

An analysis of IT software and service exports from India

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Abstract

Purpose – The aims of the paper are to investigate IT software and service export function for India. First, cointegration tests have been used to investigate the long-run equilibrium relationship of the given variables. Second, long-run coefficients and associated error correction mechanism are estimated.

Design/methodology/approach – Annual time series data on IT software and service exports, human capital, exchange rate, investment in IT, external demand and openness index have been used for the present study during the period 1980–2017. The data are collected from the National Association of Software and Service Companies (NASSCOM), Planning Commission of India, University Grants Commission (UGC) of India, real effective exchange rate (REER) database and World Bank development indicators. Auto regressive distributed lag (ARDL) model is used to analyze both short-run and long-run dynamic behaviour of economic variables with appropriate asymptotic inferences.

Findings – Results of the analysis show the stable long-run equilibrium relationship among the given variables. It is found that external demand, exchange rate, human capital and openness index have a substantial long-run impact on the IT software and service exports. We also found that the coefficient of error correction term is negative and significant at 1% of the level of significance, which confirms the existence of stable long-run relationship which means adjustment will take place when there is a short-run deviation to its long-run equilibrium after a shock.

Research limitations/implications – There may be other determinants of software and service exports apart from those considered by the present study. Due to the non-availability of data, the study considers only important determinants that determine the software and service exports in India. The IT exports are an emerging and dynamic field of economic activity and the rate of change is so rapid that the relevance of individual factors may change over time. The study period is also limited to available data.

Practical implications – The paper has implications for achieving sustainability in IT software and service exports growth. It is recommended that policies directed at improving the performance of IT software and service exports should largely consider the long-run behaviour of these variables.

Originality/value – This paper focuses on originality in the analysis of the relationship among the given variables including IT software and service exports, human capital, exchange rate, investment in IT, external demand and openness index in India. All the work has been done in original by the authors, and the work used has been acknowledged properly.

Keywords IT software and service exports, External demand, Cointegration, ARDL model and error correction mechanism

Paper type Research paper

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1. Introduction

Information technology (IT) has become one of the most crucial ingredients influencing productivity of factors of production. The adoption of IT in economic activities plays a vital role in enhancing the economic development of world economies by its direct or indirect involvement in productive capacities. It is now seen as the strongest industry as compared to other industries throughout the world because of its large economies of scale and insatiable demand from both consumers as well as producers. It has contributed enormously towards economic growth and aggregate employment in both developed as well as developing countries. The beauty of it is that it helps in leverage or growth process of others sectors of the economy as information in general is a significant factor in production processes that strongly stimulate the productivity of factor inputs, particularly of labour. The IT revolution has had an exceptional impact on societies, businesses and nations, by stimulating the growth process in the world economy.

In this regard, India is not an exception. The tremendous success of the IT sector after economic reforms, particularly in software and service exports, has influenced economic growth of the Indian economy. The importance of IT software and services has been increasing since the last decade, as reflected by its mounting shares in various macroeconomic parameters, like national income, total exports, employment and foreign exchange of the country. An abundant supply of labour force acts as a comparative advantage of the Indian software and services industry. Investments in the education industry in the form of Indian Institute of Technologies (IITs), Indian Institute of Management (IIMs) and engineering colleges over the years have significantly contributed to the growth of software and service industry. The country's abundant IT professionals have been absorbed by the software and services export sector, thus enjoying some sort of monopoly in supplying desired labour (Arora and Athreye, 2002). The benefit of the International Standard Organization (ISO) certification is also significant because it acts as a quality signal to potential customers. This certification has enabled to enjoy the firm's enhanced income through higher level of price per unit of output besides increasing the quality of output (Arora and Asundi, 1999). Large changes in the locational division of labour brought more jobs to India. The real benefit to the industry comes through exports carried out on-site, which do not involve costs of hardware or software technology for the Indian firms.

Indian IT industry has recorded exceptional growth rate, particularly after the period of liberalization. It accomplished 51% compound annual growth rate, with it being the only nation to have this rate of growth during the period 1990 to 2002. The domestic software industry growth rate was even higher than that of the global industry (Kumar 2001). However, the IT industry witnessed a falling growth amid a worldwide change in innovation and business models since 2014. Its software and services exports are experiencing a skewed nature of slowdown in growth, essentially due to the reliance on North American and European markets. Furthermore, other developing nations, like China, Malaysia and the Philippines, are also entering into the world software market in meeting the global demands of software and services of the advanced nations by overcoming their earlier hurdles. Now, an important question that arises is how to deal with the global strategic paradigm shifts [1]. Answering this question requires an assessment of the direction and magnitude of the potential factors responsible for software and service exports. This article attempts to investigate the factors that influence software and service exports from India both positively and negatively. Such a study is important to understand in depth the impact of each determinant on software and service export, for formulation of policy measures for sustainability and competitiveness of the Indian IT industry.

The rest of the paper is organized as follows. Section 2 summarizes earlier literature. Section 3 provides a conceptual framework and outlines the data sources and econometric methods adopted. Section 4 provides a pre-estimation analysis of variables and the empirical results of the study. The conclusion and policy implications are given in the final section.

2. Literature review

The relationship between IT export and economic growth is well-studied in the existing literature both for developed as well as developing countries. [Kreamer *et al.* \(2003\)](#) showed a positive relationship between investment in IT and total productivity. [Dewan and Kreamer \(1998\)](#) found that IT investment is significantly positively related to the total productivity for developed countries but not significant for developing nations. In the late 1990s, [Oliner and Sichel \(2000\)](#) found a strong positive association between information communication and technology (ICT) and economic growth. Based on the firm-level panel data for twenty large Indian firms, [Patibandla and Petersen \(2002\)](#) found that the human capital stock in the form of large pool of engineering and computer science professionals generated by the Indian policies led to the entry of MNCs. These companies started availing the opportunity of huge wage differential between developed countries like US and European Union and also India. This process of entering of MNCs created a dynamic cycle of a further generation of human capital. Based on cross-country study, [Pohjola \(2002\)](#) found a significant role played by ICT in economic growth among the developed countries. [Carmel \(2003\)](#) found eight factors, viz., government vision and policies, human capital, quality of life-talented professionals, wages differentials, linkages [2], technological infrastructure [3], capital sources and industry characteristics [4] that led success of new software exporting nations. [Arora and Bagde \(2010\)](#) found a strong impact of human capital on the software exports, which further played a vital role in the growth of the software industry at the regional level. [Khanna and Palepu \(2004\)](#) observed that globalization of labour and product markets created concurrence towards corporate governance. Farok and others (2005) compared the export performance of software industries of Taiwan and India and found that educational background and firm-level characteristics were better in Taiwan, whereas, international experience, technological innovativeness and foreign expertise of employees were better in India as compared to Taiwan. [Kumar and Joseph \(2005\)](#) stated that the export performance software and service industry in India were mainly amid the accumulative efforts made by the national government not only in building the qualified manpower but also in the building institutional infrastructure for capability developed. [Jain and Agrawal \(2007\)](#) felt that the government's efforts in making huge investment in ICT were the prerequisite for ICT development and narrowing the digital divide between developed and less developed states or rural and urban India. [Farok and Mudambi \(2008\)](#) analyzed the impacts of business environment, human capital and infrastructure on the export of commercial goods and services in twenty-five nations, including India. They found significant impacts of human capital, particularly literacy rate, had substantial impact on export of goods and services, which were quite different in developed and the emerging Asian countries. [Ark *et al.* \(2008\)](#) reported that investment in ICT has significantly reduced transaction costs and led to increased productivity of factors of production. [Kumari and Reddy \(2009\)](#) observed that India's tremendous success in the software exports was largely attributable to the industry's knowledge and expertise in the skilled workforce. [Narayanan \(2009\)](#) showed that a large number of Indian IT firms was internationally acclimated, via overseas investments and largely by exports. Firms with huge resources like human capital, R&D and capability of import of technology emerged significant in determining international competitiveness of the IT firms. Studies by [Swapna and Sujatha \(2010\)](#), [Swadesin and Kalindi \(2012\)](#), [Vijayasri \(2012\)](#) and [Erumban and Das \(2015\)](#) found that software industry contributed substantially to the total exports and gross domestic product (GDP) and also emerged as the largest private employer in the country. The exports of the industry maintained significant annual average growth rates, especially after the new economic reforms 1990s. [Sundharan \(2013\)](#) examined the structure and export performance of Indian IT industry. They found that the IT industry in India was heterogeneous in nature, focussing more on group service lines like IT services and BPO. [Sahoo and Nauriyal \(2014\)](#) found that globalization, human resources and external

demand had a strong positive impact on software exports in India. Upadhyay and Roy (2016) examined the effects of GDP and exchange rate on software exports and found no significant impacts. Using firm-level data, Gupta *et al.* (2016) analyzed the determinants of IT exports and found that world income and the exchange rate have significant impacts on IT exports from India.

It has been found that there are large number of studies about the relationships of IT software and service exports and overall growth. However, not many have examined both the short-run and long-run dynamics of IT software exports of India. The existing studies also suffer from other shortcomings, like most of the studies (with exceptions like Sahoo and Nauriyal, 2014; and Tharakan *et al.*, 2005) used cross-section data, which may not significantly explain country-specific issues over time. Again, econometric techniques for analyzing factors responsible for software and service exports from India are lacking. Hence, the present study aims to exploit time series data since the first phase of the systematic globalization process in the 1980s, to analyze long-run relationship among variables and employ auto-regressive distributed lag (ARDL) approach. The present study also attempts to investigate the determinants that impact IT software and services exports of India.

3. Data source and estimation methods

Annual time series data on variables like IT software and service exports, human capital, exchange rate, investment in IT and weighted GDP per capita income level (as per the share of IT exports) of top IT software and service export destinations and openness index have been used for the present study for the period 1980–2017. The data for IT software and service exports are collected from the National Association of Software and Service Companies (NASSCOM). Enrolment of higher education is collected from University Grants Commission (UGC). Telecommunication investments are collected from the planning Commission. Real effective exchange rate (REER) is taken from the Bruegel database on exchange rates. The openness index and GDP per capita are collected from World Bank development indicators. The given variables have been converted into the logarithmic form for the analysis. The interest in annual data is due to the fact that most IT software and services exports are reported annually. Furthermore, the power of time series analysis when the special emphasis is on cointegration lies more on the span of data, rather than the number of data points (Hakkio and Rush, 1991; and Shiller and Perron, 1985).

The study attempts to identify factors responsible for IT software and service exports, which would help in policy formulation for increasing India’s export competitiveness at the global level. Both demand and supply side factors are taken into consideration in the export determination model, like human capital, investment in IT, exchange rate, trade openness and external demand [5].

The estimated software export function is of the form:

$$LITX = \alpha_0 + \alpha_1LHC + \alpha_2LINV + \alpha_3LEXR + \alpha_4LOPI + \alpha_5LEXD + u_t \tag{1}$$

where,

- LITX = log of IT software and service exports from India;
- LHC = log of human capital;
- LINV = log of investment in the IT sector;
- LEXR = log of exchange rate;
- LOPI = log of openness index;

LEXD = log of external demand; and

u_t = error term;

Gross domestic per capita income of the top IT software and service export destinations of India are considered as a proxy for external demand for the empirical analysis. It is taken as the weighted global income (WGI) [6] for India and its stability. Around 93% of IT exports go to United States, Canada and Europe (NASSCOM, 2012). Therefore, it would be logical to anticipate that the income of these nations would affect largely IT software and service exports. It is expected that a given rise in income of these nations would create additional demand for IT software and service exports and vice-versa. This study is an advance over existing in that it allows trimming with respect to external demand for IT software and services exports. One of the serious drawbacks of existing study of Sahoo and Nauriyal (2014) is that it had taken aggregate and evenly weighted global income of the Organization of Economic Co-operation and Development (OECD) countries to measure external demand for exports. Hence, the need is to draw strong and stable inference; the present study does it by analyzing the impact of external demand in terms of WGI.

It is believed by scholars that spectacular growth of the software industry in India was mainly due to the availability of huge skilled workforce. The paper uses enrolment of higher education as a proxy to measure the stock of human capital because education plays an important role in enhancing the quality of human capital. It is expected to exercise a positive impact on IT exports. Engineering and computer application degree holders and IT PG diploma holders would have been better variable for measuring the stock of human capital, which is constrained by the non-availability of consistent data. According to NASSCOM (2012), apart from the mentioned degree holders, IT firms have also been continuously hiring a huge number of simple arts, commerce and management graduates by giving them short period training courses before employing in IT software and service production process. This proxy has also been used by various researchers like Baarao and Lee (1993); and Martin (1992).

Investment in IT sector is expected to impact positively on software and service exports. In order to measure its impact, investment in telecommunication has been used as a proxy variable because telecommunication infrastructure is considered as a crucial factor for the growing IT industry. Advanced telecommunication infrastructure not only mitigates communication gaps between parent companies and their overseas subsidiaries but also furnishes new business opportunities in global markets. This study differs from the existing ones in respect of accounting for investment in IT sector. Earlier studies like that of Kumar (2009) had considered teledensity as a proxy for measuring the impact of telecommunications infrastructure on the IT sector. However, the definition of teledensity [7] does not account for the various forms of Internet services like satellite Internet, broadband, cable Internet, etc., which are vital for IT exports. It is mainly because most of the overseas IT projects in India are delivered via these types of Internet services; investment in telecommunication infrastructure could be a better indicative proxy for investment in IT sector.

In international trade theories, openness of economy is well-emphasized by most economists, including Rodrik (1996) and Montalbano (2011). Openness creates incentives for IT firms to expand and diversify their business operations towards the global market. In the Indian context, both the government and researchers recognize software and services exports as a core segment in enhancing the overall export since the early eighties. Consequently, a number of fiscal incentives, like tax cuts on income from software and service exports, export subsidies and tax-free import of computer hardware used for export purposes, have been introduced by the government of India to boost software exports (Heeks, 1996). The most common measure of openness called openness index [8] has been used to capture the impact

of openness on software and services exports. It is expected to impact positively on software and service exports because the more open a country, the more the trade flows across the global market.

The neo-classical economists were of the opinion that the real effective exchange rate induces trade competitiveness among nations. An appreciation or depreciation in the nation's exchange rate could result in gain or loss of their competitive advantage. Likewise, an appreciation in the exchange rate (i.e. real effective exchange rate) is expected to exert a negative impact on IT software and service exports from India. As exchange rate appreciates, IT exports from India would become relatively expensive in the international market, thus decreasing the volume of exports, which in turn would discourage exports. REER is expected to act as a price for IT software and service export analysis (Sahoo and Nauriyal, 2014).

ARDL model is widely used to investigate both short-run and long-run dynamic behaviour of economic variables with appropriate asymptotic inferences. It is a standard least squares regression, which includes lagged values of the dependent variable and the current and lagged values of other variables as regressors. ARDL F bound test is performed to examine the long-run relationship among the given variables. The interest in the ARDL model is for the following reasons: (1) When compared to traditional alternatives, such as Johanson and Juselius (1990) and Engle and Granger (1987), ARDL model provides a convenient way by utilizing single equation to estimate jointly both long-run and short-run relationship among the variables (Pesaran and Shin, 2001); (2) As the present study uses a small sample size, ARDL becomes more appropriate in this case. According to Haug (2002), both short- and long-term coefficients can be estimated instantaneously with the help of ARDL method that will obtain good results for small sample size; (3) Another advantage of the ARDL model is that it is used in mixed order with the integration of I (0) and I (1); (4) ARDL model uses differing optimal number of lags to capture the data-generating process from general to specific procedure; (5) Error correction mechanism (ECM) can be derived from ARDL without losing long-run information, which amalgamates short-run adjustments with long-run equilibrium (Pesaran and Shin, 1999) and (6) in the case of endogeneity problem among regressors, ARDL bound testing approach provides an unbiased estimate and valid *t*-statistic (Narayan, 2005). However, critical bounds are based on the assumption that none of the variables is I (2), in which case *F*-statistics for cointegration becomes invalid (Pesaran *et al.*, 2001). To check the order of integration of variables, Augmented Dickey–Fuller (ADF) analysis has been conducted. Confirmation of the level of integration of given variables also has been checked by the Phillips–Perron (PP) test. PP test uses non-parametric correction for error term and corrects the presence of serial correction and heteroscedasticity in the error term, which makes robust to the presence of serial correction and heteroscedasticity.

The ARDL representation of hypothesized functional form between the given variables in Eqn (1) may be expressed as:-

$$\begin{aligned} \Delta LITX_t = & \alpha_0 + \sum_{i=1}^p \alpha_{1i} \Delta LITX_{t-i} + \sum_{i=0}^q \alpha_{2i} \Delta LHC_{t-i} + \sum_{i=0}^m \alpha_{3i} \Delta LOPI_{t-i} \\ & + \sum_{i=0}^n \alpha_{4i} \Delta LEXD_{t-i} + \sum_{i=0}^o \alpha_{5i} \Delta LEXR_{t-i} + \sum_{i=0}^r \alpha_{6i} \Delta LINV_{t-i} + \beta_1 LITX_{t-1} \\ & + \beta_2 LHC_{t-1} + \beta_3 LOPI_{t-1} + \beta_4 LEXD_{t-1} + \beta_5 LEXR_{t-1} + \beta_6 LINV_{t-1} + et \end{aligned} \quad (2)$$

In the given equation, *p*, *q*, *m*, *n*, *o* and *r* are the optimum lags of the respective variables. The parameters $\alpha_1, \dots, \alpha_6$ are anticipated to yield the short-run dynamics coefficients. Parameters $\beta_1, \dots, \beta_6$ are expected to capture the long-run dynamics of the underlying ARDL

model. The F test is applied to examine the existence of long-run relationships among the given variables. The null hypothesis in Eqn (2) for no cointegration among the given variables is $H_0: \beta_1 = \dots = \beta_6 = 0$ against the alternative $H_1: \beta_1 = \dots = \beta_6 \neq 0$, tested by computing F -statistic.

The F -statistic has a non-standard distribution that depends on (1) the number of regressors, (2) whether the model contains an intercept and/or trend and (3) whether the ARDL model includes a mixture of $I(0)$ or $I(1)$ variables. Pesaran and others (2001) computed two sets of critical values in the case of a sample size of more than 80 for a given significance level. Narayan (2005) computed two set of critical values in the case of small sample sizes between 30 and 80. In both cases, one set assumes that all the variables are $I(0)$, and another set assumes all variables are $I(1)$. If the computed F -test value exceeds the upper limit of the bound test, then the null hypothesis of no cointegration is rejected. If the computed F -statistic is below the lower bounds value, then it is not rejected. However, if the F -statistic falls into the bounds, then the results become inconclusive.

After confirming the existence of a long-run relationship among the variables, the next step is to conduct error correction mechanism (ECM). General error correction model representation of the given variables may be expressed as follows:-

$$\begin{aligned} \Delta \text{LITX}_t = & \alpha_0 + \sum_{i=1}^p \alpha_{1i} \Delta \text{LITX}_{t-i} + \sum_{i=0}^q \alpha_{2i} \Delta \text{LHC}_{t-i} + \sum_{i=0}^m \alpha_{3i} \Delta \text{LOPI}_{t-i} \\ & + \sum_{i=0}^n \alpha_{4i} \Delta \text{LEXD}_{t-i} + \sum_{i=0}^o \alpha_{5i} \Delta \text{LEXR}_{t-i} + \sum_{i=0}^r \alpha_{6i} \Delta \text{LINV}_{t-i} \\ & + \alpha_7 \text{ECT}_{t-1} + et \end{aligned} \quad (3)$$

where ECT_{t-1} points out the deviation independent variables during the short span of time to the long-run equilibrium path. It represents the residuals that are obtained from the estimated long-run cointegration equation model. The coefficient α_7 is the speed of the adjustment parameter. It shows the speed at which equilibrium among the variables is restored. It is expected to have a significant negative value.

The adequacy of specification of the present research model has been confirmed using diagnostic tests, such as Ramsey's RESET test for functional form, Langrange Multiplier (LM) serial correlation test, Engle's ARCH LM heteroskedasticity test and Jarque-Bera normality test. The stability of the short-run and long-run coefficients has been confirmed by applying the tests of the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) propounded by Brown *et al.* (1975).

4. Empirical results and discussions

4.1 Pre-estimation examination

Before estimation of the econometric model, time series of all given variables are plotted, and their descriptive statistics were estimated (see Appendix 1). The graphs of logarithmic series show more stable variance. It also shows little evidence of the presence of structural breaks among all the variables.

The descriptive statistics of the variables show that each series ITX, HC, OPI, INV, EXR and EXD are normally distributed during the sample period. This is affirmed by the Jarque-Bera test, which does not reject the null hypothesis of normal distribution at 1% level of significance. The absence of outliers, especially IT software and service exports, indicates that IT software and service export function for India can be modelled without having extremely large or small values that deviate from the historical IT software and service exports. The descriptive statistics show some variations in the

4.2 Results of stationary tests

Both ADF and PP unit root test results for the IT software and service exports, human capital, exchange rate, investment in IT, external demand and openness index are presented in Table. 1

The results of both ADF and PP tests show that the null hypothesis of the unit roots is not rejected for all the given variables at significancelevels. However, it is rejected against the alternative hypothesis that there is the presence of unit root when the variables are converted into the first difference. Thus, the first difference of the given variables is found to be stationary. The tests of stationarity support the unit root hypothesis at one percent level of significance for all variables. In other words, the unit root test of each variable tends to clear rejection of the hypothesis that given variables are integrated of order two, which is important for the genuine application of the ARDL model.

4.3 Engel and Granger residual based cointegration test

Two most famous cointegration tests in time series modeling are the cointegration tests of Johansen and Juselius (1990) and Engel and Granger (1987). The test of Engel and Granger is applicable in the case of single equation models, while Johansen’s cointegration test is applicable in the case of system equation models. The ARDL model is based on single equation modeling (Pesaran *et al.*, 2001). To investigate the long-term relationship among the variables of interest and to make results more robust, the DL cointegration procedure developed by Pesaran *et al.* (2001) has been used. Residual-based cointegration test of Engel and Granger has also been used because all the variables are integrated in the same order. Therefore, two-step procedure of Engel and Granger has also been used to test cointegration among the given variables. The test result is presented in Table 2.

The result shows that there is cointegration between IT software and service (LITX), human capital (LHC), exchange rate (LEXR), investment in IT proxied by investment in telecommunication (LINV), external demand proxied by real per capita GDP of top IT

Variables	Intercept		Trend and intercept	
	ADF	PP	ADF	PP
<i>Level</i>				
LITX	-2.65 (-3.63)	-1.53 (-3.63)	-0.18 (-4.25)	-0.13 (-4.25)
LHC	2.90 (-3.63)	3.11 (-3.63)	-0.87 (-4.25)	1.65 (-4.25)
LINV	-1.23 (-3.63)	-2.04 (-3.63)	-1.43 (-4.25)	-2.56 (-4.25)
LEXR	-1.91 (-3.63)	-1.58 (-3.63)	-0.83 (-4.25)	-0.36 (-4.25)
LOPI	0.02 (-3.63)	-0.07 (-3.63)	-2.97 (-4.25)	-2.09 (-4.25)
LEXD	-1.54 (-3.63)	-1.59 (-3.63)	-1.51 (-4.25)	-0.95 (-4.25)
<i>First difference</i>				
LITX	-2.86*** (-2.61)	-2.85*** (-2.62)	-4.33* (-4.25)	-4.28* (-4.25)
LHC	-9.82* (-2.95)	-2.60* (-2.95)	-10.04* (-3.55)	-3.88* (-3.54)
LINV	-6.82* (-2.95)	-6.88* (-2.95)	-4.41 (-3.56)	-6.75* (-3.54)
LEXR	-3.01** (-2.95)	-3.04* (-2.95)	-3.71** (-3.54)	-3.70** (-3.54)
LOPI	-4.80* (-2.95)	-5.01* (-2.95)	-4.69* (-3.55)	-4.92* (-3.54)
LEXD	-3.88* (-3.63)	-3.88* (-3.63)	-4.10** (3.54)	-4.11** (-3.54)

Table 1.

Unit root tests

Note(s): *, ** and *** indicates rejection of the null hypothesis of unit roots at 1%, 5% and 10% levels of significance levels respectively; and figures in brackets show respective critical value

software and service export nations of India and trade openness (LOPI). Since the ADF statistic of the residual is higher than 5% critical value, the residual series is found to be stationary. Thus, the time series are cointegrated, indicating that there exists a long-run stable relationship among the variables used in this study. This also means that any deviation in their relationships in the short run could return to equilibrium in the long run.

In the first stage procedure of the ARDL model, the order of lags for Eqn (1) with constant and no trend and with constant and trend has been obtained. Based on automatic lag selection criteria in E-views – 9, ARDL (1, 2, 2, 0, 2,0) with constant and no trend, which includes one lag for LITX, two lags for LEXD, two lags for LEXR, zero lag for LHC, two lags for LINV and zero lag for LOPI have been estimated (see Figure A4 in Appendix 1). Optimal lag length when constant and trend were added in the model has been estimated (2,0,2,0,2,2), which includes two lags for LITX, zero lag for LEXD, two lags for LEXR, zero lag for LHC, two lags for LINV and two lags for LOPI (see Figure A5 in Appendix 1).

4.4 Cointegration bound test

In order to confirm the long-run relationship between the variables of interest for the two models, F -statistic of bound testing has been used and compared with Pesaran *et al.*'s (2001) and Narayan's (2005) critical values. Given the limited number of observations amid the use of annual data, AIC criteria have been used for optimal lag selection with a maximum order of lags two. The results are presented in Table 4. It presents F -Statistics and critical values of the ARDL (1, 2, 2, 0, 2, 0) estimated with constant and no trend; and ARDL (2, 0, 2, 0, 2, 2) estimated with constant and trend. (see Table 3)

The results show that when tested for joint significance of lagged level variables of the model – 1 with intercept and no trend, the calculated F -statistics is 7.28, which exceeds the upper bound critical value at all levels of significance, indicating strong evidence of long-run relationship among the given variables. The estimated F -statistics for model – 2 with intercept and trend for five regressors is 8.05, which is greater than the upper bounds critical value at all levels of significance. Thus, the null hypothesis of no cointegration among the variables cannot be accepted in both models, indicating that there is a cointegrating relationship between software and service exports and its key determinants, *namely*, human capital, exchange rate, investment in IT, external demand and openness index.

At the second stage, the long-run and associated ECM have been estimated. Akaike information criteria method has been used to select the optimal lag lengths. The reason for using AIC criteria is that its estimated standard errors are much smaller and also gives a much higher order ARDL. After estimating the long-run relationship under F -statistics, the ARDL procedure is applied to estimate the long-run coefficients. In estimating the long-run relationship for the specified model, a maximum of two lags has been used, and the model is selected based on AIC along with trend and intercept. However, the trend was found to be insignificant and was dropped, and the model was re-estimated. Its results are shown in Table 4.

Series	ADF statistic	5 percent critical value	Order of integration	Result
Residual	–5.10	–4.98	I(0)	Cointegrated

Note(s): ADF value is compared with 5 percent critical value taken from Davidson and Mackinnon (1993) table

Table 2.
Engel–Granger
cointegration test

4.5 ARDL estimates

Table 4 presents the long-run coefficients of ARDL (1, 2, 2, 0, 2, 0) model.

The estimated results of the long-run model show that the coefficients of human capital, exchange rate and external demand satisfy the expected signs and have significant long-run impact on IT software and service exports at all levels of significance. External demand has the largest significant impact (13.65 percent) on IT software and service exports during the study period, followed by the exchange rate (5.44) and human capital (4.40) respectively. The external demand (as measured by GDP per capita of top IT export countries of India) has a direct positive impact on software exports from India in the long run. The estimated coefficient is positive (13.65) and statistically significant, which implies that 1 % change in the level of income of these countries would lead to 13.65 percent change in IT exports from India. This result is logical because India has the world's largest IT sector, comprising 5,000 companies with an experience of 25 years. Indian IT firms have set up around 600 delivery centres in 75 countries and are captivating in providing services with presence in over 200

ARDL (1, 2, 2, 0, 2, 0)

Critical value (Narayan, 2005)	Lower bounds (I0)	Upper bounds (I1)
1%	4.849	6.511
5%	3.353	4.500
10%	2.831	3.879
Critical value (Pesaran et al., 2001)	Lower bounds (I0)	Upper bounds (I1)
1%	2.49	3.38
5%	2.81	3.76
10%	3.50	4.63
Calculated <i>F</i> -Statistics = 7.28, <i>k</i> = 5		

ARDL (2,0,2,0,2,2)

Critical value (Narayan, 2005)	Lower bounds (I0)	Upper bounds (I1)
1%	3.41	4.68
5%	2.62	3.79
10%	2.26	3.35
Critical value (Pesaran et al., 2001)	Lower bounds (I0)	Upper bounds (I1)
1%	3.06	4.15
5%	2.39	3.38
10%	2.08	3

Calculated *F*-Statistics = 8.05, *k* = 5

Table 3.

Cointegration bound testing

Note(s): Critical values are taken from Pesaran (2001) and Narayan's (2005) table: unrestricted intercept and no trend. *K* is the number of regressors

ARDL (1, 2, 2, 0, 2, 0) dependent variable: LITX
Independent variables

	Coefficients	S.E.	<i>p</i> -values
LEXD	13.6586*	3.6142	0.0010
LEXR	-5.4404*	1.4242	0.0010
LHC	4.4010*	1.4393	0.0060
LINV	4.4773	2.0850	0.4436
LOPI	2.2027**	0.9290	0.0274
Constant	-142.34*	13.8166	0.0105

Table 4.

Estimated long run coefficients

Note(s): *, ** and *** indicate 1, 5 and 10 percent levels of significance respectively; and parentheses show *t*-values

cities (NASSCOM, 2015). Strong ecosystem, a large number of delivery centres, training and certification are the major attractions of Indian IT sector. It is 60% to 70% cost-effective than any other source countries and 15% to 20% lower in cost than the other off-shore destinations. Software and service exports dominate the industry, constituting around 77% of the total revenue. It has maintained a leadership position in global sourcing, accounting for almost 55% of the global outsourcing market size in 2017 (NASSCOM, 2017).

REER also has a strong influence on IT software and service exports from India. Appreciation in REER has exercised a negative and significant impact on the IT software and service exports. The estimated coefficient is -4.55 and significant, which implies 1% change in REER leads to 4.55% negative change in IT software and service exports. This result is also endorsed by the findings of Sahoo and Nauriyal (2014).

Similarly, human capital has a substantial impact on IT software and service exports from India. The estimated coefficient is 4.4 and significant at 1% level of significance, which implies that 1% change in human capital leads to 4.40 percent change in IT software and service exports. This finding is also logical because an unlimited supply of skilled labour force acts as a comparative advantage for Indian software and service industry. Investment in education in the form of IITs, IIMs and engineering colleges has been enormously contributing towards the growth of software and service industry. Besides, the cost-incentiveness attracts the advanced countries like the United States to hire skilled labour suitable for IT services from India. They find it profitable to hire cheap labour at relatively much lower salaries. IT companies from the United ST states are quite aware of the skills of Indian IT professionals. The cost of providing Indian IT services is approximately 3–4 times lesser than in the United States, where in the larger IT companies 30% of the employees are from India. Furthermore, many works from the United States companies have been outsourced to the Indian software development companies (Arora and Athreye, 2002).

Openness, measured as total trade as a percentage of GDP does have a substantial effect on IT software and service exports. The estimated coefficient is 2.20 and statistically significant, which implies that 1% change in openness index leads to 2.20% change in software exports. This finding is consistent with the findings of Heeks (1996) and Kumar (2009). After the economic reforms, Indian software and service exports spread to other countries like Canada and Europe, apart from the United States (the top software export destination of India) whose share has come down during the late twenties (NASSCOM, 2012). Furthermore, a substantial rise in demand for IT services throughout the world caused the Indian exporters to expand businesses across the globe. Also, with the adoption of Liberalization Privatization and Globalization (LPG) policy, multinational companies set up research centers and subsidiaries in India to facilitate outsourcing, especially in programming and engineering activities. India is also ranked top and remains the chief destination for off-shore services, business processing management (BPM) and voice services (Kearney's Global Services Location Index, 2017). Openness has also facilitated the importation of advanced technology like high-speed computers in India, which helped in maintaining the price competitiveness in IT software and service exports. All these combined developments had a positive bearing on IT software and service exports from India.

Advanced telecommunication infrastructure is considered an important determinant of the IT industry growth. It facilitates speedy business transactions among the countries. But in the Indian case, the estimated investment coefficient though positive has not a significant effect on IT software and service exports at any levels of significance.

Table 5 presents the short-run dynamic coefficients associated with long-run relationships between software and service exports and the included explanatory variables.

The coefficient of error correction term (Ect-1) is negative and significant at 1% level of significance, which implies that deviations from long-term growth in IT exports are corrected by it. It also strongly supports convergence results obtained by F -test at the first stage of the

ITPD
4,1

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ARDL (1, 2, 2, 0, 2, 0) Dependent variable: d(LITX)				
Independent variables		Coefficients	S.E.	p-values
d(LEXD)		4.7321**	1.8611	0.0189
d(LEXD(−1))		−3.0380***	1.6961	0.0877
d(LEXR)		−1.5059*	0.4691	0.0042
d(LEXR(−1))		−1.0863**	0.4485	0.0246
d(LHC)		1.1990*	0.3416	0.0021
d(LINV)		−0.3274	0.3221	0.3211
d(LINV(−1))		0.6045**	0.2778	0.0411
D(LOPI)		0.6001*	0.0859	0.0046
Ect-1		−0.2726*	0.0859	0.0046

Table 5.
 Estimated short-run coefficients

Note(s): *, ** and *** indicate 1, 5 and 10 percent level of significance respectively; and parentheses show t-values

ARDL procedure (Banerjee *et al.*, 1998). In other words, the Ect-1 term confirms the existence of a stable long-run relationship, which means adjustment will take place when there is a short-run deviation to its long-run equilibrium after a shock. The error correction term of −0.27 implies that 27 percent of disequilibrium from the previous year’s shocks converges back to the long-run equilibrium in the current year. It also means that if for example, IT exports from India exceeds its long-run relationship with other variables, then human capital, openness index, external demand and the exchange rate would adjust downwards at an annual rate of 27 percent.

After confirming the existence of a long-run relationship among the lags of IT software exports, human capital, investment in IT sector, exchange rate, openness index and external demand, diagnostic tests have been performed to confirm that all the assumptions of the specified model are met. These include Lagrange multiplier test of residual serial correlation, Jarque–Bera normality test based on the skewness and kurtosis measures of the residuals, Breusch–Godfrey heteroscedasticity test and Ramsey’s RESET test. The reported diagnostic tests in the Table A1 show that apart from the high significance levels of the variables and existence of the long-run relationship, the model is statistically well-behaved. Diagnostic tests, such as Breusch–Godfrey, or Lagrange multiplier test of residual serial correlation have been applied. The results showed no evidence of autocorrelation in the disturbance term. The Engle’s ARCH LM test of heteroskedasticity suggests that the errors are homoscedastic and independent of the regressors. The Jarque–Bera statistic confirms the normality of residuals. The Ramsey’s RESET test of functional form suggests that the model is well-specified. This means that the model is valid and can be used for the formulation of policy strategies.

4.6 Stability test

Model instability could result from inaccurate modeling of the short-run dynamics characterizing divergence from long-run relationship. Hence, it is important to consider the short-run dynamics for consistency of long-run parameters. In view of this, the CUSUM-of-squares (CUSUM-SQ) test, developed by Brown *et al.* (1975) has been applied. If the plot of CUSUM-SQ statistic rests under the 5.0 percent significance level, then the given estimated coefficients are said to be reliable. A graphical presentation of the test is provided in Figure A3. Within the lower and upper bounds at 5% level of significance, the null hypothesis of all coefficients in the given model is stable and cannot be rejected. This clearly indicates that ARDL IT software and service export function are stable, and ITX can be used as a target variable.

5. Conclusion

The formulation and implementation of policies related to Indian IT industry require the valid information on the factors that are responsible for the growth of the IT sector, especially like the IT exports, which dominates in industry revenues. Many studies have empirically analyzed the determinants of IT software and service exports, due to their importance in policy formulation. But most studies have used firm-level data for analysis. In this paper, the researcher uses annual time series data to investigate both the short-run and long-run dynamics of IT software and service exports, in the context of IT exports, human capital, exchange rate, investment in IT, external demand and openness index. The study aimed to investigate the long-term equilibrium relationship among the variables and to make the results more robust. As all the included variables are integrated in the same order, both Engel and Granger residual-based cointegration test and bound-based cointegration test have been used. The direction and magnitude of long-run coefficients and associated error correction mechanism were estimated using ARDL procedure. The study found strong evidence of a stable long-run relationship among the selected variables. The empirical results of the long-run model showed that the estimated coefficients of human capital, exchange rate and external demand had the expected signs and significant long-run impacts on IT exports at all levels of significance. External demand had the largest significant impact on IT software and service exports during the study period, followed by exchange rate and human capital respectively. This is attributable to India being the world's largest IT sector, comprising a large number of companies (more than 5,000), with a maturity of more than 25 years. Indian IT companies have a large number delivery centres (600) in 75 countries and provide services in several cities, besides possessing strong ecosystem, training and certification, which form the major attraction of India in the IT sector arena. Furthermore, India has maintained a leadership position in global sourcing, accounting for more than half of the global sourcing market size in 2017 (NASSCOM, 2017). REER strongly influenced IT software and service exports. Appreciation in REER exercised negative and significant impact on IT software and service exports, which endorses the findings of Sahoo and Nauriyal (2014). Human capital also substantially and significantly impacted IT software and service exports due to the unlimited supply of skilled labour force and a comparative cost-effectiveness advantage of the Indian IT industry. The openness of the economy had a substantial significant effect on IT software and service exports, especially after the adoption of economic reforms policy. This result was consistent with the findings of Heeks (1996) and Kumar (2009). The country's software and service exports have spread to other countries, like Canada and Europe, apart from the United States, whose share is coming down over the late twenties (NASSCOM, 2015). Furthermore, India also ranked top in 2017 and remained the chief destination for off-shore services, BPM and voice services (Kearney's Global Services Location Index, 2017). The error correction term confirmed the existence of stable long-run relationship, indicating that when there is a short-run deviation adjustment would take place to its long-run equilibrium after the shock. The error correction term coefficient implied that disequilibrium from the previous year's shocks converged back to long-run equilibrium in the current year. In sum, the study found that the main determining variables of IT exports growth in India were external demand, human capital, exchange rate and openness index. To achieve sustainability of the IT exports growth, it is recommended that government policies should be directed at enhancing the performance of IT exports, considering the long-run behavior of these determinants.

Notes

- (1) Information technology (IT), as defined by the Information Technology Association of America (ITAA), "is the study, design, development, implementation, support or

management of computer-based information systems, particularly software applications and computer hardware”.

- (2) Indian IT sector is classified into four major categories as follows: (1) IT services, which comprises a 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; (2) ITES/BPM, which are those services which make 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; (3) software sector, which comprises software products and product development services and (4) hardware sector which comprises manufacturing and assembling of computer hardware.
- (3) Therefore, IT software and service, IT-ITES and IT-BPM exports have been used interchangeably in this paper.
- (4) The paper does not include a hardware segment of IT due to its meagre impact on IT exports. As per NASSCOM, around 75 percent of the IT-BPM sector revenues (excluding hardware) depend on exports.
- (5) NASSCOM, a non-profit organization, is the apex body of software and service companies in the IT-BPM sector in India. It has made significant contributions to India's national income, total exports, total employment, infrastructure and global visibility.
- (6) Kearney's Global Services Location Index analyses and measures attractiveness as an off-shore location in 55 nations with respect to three major indicators, namely, business environment, people skills and availability and financial attractiveness.
- (7) There are different measures for openness as follows: openness index is the ratio of exports plus imports over GDP; bilateral payments arrangements is a measure of openness and measures of trade barriers that includes import tariff, export tariff and indices of non-tariff barriers (for details see [Yanikkaya, 2003](#)).
- (8) REER measures the development of the real value of a nation's currency with respect to the basket of currencies of the trading partners of the nation. It is frequently used in both theoretical as well as empirical research and policy analysis. Apart from obtaining the equilibrium value of a currency, it also assesses the change in price or cost competitiveness.
- (9) Bruegel is the European think tank that specializes in economics. Bruegel database publishes REER for 178 countries.
- (10) Time series analysis requires to check the properties of the time series variables. ADF test has been used to confirm the order of integration for each variable. The functional form of the ADF may be expressed as follows:-

$$\Delta Y_t = \alpha + \Phi Y_{t-1} + \sum_{i=1}^m \beta_i \Delta Y_{t-i} + \epsilon t$$

$H_0 : \beta_i = 0$ (i.e., time series has unit root)

$H_1 : \beta_i \neq 0$ (i.e., time series has not unit root)

Confirmation of stationarity of given series has also been checked using PP test. PP test is non-parametric and corrects statistics for the presence of serial correlation and heteroscedasticity in the error term. This renders robustness to the presence of serial correlation and heteroscedasticity. The test also has another advantage over the ADF test. For it, there is no need to specify the number of lags. The functional form of the test is given as follows:

$$Y_t = \alpha + \rho Y_{t-1} + \epsilon_t$$

Notes

1. Paradigm shift in production process over time occurs when new technology radically alters the ways of production processes.
2. Which emerged between individuals, work groups, firms and nations due to geographic, cultural, linguistic or ethnic connections.
3. Software firms require reliable telephone and broadband data communication connections especially for foreign software and services projects.
4. Including clustering effects, number of firms, size of the firms and the associations which organize the industry's firms.
5. However, there are other factors like trade restrictions, trade agreements, competitiveness of rival nations, economic and political stability of trade partners, etc., that could affect IT exports but are not included in the model due to their complications of data constraints.
6. $WGI = \sum_{i=1}^n wx_i$, where wx_i is weighted income of software and service export countries, and n is the number of countries.
7. Teledensity is defined as the number of telephone lines for every hundred people in a country or it is the measurement of the total number of telephones in a country available for per hundred population.
8. Index of Openness is defined as the ratio of total imports and exports to the GDP of an economy.

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Appendix 1

A.1.

IT software
and service
exports from
India

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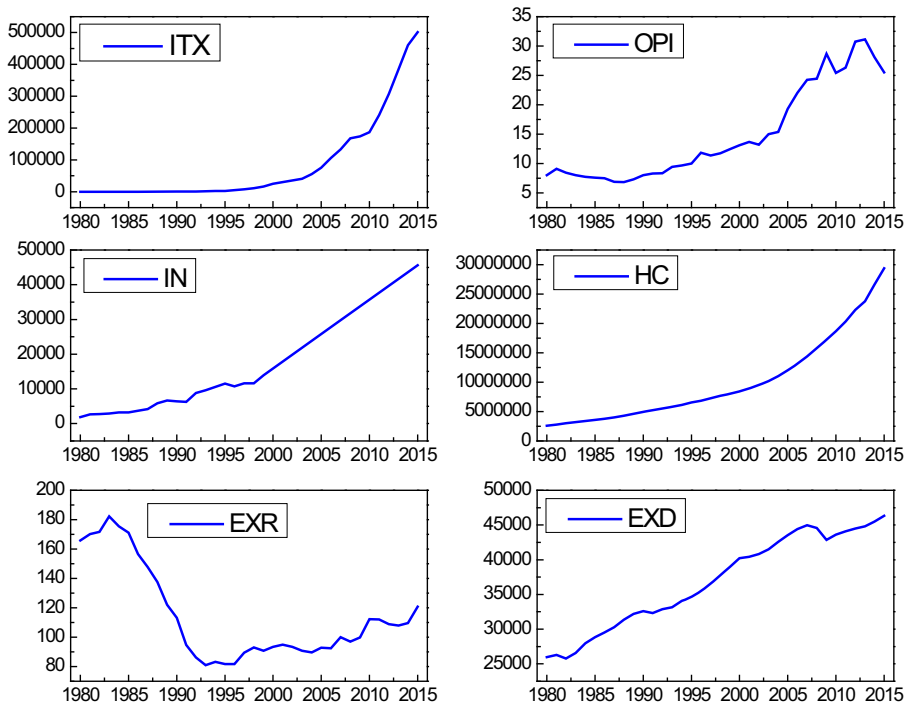


Figure A1.
Shows the multiple
graphs of the variables
at the level form

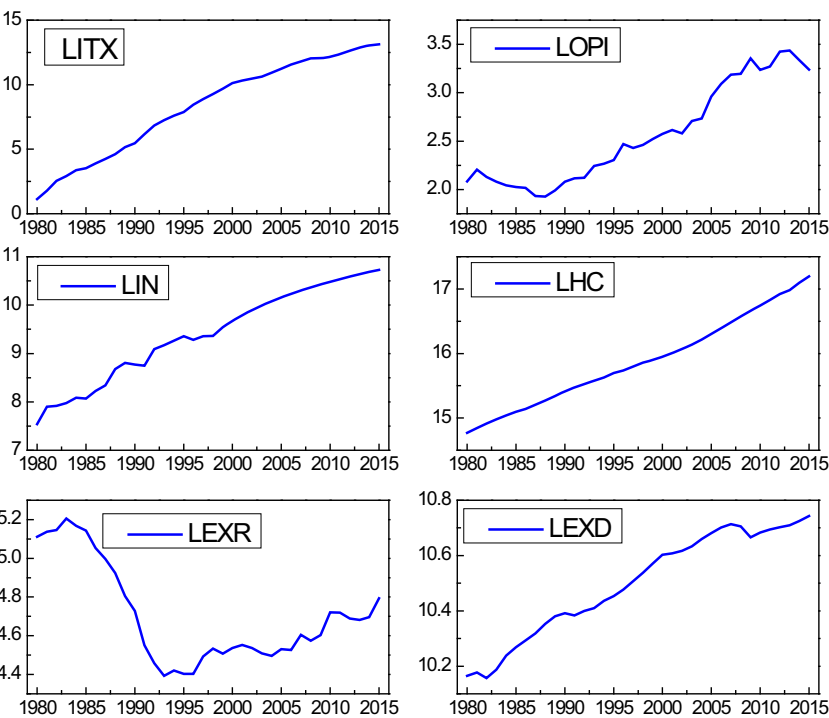


Figure A2.
Shows the multiple
graphs of the
logarithmic variables

A.2. Descriptive statistics and results of diagnostic tests

Descriptive statistics	ITX	HC	OPI	INV	EXR	EXD
μ	8.277	15.882	2.567	9.390	4.704	10.498
M	9.078	15.827	2.465	9.360	4.604	10.523
Max.	13.125	17.196	3.437	10.728	5.205	10.743
Min.	1.137	14.771	1.925	7.540	4.393	10.156
σ	3.713	0.697	0.510	0.956	0.256	0.189
m_3	-0.379	0.228	0.434	-0.278	0.745	-0.372
m_4	1.796	1.974	1.704	1.852	2.186	1.803
J-B	3.033 (0.21)	1.891 (0.38)	3.643 (0.16)	2.437 (0.30)	4.323 (0.12)	2.980 (0.22)

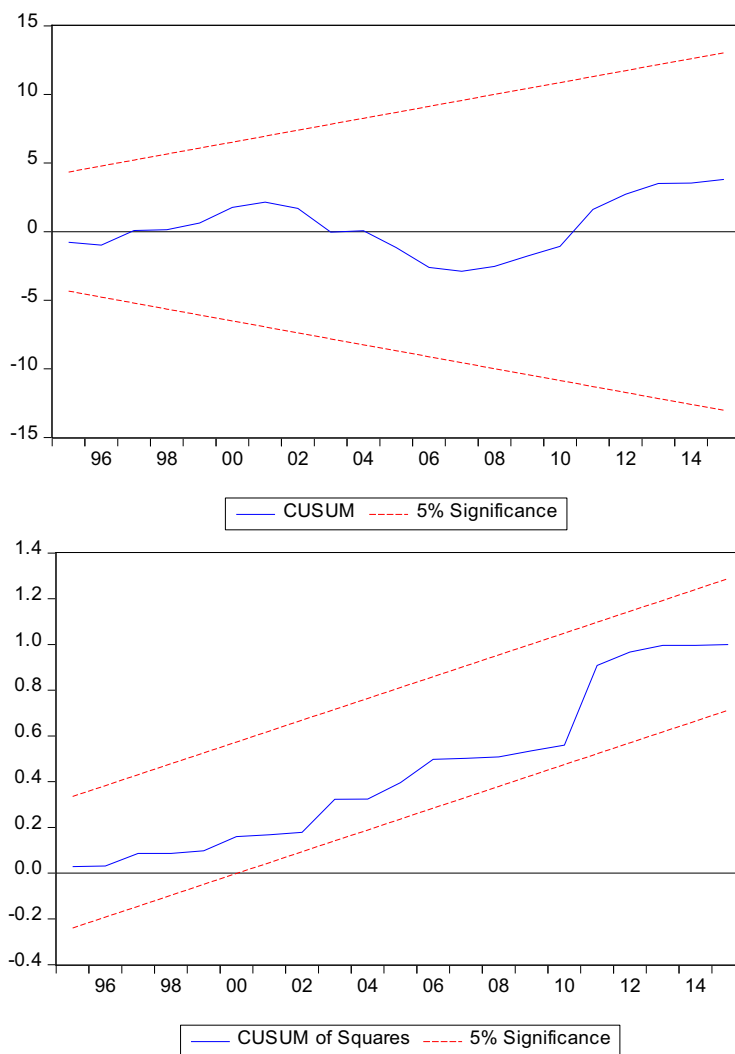
Table A1.
Descriptive statistics of
key variables

Note(s): 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 respectively; and figures in parenthesis are respective p -value

Table A2.
Results of diagnostic
tests of the ARDL
models

Model	Diagnostic test	LM version	F version
ARDL (1,2,2,0,2,0)	Jarque Bera test	$\chi^2 = 1.581 (0.46)$	–
	Lagrange Multiplier (LM) test	$\chi^2 = 1.129 (0.56)$	$F(2,19) = 0.326 (0.75)$
	Breusch–Godfrey test	$\chi^2 = 16.33 (0.17)$	$F(12,21) = 1.619 (0.16)$
	Ramsey’s test	$\chi^2 = 1.228 (0.24)$	$F(1,20) = 1.510 (0.23)$
	Note(s): Value in parenthesis are probability values		

A.3. Stability Test

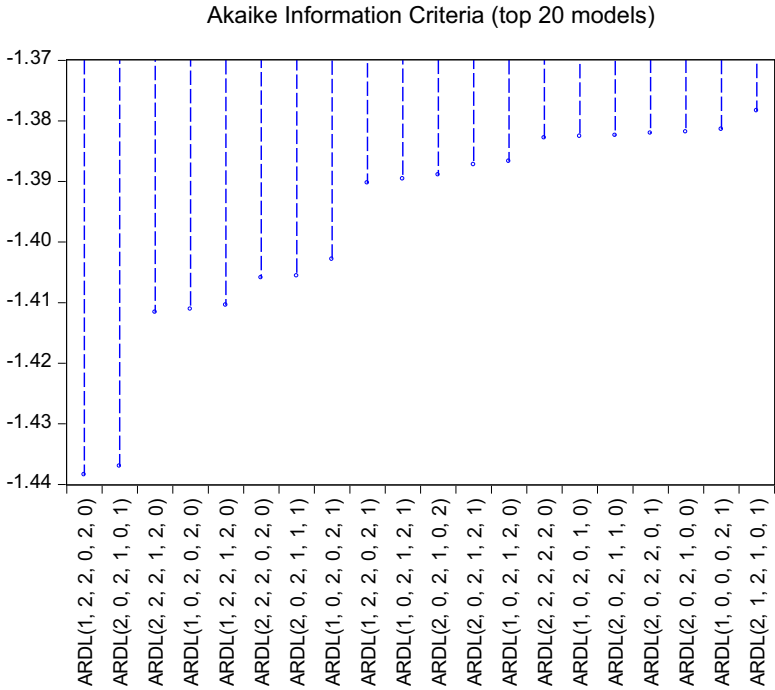


Note(s): The straight lines represent critical bounds at 5 percent significance level

Figure A3.
Plots of cumsum and
cumsumq statistics for
model-1

Figure A4.
Akaike information
criteria's

A.4. Optimal Lag Length



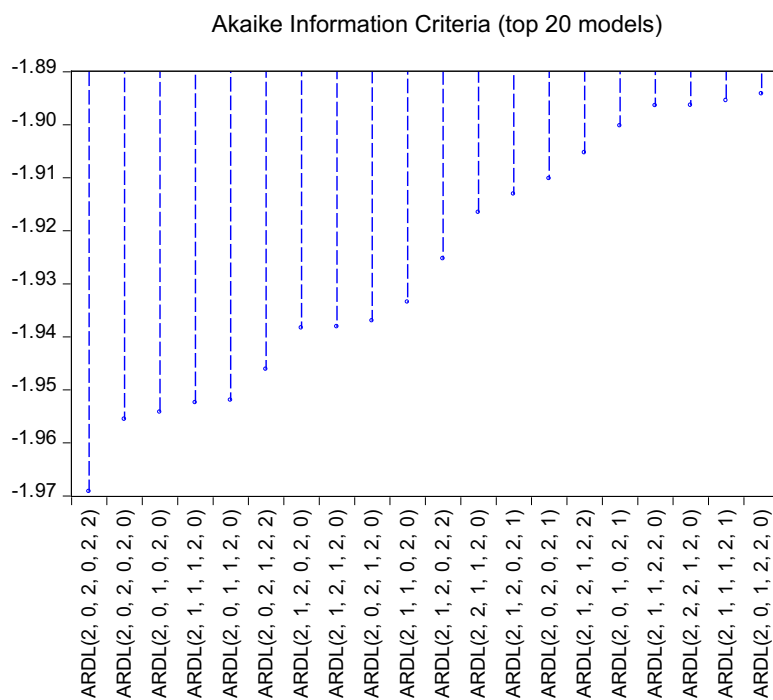


Figure A5.
Akaike information
criteria's

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