in India. The findings of this study have been endorsed by Lakha (1994), Heeks (1998), Carmel (2003) and Bhatt and Sarangdevot (2013). As India's software industry lacks diversifications in terms of various kinds of software exports and relied highly on software services exports. The findings of the paper recommends the

formulation of suitable policies and strategies by the Government of India for software and services export diversification, expansion market concentration and also investments in the ICT sector for enhancing its competitive position at the global level.

Notes:

- (1) IT, as defined by the IT Association of America (ITAA), “is the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware.” Indian IT sector is categorized into four categories, IT services, which comprises major portion of the Indian IT industry. These services include clients, server and web-based services like banking, financial, retail and distribution, manufacturing and Government; ITES/BPM, which are those services which makes use of information communication technologies while delivering. These include back office services, revenue accounting, data search, market research, HR services, customer interactions, transcription and translations, remote education, network consultancy, data entry and data conversion, animation, gaming, content development and publishing, procurements and logistics, and document management; software sector which comprises of software products and product development services; hardware sector which comprises manufacturing and assembling of computer hardware. Therefore, software and services export used in this paper comprises software product and all above mentioned services. It is the aggregate revenue from exports of software products plus above services. Software exports and software and services export has been used as substitutable.
- (2) Software product and services include all those activities which entails developing or producing softwares. It involves different stages like Analysis and specification of the software requirement, Designing, Coding, Writing, Testing, Delivery and Installation and Maintenance, suggested by Heeks (1998), in his system development lifecycle model.
- (3) NASSCOM is a non-profit organization, is the apex body of Indian software and service companies in the IT sector. It made an enormous contribution in enhancing the business activities of the country’s software companies at international level.
- (4) The hardware segment of IT not has been included in the present paper due to its less impact on IT exports. According to NASSCOM, around 75 percent of IT revenues excluding hardware comes via software and services export.
- (5) ISO is a global standard-setting organization composed of representatives from various national standards organizations.
- (6) Global Services Location Index measures off-shore location attractiveness in 55 nations via three indicators: business environment, people skills, and availability, and financial attractiveness.

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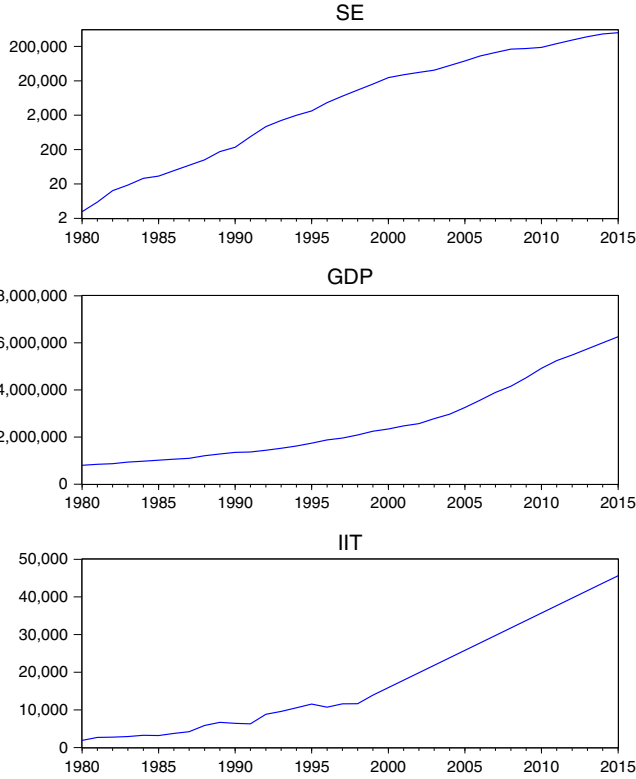


Figure A1.
The graphs of the
variables at level form

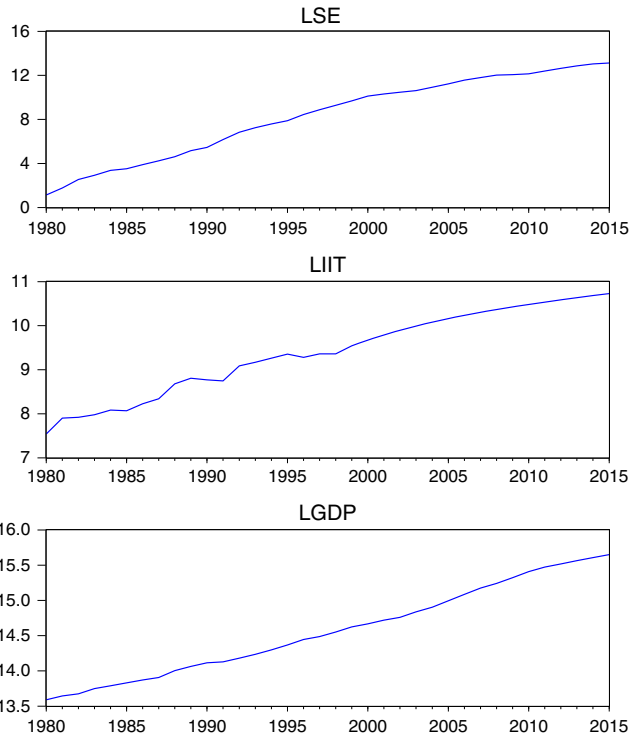


Figure A2.
The graphs of the logarithmic variables

| Descriptive statistics | SE | IIT | GDP |
|------------------------|--------------|-------------|-------------|
| μ | 82,474.89 | 17,517.14 | 2,595,877 |
| M | 8,951.00 | 11,615.50 | 2,022,430 |
| Max. | 501,400.0 | 45,621.00 | 6,261,150 |
| Min. | 3.1200 | 1,883.00 | 798,506.0 |
| σ | 136,677.1 | 13,801.41 | 1,683,011 |
| m_3 | 1.8374 | 0.6382 | 0.846987 |
| m_4 | 5.3655 | 2.0493 | 2.4216 |
| J-B | 28.65 (0.11) | 3.79 (0.14) | 4.80 (0.09) |

Notes: μ , mean; M, median; Max., maximum; Min., minimum; σ , standard deviation; m_3 , Skewness; m_4 , kurtosis; and J-B, Jarque-Bera test for normality; and figures in parenthesis are respective p -value

Table AI.
Descriptive statistics of key variables

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