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Role of Foreign Direct Investment in the Growth of Indian Telecom Sector: An Econometric Analysis

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Abstract

The Government of India has undertaken various policy initiatives for the growth of telecom sector in the country such as regulatory liberalisation, structural reforms and gradually raising the Foreign Direct Investment (FDI) limit to 100%. Due to these policies adopted by India since 1991, the Indian telecom sector has made tremendous progress and FDI has been one of the main drivers of the continuous growth in the sector. FDI is a good policy instrument in the hands of governments of developing countries to remove the financial constraints and improve the supply of telecom services in their countries. The present study has examined the role of FDI in the growth of the Indian telecom sector in terms of telecom sector revenue, internet access and subscriber base over the period 1991–2018, by applying the cointegration technique-Auto-Regressive Distributed Lag approach and Toda-Yamamoto method of Granger Non-causality test. The empirical findings reveal that FDI inflows do not impact the telecom sector revenue, internet access and subscriber base in the country both in the short-run and in the long-run, thereby, playing a submissive role in the growth of the sector. However, while making investment in the Indian telecom sector, the foreign investors take into consideration the telecom sector revenue and internet access available in the country because growth in revenue generates more profits for foreign firms and an expansion in internet access facilitates them to do business in a host country.

Keywords: Privatisation, Foreign Direct Investment, Indian Telecom Sector Growth, Auto-Regressive Distributed Lag Model, Toda-Yamamoto Model

JEL Classification: F21, F23, L51, L52, L96

Introduction

Over the past 30 years, the Indian telecom industry has experienced remarkable expansion, primarily attributed to the government's implementation of various policy initiatives and the commendable efforts of industry players. Key factors contributing to this growth include regulatory liberalisation, structural reforms and increased competition, all of which have facilitated the industry's transition from a state-owned monopoly to a competitive regime. This transformation has had significant implications for the sector's productivity and efficiency.

Foreign Direct Investment (FDI) has emerged as a key driver of the Indian telecom sector's continuous growth. Since the adoption of liberalisation policies in the 1990s, the sector has attracted substantial FDI inflows, resulting in increased competition, higher telecom penetration rates and significant reductions in tariffs. Recognizing the potential benefits, the Government of India raised the FDI limit from 74 to 100% in 2013, aiming to further boost the growth of the country's telecom sector by removing restrictions on FDI inflows.

Review of Literature

Several studies in the literature have found that FDI has a significant positive association with the growth of the telecom sector. Ros (1999) found that both privatisation and competition in 110 countries over the period 1986–1995 lead to an increase in the efficiency of the telecommunication sector measured in terms of mainlines per employee. Fink et al. (2001) supports the positive contribution of liberal policy to the performance

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of telecommunication services in developing Asian countries. Wallsten (2001) finds that privatisation helps in improving telecom performance only if it is combined with effective and independent regulations. Contessi (2003) points that the share of foreign ownership in the incumbent telecom companies of Transition and Less Developed Countries has a positive impact on various telecom indicators like tele-density, the number of fixed lines installed the growth rate of tele-density, tele-density/staff ratio and the number of cellular subscriptions per 100 persons. Lydon and Williams (2005) reveal that growth in mobile penetration is a positive outcome of FDI inflows in developing countries. According to Sinha's study in 2008, the investment from foreign sources in India's telecom services has yielded various advantages, including enhanced market access, technology transfer, improved voice and data quality and the development of organisational skills. The inflow of FDI in the telecommunications sector not only delivers essential resources but also contributes to the growth of other productive sectors, ultimately boosting investment and enhancing the competitiveness of the economy. Lin (2008) observes that many developing countries are now open to foreign investment and allow liberal FDI in the telecommunication sector that brings new and improved telecom products at lower prices. This provides a wide choice of service providers to the consumers and brings innovation and developmental funds to telecom industries. Izuchukwu (2010) uses ordinary least squares method to ascertain the relationship between FDI and telecommunication growth in Nigeria during 2001–2008 by taking four proxy variables for telecom sector growth viz. the number of subscribers, private investment, Gross Domestic Product and value of technology and finds that except for Gross Domestic Product, all other proxy variables of telecom growth in Nigeria exhibit a significant positive relationship with FDI. Acharya and Patel (2012) note that FDI in India's telecommunication sector brings forth numerous advantages, including technology transfer, market expansion, improved voice and data quality, organisational skill development, and the availability of telecom services at subsidised rates, among others. According to Shrivastava et al. (2016), huge FDI inflows brought a boom in the Indian telecom sector in respect of increased competition, lower prices and better quality of services especially in case of cellular services. However, the empirical findings of Parvez and Chary (2017) highlight that the impact of FDI on the growth of subscribers in India is insignificant and FDI are playing a submissive role in the Indian telecom sector.

Objective of the Study

This study aims to provide a comprehensive understanding of foreign investment in the Indian telecom industry by empirically analysing the extent to which the introduction of FDI has contributed to the growth of the sector. The analysis focuses on key indicators such as sectoral revenue, internet access and subscriber base to assess the impact of FDI on the Indian telecom industry.

Research Methodology

Data Sources

The present study is based on annual time series data for the period 1991–2018. The data regarding the total revenue of the Indian telecom sector, total internet subscribers and total telecom subscribers have been obtained from the various issues of the Telecom Regulatory Authority of India (TRAI) and the Department of Telecommunications (DoT), Ministry of Communications & Information Technology, Government of India. Data for FDI equity inflows in the Indian telecom sector are taken from the Department of Industrial Policy and Promotion (DIPP), Ministry of Commerce and Industry, Government of India.

Methodology

In this study, the Auto-Regressive Distributed Lag (ARDL) approach developed by Pesaran and Pesaran (1997) is employed to investigate the impact of FDI inflows on the growth of the telecom sector. The analysis is conducted using EViews software version 9. The ARDL model offers several advantages, including the ability to estimate both long-run and short-run parameters simultaneously. It also accommodates variables with different orders of integration. Additionally, the ARDL framework is particularly suitable for analysing small sample sizes, which is relevant for this study.

Before applying the ARDL methodology, the Augmented Dickey-Fuller (ADF) test is employed to test for unit roots in the series. To determine the presence of a long-run relationship between the variables, the study employs the Bounds test based on F-statistics proposed by Pesaran (2001). This test provides two sets of critical values: the upper bound critical values for I(1) series and the lower bound critical values for I(0) series. By comparing the calculated F-statistic with these critical values, conclusive inferences can be drawn. If the F-statistic exceeds the upper critical bound, the null hypothesis of no cointegration is rejected, indicating the presence of a long-run relationship. Conversely, if the F-statistic falls below the lower critical bound; the null hypothesis is accepted, suggesting no cointegration. If the F-statistic falls between the upper and lower bounds, no conclusive inference can be made.

To assess the goodness of fit of the ARDL model, residual diagnostic tests are conducted. These tests examine serial correlation, functional form, normality and heteroscedasticity associated with the model, providing insights into the adequacy and reliability of the model.

Model Specifications and Hypothesis of the Study

Model 1

The following model has been developed to investigate the relationship between total revenue and FDI inflows in the Indian telecom sector:

$$TR = f\,(FDI) \tag{1}$$

where FDI = Foreign Direct Investment in the Indian telecom sector. (Unit: USD in millions);

TR = Total Revenue of Indian telecom sector (total revenue comprises the revenue generated by the telecom services sector, encompassing revenue from access providers and long-distance service providers, excluding small standalone ISPs and VSAT, etc.). (Unit: Rs. in Crores).

To get the estimators, equation (1) is represented in the following logarithmic form:

$$\ln(TR)_t = \alpha_1 + \beta_1 \ln(FDI)_t + \varepsilon_t \tag{2}$$

In the above equation, α_1 is the intercept term, β_1 is the regression coefficient and ε_t denotes a white noise error term with zero mean and constant variance.

For model 1, the null hypothesis of no cointegration (β_1= 0) is tested against the alternative hypothesis ($\beta_1 \neq 0$).

Model 2

$$TIS = f\,(FDI) \tag{3}$$

where FDI = Foreign Direct Investment in the Indian telecom sector. (Unit: USD in millions);

TIS = Total Internet Subscribers in India, encompassing both narrowband and broadband subscribers. (Unit: in millions).

The logarithmic form of equation (3) is given as below:

$$\ln(TIS)_t = \alpha_2 + \gamma_1 \ln(FDI)_t + \varepsilon_t \tag{4}$$

In equation (4), α_2 is the intercept term, γ_1 is the regression coefficient and ε_t is a white noise error term.

In this model, the null hypothesis of no cointegration (γ_1=0) is tested against the alternative hypothesis ($\gamma_1 \neq 0$).

Model 3

$$TTS = f\,(FDI) \tag{5}$$

where FDI = Foreign Direct Investment in the Indian telecom sector. (Unit: USD in million);

TTS = Total Telecom Subscribers in India, comprising both wireline and wireless subscribers. (Unit: in millions).

The logarithmic form of equation (5) is represented as follows:

$$\ln(TTS)_t = \alpha_3 + \boldsymbol{\theta}_1 \ln(FDI)_t + \varepsilon_t \tag{6}$$

In this case, α_3 is the intercept term, $\boldsymbol{\theta}_1$ is the regression coefficient and ε_t is a white noise error term.

The null hypothesis of no long-run relationship between TTS and FDI ($\boldsymbol{\theta}_1$= 0) is tested against the alternative hypothesis of a long-run relationship between TTS and FDI ($\boldsymbol{\theta}_1 \neq 0$).

Data Analysis, Empirical Estimations, Results and Discussion

Testing Unit Roots

In the present study, the ADF test under Schwarz Info Criterion (SIC) is used to test unit root in the series and the results are reported in the following table:

Table 1: Unit Root Table: ADF (Schwarz Info Criterion)

Sr. No	*Variables*	*At Level*				*At First Difference*				*At Second Difference*		*Order of Integration*
		Intercept		*Trend and Intercept*		*Intercept*		*Trend and Intercept*		*Intercept*		
		ADF-Statistics	*P-Value*	*ADF-Statistics*	*P-Value*	*ADF-Statistics*	*P-Value*	*ADF-Statistics*	*P-Value*	*ADF-Statistics*	*P-Value*	
1	Foreign Direct Investment (FDI)	-2.238877	0.1981	-2.468107	0.3397	-4.402821	0.0019***					I(1)
2	Total Revenue (TR)	-1.471732	0.5323	-1.21313	0.8874	-4.326999	0.0023***					I(1)
3	Total Internet Sub-scribers (TIS)	-0.588300	0.8575	-1.705325	0.7209	-4.153992	0.0035***					I(1)
4	Total Telecom Sub-scribers (TTS)	-1.709632	0.4149	-1.762941	0.6932	-1.260257	0.6321	-1.50593	0.8013	-4.254224	0.0029***	I(2)

Note: *** represents significance at 1% level of significance.

Table 1 exhibits that:

- The data for FDI, TR and TIS are stationary at the first order of difference, that is, at I(1) order of integration using intercept and the p-values in these cases, are significant even at 1% level of significance.
- The data for TTS is stationary at the second-order of difference, that is, I(2) using intercept. Since the order of integration for TTS is I(2), so ARDL co-integration technique cannot be used in Model 3 which is based on the condition that the order of integration of the variables must be either I(0) or I(1).

Auto-Regressive Distributed Lag (ARDL): A Cointegration Approach for Models 1 and 2

The present study uses the ARDL approach to analyse the impact of FDI on TR and TIS. Before examining the long-run relationship, the study determines the optimal lag length, conducts the Bounds test and assesses Granger's causality to examine short-term causality.

Model 1

$$\ln(TR)_t = \alpha_1 + \beta_1 \ln(FDI)_t + \varepsilon_t$$

In the present case, the optimum lag structure for the given model is assessed using Vector Auto-Regressive (VAR) lag order selection model based on minimum Akaike Informatio Criteria and SBC criteria.

Table 2: Lag-Length Selection for Model 1

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	-89.98491	NA	4.055540	7.075762	7.172539	7.103630
1	-34.62883	97.93767*	0.078207*	3.125295*	3.415625*	3.208899*
2	-30.99169	5.875387	0.081037	3.153207	3.637090	3.292548

Note: * Indicates the lag order selected by the criterion.

The optimum lag-length structure for the given model is 1-1. Hence, the ARDL model by taking lag-structure of 1-1 is used to test the existence of a long-run relationship between TR and FDI. To estimate the log-linear equation (2), the ARDL equation of the bivariate model at time t is given as:

$$ln\ (TR)_t = \alpha_1 + \sum_{j=1}^{p} b_j\ ln\ (TR)_{t-j} + \sum_{j=1}^{p} c_j\ ln\ (FDI)_{t-j} + \delta_1 ln\ (TR)_{t-1} + \delta_2 ln\ (FDI)_{t-1} + e_{1t}$$

In the equation mentioned above, α1 represents the drift component, while the parameters bj and cj denote the short-term dynamic coefficients. TRt-j and FDIt-j represent the lagged values of the variables, indicating the short-term dynamic structure with a lag length ranging from j=1 to p. The term e1t represents the white noise term. The parameters δ1 and δ2 correspond to the long-run coefficients of the ARDL model. The null hypothesis of the model assumes no cointegration (δ1 = δ2 = 0), which is tested against the alternative hypothesis that suggests the existence of cointegration (δ1≠ δ2 ≠ 0).

In the first stage of the ARDL cointegration model, the coefficient of determination (r-square) is calculated to be 0.976725. This value indicates that approximately 97.67% of the variation in the model is explained by the independent variable FDI. The p-value of F-statistic is found to be zero, indicating that the model is statistically well-fitted. Additionally, the Durbin-Watson statistic has a value of 2.074840, suggesting the absence of autocorrelation.

To investigate the presence of a long-run relationship between TR and FDI, a Bounds test is conducted. The F-statistic and the corresponding Bound range for the dependent variable TR are presented in Table 3.

Table 3: ARDL Bounds Test of Model 1

Test Statistic	*Value*	*K*
F-statistic	2.036745	1
Significance	**I(0) Bound**	**I(1) Bound**
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

The findings from the ARDL Bounds test indicate that the null hypothesis is accepted, as the value of the F-statistic (2.036745) is lower than the I(0) bound (4.04), even at a 10% level of significance. This strongly suggests the absence of long-run cointegration between TR and FDI inflows. Consequently, it can be concluded that FDI inflows do not have a long-term impact on the total revenue of the sector.

Before analysing the short-run causal relationship between the variables, diagnostic testing of ARDL Model 1 has been conducted and the results are given in Table 4.

Table 4: Diagnostic Tests of Model 1

Serial Correlation				*Heteroscedasticity*			
Test Statistic		*LM Version*		*Test Statistic*		*LM Version*	
F-Statistic	*P-Value*	*Chi- Square*	*P-Value*	*F-Statistic*	*P-Value*	*Chi-Square*	*P-Value*
0.290826	0.5949	0.337141	0.5615	1.241839	0.3068	2.532099	0.2819

The results of the serial correlation LM test by Breusch-Godfrey and heteroskedasticity test by Breusch-Pagan-Godfrey exhibit that the ARDL model is free from the problems of serial correlation and heteroskedasticity as p-value is insignificant in both the cases indicating the accuracy and reliability of the model.

Short Run Analysis

Since there is no long-run relationship between TR and FDI, when TR is a dependent variable, therefore, in the present section, the short-run causal impact of the variables on each other is examined using VAR based Granger's causality test/Block Exogeneity Wald test. In case of two variables (Y_t and X_t), the variable Y_t is Granger caused by X_t, if past values of variable X_t contains information about the future values of variable Y_t, which is not contained only in the past values of variable Y_t. The short-run equations of the model 1 are given below:

$$ln\,(TR)_t = \alpha_1 + \sum_{j=1}^{p} \beta_j\, ln\,(TR)_{t-j} + \sum_{j=1}^{q} \gamma_j\, ln\,(FDI)_{t-j} + e_{1t}$$

$$ln(FDI)_t = \alpha_2 + \sum_{j=1}^{p} \theta_j\, ln(FDI)_{t-j} + \sum_{j=1}^{q} \delta_j\, ln(TR)_{t-j} + e_{2t}$$

The null hypothesis of the model represents the non-existence of any causal relationship between the variables against the existence of the relationship as an alternate hypothesis. Table 5 presents the short-run impact of TR and FDI on each other.

Table 5: VAR Granger Causality/ Block Exogeneity Wald Test for Model 1

Dependent variable: TR			*Dependent variable: FDI*		
Chi-square	df	p-value	Chi-square	df	p-value
1.364635	2	0.5054	8.018887	2	0.0181

The table above reveals that even in the short run, when TR is considered as the dependent variable, there is no significant impact of FDI inflows on the total revenue of the telecom sector. This conclusion is supported by the insignificant p-value obtained from the Chi-square statistic, which holds true at both the 5% and 10% levels of significance. Consequently, the null hypothesis, indicating the absence of a short-run causal relationship between TR and FDI, is accepted. This implies that FDI inflows do not influence the total revenue of the telecom sector, both in the short run and in the long run.

However, when FDI is treated as the dependent variable and total revenue as the independent variable, the p-value of the Chi-square statistic is found to be 0.0181, which is significant at the 5% level of significance. This signifies that the total revenue of the telecom sector has an impact on FDI inflows. It suggests that foreign investors consider the total revenue of the telecom sector when making investments in the Indian telecom industry.

Model 2

$$\ln(TIS)_t = \boldsymbol{\alpha}_2 + \boldsymbol{\gamma}_1 \ln(FDI)_t + \mathcal{E}_t$$

In this model, the relationship between TIS and FDI is analysed by taking TIS as a dependent variable and FDI as an independent variable. The optimum lag structure for the given model is deduced by using the VAR model.

Table 6: Lag-Length Selection for Model 2

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-113.561	NA	24.86842	8.889277	8.986054	8.917145
1	-53.7278	105.8580*	0.339853*	4.594446*	4.884776*	4.678051*
2	-50.066	5.915227	0.351483	4.620461	5.104345	4.759802

Note: * Indicates lag order selected by the criterion.

It is seen that the optimum lag structure for the given model is 1-1 by using the AIC criterion and SBC criterion. The ARDL approach is applied by using 1-1 lag-length to test the presence of cointegration between TIS and FDI variables given in log-linear equation (4) and is exhibited in the form of following ARDL equation:

$$ln\,(TIS)_t = \alpha_1 + \sum_{j=1}^{p} b_j\, ln\,(TIS)_{t-j} + \sum_{j=1}^{p} c_j\, ln\,(FDI)_{t-j} + \delta_1 ln\,(TIS)_{t-1} + \delta_2 ln\,(FDI)_{t-1} + e_{1t}$$

In the given equation, α1 represents the drift component, while the parameters bj and cj denote the short-term dynamic coefficients. TISt-j and FDIt-j represent the lagged values of the variables, reflecting the short-term dynamic structure with a lag length ranging from j=1 to p. The term e1t represents the white noise term. The parameters δ1 and δ2 correspond to the long-run coefficients of the ARDL model. The null hypothesis of the ARDL model assumes the non-existence of cointegration (δ1 = δ2 = 0), while the alternate hypothesis suggests the presence of cointegration (δ1 ≠ δ2 ≠ 0).

The first stage of the ARDL model analysis reveals that the coefficient of determination (r-square) is 0.982875, indicating that approximately 98% of the variation in the model is explained. Additionally, the p-value of the F-statistic is zero, indicating a statistically well-fitted model. The Durbin-Watson statistic, with a value close to 2, suggests the absence of autocorrelation.

To test the existence of cointegration between TIS and FDI, a Bounds test is conducted. The F-statistic and the corresponding Bound range for the dependent variable TIS are presented in Table 7.

Table 7: ARDL Bounds Test of Model 2

Test Statistic	Value	K
F-Statistic	1.691294	1
Significance	**I(0) Bound**	**I(1) Bound**
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

The analysis suggests that there is no long-run relationship between the variables, as the value of the F-statistic (1.691294) is lower than the I(0) bound (4.04), even at a 10% level of significance. Consequently, it can be concluded that FDI inflows in the Indian telecom sector do not have a significant impact on the total number of internet subscribers in the long run.

Table 8 presents the results of the residual diagnostic tests conducted for model 2.

Table 8: Diagnostic Tests of Model 2

Serial Correlation				Heteroscedasticity			
Test Statistic		LM Version		Test Statistic		LM Version	
F-Statistic	P-Value	Chi-Square	P-Value	F-Statistic	P-Value	Chi-Square	P-Value
0.53887	0.4707	0.645529	0.4217	0.88832	0.4619	2.803586	0.4229

It is clear that the model is fitted well as p-value is insignificant in both cases. Hence, ARDL-Bounds model 2 is free from the problems of serial correlation and heteroscedasticity.

Short-Run Analysis

The short-run causal effect of FDI and TIS on each other is analysed by using VAR based Granger's causality test/Block Exogeneity Wald test. Following equations have been used to test the short-run causality:

$$ln\ (TIS)_t = \alpha_1 + \sum_{j=1}^{p} \beta_j\ ln\ (TIS)_{t-j} + \sum_{j=1}^{q} \gamma_j\ ln\ (FDI)_{t-j} + e_{1t}$$

$$ln\ (FDI)_t = \alpha_2 + \sum_{j=1}^{p} \theta_j\ ln\ (FDI)_{t-j} + \sum_{j=1}^{q} \delta_j\ ln\ (TR)_{t-j} + e_{2t}$$

Table 9 provides the results of the short-run analysis of the model:

Table 9: VAR Granger Causality/Block Exogeneity Wald Test of Model 2

Dependent Variable: TIS			*Dependent Variable: FDI*		
Chi-Square	*df*	*P-Value*	*Chi-Square*	*df*	*P-Value*
3.893484	2	0.1427	6.756022	2	0.0341

The findings suggest that FDI inflows in the telecom sector of India do not have an impact on the total number of internet subscribers in the short run, as evidenced by the statistically insignificant p-value of 0.1427 (> 0.05). Consequently, it can be concluded that FDI inflows in the Indian telecom sector do not influence the total number of internet subscribers in both the long run and the short run.

However, when FDI is treated as the dependent variable and the TIS as the independent variable, a significant relationship is observed. The p-value in this case is 0.0341 (< 0.05), indicating statistical significance at the 5% level. This implies that the total number of internet subscribers does impact FDI inflows in the Indian telecom sector. Moreover, the analysis reveals auni-directional causality between FDI and TIS in the short run, with TIS as the independent variable and FDI as the dependent variable. These findings indicate that foreign investors consider the total number of internet subscribers when making investments in the Indian telecom sector.

Model 3

$$\ln(TTS)_t = \boldsymbol{\alpha}_3 + \boldsymbol{\theta}_1 \ln(FDI)_t + \boldsymbol{\mathcal{E}}_t$$

The present model focuses on the relationship between TTS and FDI, with TTS as the dependent variable and FDI as the independent variable. However, the results of the ADF test indicate that FDI has an order of integration of I(1), while TTS has an order of integration of I(2). Due to this disparity in the order of integration, the ARDL approach cannot be used to test the cointegration between TTS and FDI.

To determine the causal relationship between total telecom subscribers and FDI inflows in the Indian telecom sector, the study employs the Toda-Yamamoto method of Granger Non-causality test.

Toda–Yamamoto Causality Analysis

The Toda and Yamamoto method of Granger causality test is particularly useful in situations with small sample sizes or when the order of integration of time series variables is unknown, varied, or higher than two. This method involves extending the lag length of the VAR model by adding additional lags based on the maximum order of integration in the empirical system.

To apply the Toda and Yamamoto procedure, the maximum order of integration of the time series, denoted as dmax, needs to be determined initially. Next, the optimal lag length of the VAR model, denoted as k, is determined using criteria such as AIC. Subsequently, a VAR model of order p = k + dmax is estimated. Finally, the null hypothesis of non-causality is tested using a standard Wald statistic, denoted as W. The Wald test statistic (W) follows an asymptotic chi-square ($\chi 2$) distribution with k degrees of freedom.

Below are the equations representing the model used in the Toda and Yamamoto method:

$$ln\ (TTS)_t = \alpha_1 + \sum_{j=1}^{k+dmax} \beta_j\ ln\ (TTS)_{t-j} + \sum_{j=1}^{k+dmax} \gamma_j\ ln\ (FDI)_{t-j} + e_{1t}$$

$$ln\ (FDI)_t = \alpha_2 + \sum_{j=1}^{k+dmax} \theta_j\ ln\ (TTS)_{t-j} + \sum_{j=1}^{k+dmax} \delta_j\ ln\ (FDI)_{t-j} + e_{2t}$$

Firstly, it is required to examine the order of integration for each variable used in this study. The results suggest

FDI has I(1) order of integration and TTS has I(2) order of integration. The maximum order of integration in the present model is two, that is, dmax= 2. Therefore, the Toda-Yamamoto test involves the addition of two extra lags of each of the variables (TTS and FDI) to control for potential cointegration.

In the next step, the appropriate lag length for the VAR model is selected to perform the causality test using AIC and SBC criteria.

Table 10: Lag-Length Selection for Model 3

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	-76.84059	NA	2.445847	6.570049	6.668220	6.596094
1	-11.41068	114.5023	0.014666	1.450890	1.745404	1.529025
2	3.588935	23.74939*	0.005922*	0.534255*	1.025111*	0.664480*
3	4.876514	1.824070	0.007593	0.760291	1.447489	0.942604
4	6.955175	2.598326	0.009294	0.920402	1.803942	1.154806

Note: * Indicates the lag order selected by the criterion.

After selecting the optimal lag length, which in this case is determined to be k = 2, the augmented VAR model of order p = k + dmax is chosen. In this study, p = 4 (k = 2, dmax = 2) is estimated to capture the relationship between the variables. Subsequently, the Wald test is conducted using the standard chi-square distribution.

The results of the Toda and Yamamoto Granger non-causality test, which examines the presence of causal relationships between the variables, are reported in Table 11.

Table 11: VAR Granger Causality/Block Exogeneity Wald Test for Model 3

Dependent Variable: TTS			*Dependent Variable: FDI*		
Chi-Square	*df*	*P-Value*	*Chi-Square*	*df*	*p-Value*
1.123555	2	0.5702	2.361399	2	0.3071

The obtained results, at a significance level of 5%, suggest that the null hypotheses stating that 'FDI does not Granger Cause TTS' and 'TTS does not Granger Cause FDI' are accepted. This indicates that there is no causal relationship between TTS and FDI inflows in the Indian telecom sector.

Conclusion

The empirical findings of the present study indicate that the impact of FDI inflows on the growth of the Indian telecom sector, including telecom sector revenue, internet access, and subscriber base, is insignificant. Despite FDI's presence in the Indian telecom sector for the past three decades and its significant growth, it is observed to have a limited role in the sector's overall growth. This suggests that the sector is yet to experience the expected vibrancy and infusion of innovative foreign technologies.

However, the study also highlights that the substantial growth in telecom sector revenue and internet access has attracted FDI inflows to the sector. Therefore, it is recommended that the Government of India focuses on strategies to increase the total revenue of the telecom sector and improve internet access. These efforts can help in attracting more FDI inflows into the Indian telecom sector, which could contribute to its further development and growth.

Appendices

Appendix 1

Year	*FDI Equity Inflows in the Telecom Sector (USD millions)* *Source: Department of Industrial Policy and Promotion (DIPP), Ministry of Commerce and Industry, Government of India*	*Total Revenue (in Rs Crores)* *Source: Ministry of Communications & Information Technology, Govt. of India for Telecom*	*Total Internet Subscribers (in millions)* *Source: Telecom Regulatory Authority of India, Various Issues*	*Total Telecom Subscribers (in millions)* *Source: Dept. of Telecommunications (DoT) and Telecom Regulatory Authority of India (TRAI), Various Issues*
1991	0.68	3,405	0.01	5.07
1992		3,875	0.01	5.81
1993		4,758	0.01	6.8
1994	4.47	6,095	0.01	8.03
1995	63.75	7,799	0.01	9.8
1996	215.87	9,761	0.05	12.06
1997	342.93	12,266	0.09	14.88
1998	430.35	14,587	0.14	18.68
1999	49.39	17,744	0.28	22.79
2000	64.21	18,257	0.95	28.39
2001	177.69	10,176	3.04	36.03
2002	873.23	22,386	3.42	45.22
2003	191.6	45,672	3.64	54.63
2004	86.49	61,000	4.55	73.78
2005	118.33	71,674	5.54	93.64
2006	617.98	86,720	6.94	131.68
2007	476.51	1,05,319	9.27	205.88
2008	1260.7	1,29,083	11.1	300.49
2009	2548.63	1,52,360	13.54	429.73
2010	2539.26	1,57,985	16.18	621.28
2011	1664.5	1,71,719	19.67	846.32
2012	1997.24	1,95,442	22.86	951.34
2013	303.87	2,12,592	164.81	898.02
2014	1306.95	2,33,815	251.59	933.02
2015	2894.94	2,54,547	302.35	996.49
2016	1324.4	2,63,709	342.65	1058.85
2017	5563.69	2,79,591	422.2	1194.58
2018	6212	2,55,655	493.96	1206.22

Appendix 2

MODEL 1: Total Revenue (TR) and FDI

Dependent Variable: TR
Method: ARDL
Date: 10/24/19 Time: 12:59
Sample (adjusted): 1992 2018
Included observations: 27 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): FDI
Fixed regressors: C
Number of models evaluated: 2
Selected Model: ARDL (1, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
TR (-1)	0.914011	0.049907	18.31438	0.0000
FDI	0.029887	0.028606	1.044783	0.3065
C	0.908919	0.417960	2.174658	0.0397
R-squared	0.976725	Mean dependent var		10.80585
Adjusted R-squared	0.974785	S.D. dependent var		1.451369
S.E. of regression	0.230465	Akaike info criterion		0.007008
Sum squared resid	1.274744	Schwarz criterion		0.150990
Log likelihood	2.905397	Hannan-Quinn criterion		0.049821
F-statistic	503.5699	Durbin-Watson stat		2.074840
Prob(F-statistic)	0.000000			

*Note: p-values and any subsequent tests do not account for modelselection

Appendix 3

MODEL 2: Total Internet Subscribers (TIS) and FDI

Dependent Variable: TIS
Method: ARDL
Date: 10/24/19 Time: 13:15
Sample (adjusted): 1992 2018
Included observations: 27 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): FDI
Fixed regressors: C
Number of models evaluated: 2
Selected Model: ARDL (1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
TIS (-1)	0.915051	0.046570	19.64885	0.0000
FDI	-0.055843	0.088933	-0.627919	0.5362
FDI (-1)	0.155174	0.083971	1.847938	0.0775
C	-0.026700	0.322167	-0.082876	0.9347
R-squared	0.982875	Mean dependent var		1.194209
Adjusted R-squared	0.980641	S.D. dependent var		3.520627
S.E. of regression	0.489850	Akaike info criterion		1.546520
Sum squared resid	5.518926	Schwarz criterion		1.738496
Log likelihood	-16.87802	Hannan-Quinn criterion		1.603604
F-statistic	440.0109	Durbin-Watson stat		1.993815
Prob(F-statistic)	0.000000			

*Note: p-values and any subsequent tests do not account for model selection.

Appendix 4

MODEL 3: Total Telecom Subscribers (TTS) and FDI (Toda Yamamato Model)

Vector Autoregression Estimates		
Date: 04/21/20 Time: 12:30		
Sample (adjusted): 1995 2018		
Included observations: 24 after adjustments		
Standard errors in ( ) & t-statistics in [ ]		
	TTS	FDI
TTS (-1)	1.917314	3.257581
	(0.22566)	(2.45672)
	[8.49630]	[1.32599]
TTS (-2)	-0.984461	-3.613999
	(0.31378)	(3.41600)
	[-3.13743]	[-1.05796]
FDI (-1)	-0.022220	0.266932
	(0.02156)	(0.23476)
	[-1.03039]	[1.13704]
FDI (-2)	0.006577	-0.138178
	(0.01613)	(0.17565)
	[0.40764]	[-0.78665]
C	0.152990	2.291078
	(0.07118)	(0.77494)
	[2.14926]	[2.95647]
TTS (-4)	0.061863	1.137349
	(0.11529)	(1.25512)
	[0.53658]	[0.90616]
FDI (-4)	0.001373	-0.124749
	(0.01089)	(0.11854)
	[0.12605]	[-1.05237]
R-squared	0.998388	0.734602
Adj. R-squared	0.997819	0.640932
Sum sq. resids	0.109212	12.94369
S.E. equation	0.080151	0.872579
F-statistic	1754.455	7.842457
Log likelihood	30.65566	-26.64518
Akaike AIC	-1.971305	2.803765
Schwarz SC	-1.627706	3.147364
Mean dependent	5.033521	6.324028
S.D. dependent	1.716108	1.456184
Determinant resid covariance (dof adj.)		0.004470
Determinant resid covariance		0.002243
Log likelihood		5.090503
Akaike information criterion		0.742458
Schwarz criterion		1.429656

References

Acharya, R., & Patel, R. (2012). Technology transfer, FDI and economic growth in telecom sector: A review. *Shiv Shakti International Journal in Multidisciplinary and Academic Research*, *1*(4), 1-11.

Annual Report. (2003-2004). Department of Telecommunications, Ministry of Communications & Information Technology, Government of India, New Delhi.

Bansal, S., & Gupta, S. K. (2013). FDI in India - A study of telecommunication industry. *International Journal of Advanced Research in Management and Social Sciences*, *2*(3), 189-201.

Boer, D. B. D., & Evans, L. (1996). The economic efficiency of telecommunications in a deregulated market: The case of New Zealand. *Economic Record*, *72*(216), 24-35.

Boylaud, O., & Nicoletti, G. (2000). Regulation, market structure and performance in telecommunications. Economics Department Working Papers no. 237. Retrieved from http://www.oecd.org/eco/eco.

Clark, T. H., & Petrazzini, B. (1996). Costs and benefits of telecommunications liberalization in developing countries. In *Institute for International Economics Conference on Liberalizing Telecommunications Services.* Washington, DC.

Contessi, S. (2003). *FDI in the telecommunication sectors of transition and developing countries.* Johns Hopkins University.

Department of Telecommunications. (2018). *Telecom Statistics India-2018.* Retrieved from https://dot.gov.in/reportsstatistics/telecom-statistics-india-2018

Dwivedi, H., & Saini, K. (2011). Indian telecommunication sector: A paradigm shift. *International Journal of Research in Commerce, IT & Management, 1*(5), 29-37.

Fink, C., Mattoo, A., & Rathindran, R. (2001). *Liberalizing basic telecommunications: The Asian experience.* The World Bank.

Gupta, A. K., & Sharma, A. K. (n.d.). Benefits of FDI in telecom sector. *Professional Panorama,* 48-66.

IBEF, Telecommunication Sector in India. Retrieved from http://www.ibef.org/industry/telecommunications.aspx

International Telecommunication Union. (2003). *World telecommunication/ICT development report and database*.

Izuchukwu, O. O. (2010). Relationship between FDI and telecommunication growth in Nigeria. *Proceedings of the 7th International Conference on Innovation & Management.*

KPMG. (2009). *The Indian telecom success story.* Retrieved from https://www.kpmg.de/docs/The_Indian_Telecom_Success_Story.pdf

Lydon, R., & Williams, M. (2005). Communications networks and foreign direct investment in developing countries. *Communications & Strategies*, *58,* 43-60.

Lin, C. H. (2008). Role of foreign direct investment in telecommunication industries: A developing countries' perspective. *Contemporary Management Research*, *4*(1), 29-42.

Mahajan, D. (2014). Telecommunication sector and foreign direct investment: An Indian perspective. *Journal of Commerce & Trade*, *9*(2), 77-82.

Parvez, M. A., & Chary, T. S. (2017). Foreign direct investment (FDI) and telecommunication sector in India. *Journal of Telecommunications System & Management*, *6*(1), 1-5.

Pesaran, M. H., & Pesaran, B. (1997). *Working with Microfit 4.0: Interactive econometric analysis,* [Windows version]. Oxford University Press.

Pesaran, M. H., & Smith, R. P. (1998). Structural analysis of cointegrating VARs. *Journal of Economic Surveys*, *12*(5), 471-505.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289-326.

Pritish, & Saxena, T. (2015). An analysis of the Indian telecom industry. *IOSR Journal of Business and Management*, *17*(10), 35-42.

Ros, A. J. (1999). Does ownership or competition matter? The effects of telecommunications reform on network expansion and efficiency. *Journal of Regulatory Economics*, *15*(1), 65-92.

Shrivastava, R., Barodiya, P., & Jatav, M. K. (2016). A study of foreign direct investment in the Indian telecommunication industry. *International Journal of Commerce and Management Research*, *2*(12), 30-34.

Sinha, D. (2008). *Foreign direct investment in telecommunication sector.* Retrieved from http://www.legalserviceindia.com/article/1280

Sridhar, K. S., & Sridhar, V. (2004). Telecommunications Infrastructure and Economic Growth: Evidence from Developing Countries. National Institute of Public Finance and Policy. Working Papers 04/14.

Telecom Regulatory Authority of India. (2012). *Telecom sector in India: A decadal profile*. Retrieved from http://www.trai.gov.in/WriteReadData/Publication/Document/201304121052403536675NCAER--Report08june12.pdf

Telecom Regulatory Authority of India. (2017). *A Twenty-Year Odyssey 1997-2017*. Retrieved from https://trai.gov.in/sites/default/files/A_TwentyYear_Odyssey_1997_2017.pdf

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, *66*(1-2), 225-250.

Wallsten, S. J. (2001). An econometric analysis of telecom competition, privatization and regulation in Africa and Latin America. *The Journal of Industrial Economics, 49,* 1-19.