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Nexus between foreign direct investment and economic growth in Bangladesh: an augmented autoregressive distributed lag bounds testing approach

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Abstract

The relationship between foreign direct investment (FDI) inflows and economic growth in host countries is a heavily debated issue. Although some studies have found evidence of the positive impact of FDI on economic growth, others have revealed the opposite result. Studies that examined the causality between FDI and gross domestic product (GDP) also have found evidence of unidirectional causality and, in some cases, a bidirectional causality. This study investigated the causal nexus between FDI and GDP in Bangladesh by employing standard time-series econometric tools, namely, augmented Dickey-Fuller, augmented Dickey-Fuller generalized least square, Kwiatkowski-Phillips-Schmidt-Shin, and Lee-Strazicich unit root tests to check stationarity, augmented autoregressive distributed lag (augmented ARDL) bounds testing approach to check cointegration, and Granger causality to explore the direction of causality. The augmented ARDL model found a long-run relationship between FDI and GDP. In addition, the error correction model and Granger causality results indicated the presence of a unidirectional causality running from GDP to FDI.

Keywords: FDI, GDP, Augmented ARDL, Causality, Economic growth

JEL classification: C22, F31, O47

Introduction

Foreign direct investment (FDI) is one of the most significant factors to influence economic growth in a developing country like Bangladesh, where capital is scarce because of insufficient domestic savings—both private and public. This investment is crucial for the much-needed industrialization in a country (Mujeri and Chowdhury 2013). In the absence of adequate local investment, FDI has been attracted from industrially advanced countries to accelerate the path of industrialization, to foster and maintain sustained economic growth, and to reduce the level of unemployment (Hussain and Haque 2016). In addition, the effectiveness of FDI in the host countries depends on the efficiency of domestic investment (Razin and Sadka 2003).

Gradually, countries are becoming more integrated to achieve faster economic growth and are opening up for free trade as a result of globalization (Middleton 2007). Economic and technological factors drive the growth of international production,

which is facilitated by the liberalization of trade policies and increased FDI flows. In this context, globalization provides an unparalleled opportunity for developing countries to foster and achieve economic growth through trade and investment (Arndt 1999). Hence, many countries—especially the least developed countries—are implementing liberal economic policies to encourage more capital inflows from developed countries (Bengoa and Sanchez-Robles 2003).

Today, the importance of FDI has increased in the form of technology transfer and market networks that can result in efficient production and sales globally (Lipsey and Sjöholm 2010; Urata 1998). Over the past few decades, FDI inflows also have increased remarkably in developing countries. Foreign investors benefit by utilizing their assets and resources efficiently through FDI, while the recipients are expected to benefit by securing technologies and becoming involved in international trade networks (Louzi and Abadi 2011). The question, therefore, naturally arises as to whether these FDI inflows have any impact on local development, and vice versa. This issue, therefore, demands an empirical inquiry (Figlio and Blonigen 2000). Because gross domestic product (GDP) is one of the measures of the level of development, this study aims to explore the relationship between FDI and GDP in Bangladesh.

FDI often is considered to be an important vehicle for economic growth (Vu Le and Suruga 2005a, b). A vast majority of empirical studies have focused on the effect that FDI may exert on economic growth along with the causal link from FDI to growth. As noted by Chakraborty and Basu (2006), however, the causal link from economic growth to FDI and the feedback relationship deserve further attention. Therefore, the direction of this relationship between FDI and economic growth needs to be stressed because the FDI-related spillover effect of knowledge encourages economic growth, which, in turn, attracts more FDI (Chakraborty and Basu 2006).

Empirical studies, such as Vu Le and Suruga (2005a, b), Durham (2004), Borensztein et al. (1998), and Balasubramanyam et al. (1996), have investigated the FDI-growth nexus. They have stressed that the possibility of a positive impact of FDI on economic growth depends on such mechanisms as the technology-upgrading progress, human capital investment, absorptive capacity, and trade policy adopted by the host country (Gönel and Aksoy 2016; Katircioglu 2009; Silajdzic and Mehic 2016). These studies generally considered a panel of countries, suggesting that FDI can have a positive but indirect effect on economic growth. In contrast, in the case of India, Vu Le and Suruga (2005a, b) suggested that FDI, public capital, and private investment all played important roles in promoting economic growth. They also advocated against uncontrolled spending in public capital expenditure, which can impede the positive effects of FDI in a country.

The mobility of capital and technology is the single most important reason for low-income countries to grow at a higher rate (Li and Chen 2010). The stability of FDI inflows and required macroeconomic and financial adjustments have been identified as the contributing factors for economic growth in developing countries (Chao et al. 2019; Sridharan et al. 2009). The issue that FDI enhances and accelerates economic growth has not received common empirical support. The positive effect that FDI may exert on economic growth may start only if the financial market, an interdependent system with a broad and interconnected network (Kou et al. 2019), is developed more than at a threshold level (Azman-Saini et al. 2010). The positive impact of FDI and foreign trade

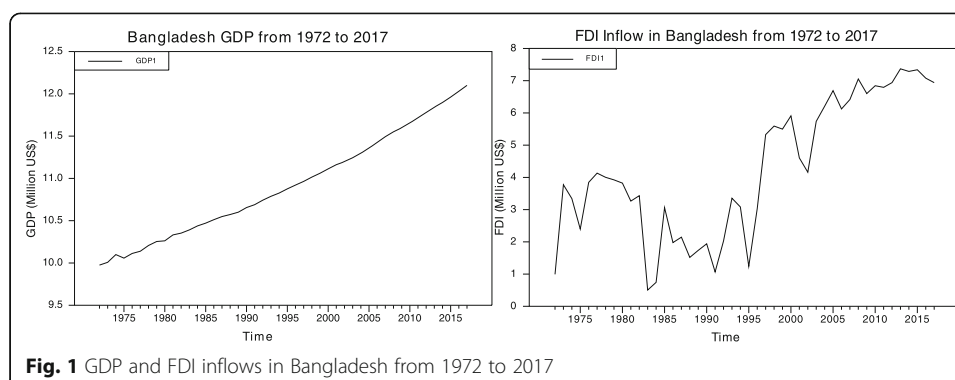
on economic growth may be realized only by the FDI inflows in the economies that are expected to grow faster and follow open-trade policies (Adhikary 2010; Shimul et al. 2009). FDI has been channeled effectively by transferring technology and promoting economic growth in developing countries within the framework of the neoclassical models (Bitzer and Kerekes 2008; Solow 1956; Sridharan et al. 2009). Therefore, the host countries should facilitate a financial liberalization and stabilization policy before experiencing any increase in FDI (De Gregorio and Guidotti 1995).

Bashir (1999) found that foreign firms tended to increase the level of human capital and accelerate the growth rate of an economy. It has been argued that although the effect varies across geographic regions and over time, FDI, for the most part, has led to economic growth. Feridun (2004) conducted a study on the causality between FDI and GDP per capita in Cyprus and found strong evidence of GDP being Granger caused by FDI, but not vice versa. Results further suggested that Cyprus's capacity to achieve progress on economic development will depend on how much the country attracts foreign capital (Borensztein et al. 1998). Moreover, Wu (2000) emphasized the development of infrastructure, growth of the non-state sector, and economic reform for host economies to realize the positive effects of FDI.

The internationalization theory implies that FDI takes place in countries as multinational corporations are replacing external markets with more efficient internal markets (Asghar et al. 2012; Dunning 1977; Rugman 1985, 1986). Empirically, a lot of disagreement has been observed in the relationship between FDI and economic growth as most of the studies either have provided mixed results or have failed to reach any definite conclusions (Borensztein et al. 1998; Carkovic and Levine 2002). Various empirical studies have focused on the significant role played by FDI inflows to foster economic growth of the developing countries through its contribution of human resources, capital formation, and enhanced organization and managerial skills, as well as the transfer of technologies because of their scarce capital (Aitken and Harrison 1999; Barro 1990; Blomstrom and Wolff 1989; Markusen and Venables 1999; Zhang 2001). To date, the existing empirical evidence on the relationship between FDI and economic growth nexus has not been conclusive. Therefore, this has become the basis for academics and policy makers to analyze this relationship further using recent developments in econometric modeling (Asghar et al. 2012).

Figure 1 shows GDP and FDI inflows (in million US dollars and natural logarithm) in Bangladesh over the period from 1972 to 2017. The amount of FDI inflows was not significant until 1996. This may be partly due to the fact that the country was ruled by a long-held military regime, and that year, a democratic government was formed. The volume of FDI inflows increased gradually from 2002 onward with little fluctuation. In recent years, the growth rate of FDI inflows in Bangladesh has declined, although it is considered to be a potent vehicle for economic development. The Seventh Five-Year Plan (2016–2020), however, set a target of FDI increase of \$5.87 billion by 2018. Figure 1 exhibits the increasing trend in both variables, which confirms that GDP increases gradually over the considered time period. The growth rate of GDP increased slightly after 2004 and continued to increase up to recent periods, with an average growth rate of 6.0% or more (Bangladesh Bank 2017).

The previous literature on FDI and economic growth nexus in Bangladesh, for example, Shimul et al. (2009), using a smaller dataset (1973–2007), utilized the ARDL



technique, and found no causal relationship between FDI and economic growth. Conversely, Tabassum and Ahmed (2014), using data for the period 1972–2011 and applying a multiple regression model, found FDI to be insignificant in influencing economic growth. Therefore, the literature is limited on the selected topic in the case of Bangladesh. In addition, the FDI and economic growth relationship is one of the debatable issues in the literature, which needs further investigation. This study, however, used a longer dataset (1972–2017) than previous studies. It revealed the causal nexus between FDI and economic growth in Bangladesh by applying appropriate time-series econometric tools and robustness check techniques. Therefore, this study filled in the gap in the literature using relatively upgraded time-series econometric techniques and a newer and larger dataset.

The remainder of this study is organized as follows: Section 2 provides a brief overview of data and the methodology used to analyze the results. In section 3, empirical results based on the time-series econometric methodology are presented and discussed in detail. Section 4 gives the conclusion and recommendations of this study.

Data and methodology

To explore the relationship between the two variables, FDI and GDP in Bangladesh, this study used data collected from the World Bank's *World Development Indicators* database. The data series included annual data (in millions of U.S. dollar) for both FDI and GDP covering the period from 1972 to 2017. We took the GDP variable as a real series measured in constant 2000 U.S. dollars. We took FDI as a net inflow and converted it to a real unit by applying a GDP deflator. We then expressed both series in a natural logarithm.

For econometric analysis, we first applied unit root tests to check for the order of integration of the data series.¹ Second, we applied the augmented ARDL modeling approach to see whether any long-run relationships existed between the variables. Third, we applied a Granger causality test to determine the direction of causality, that is, whether FDI caused GDP or GDP caused FDI. Finally, we applied several diagnostic tests for a robustness check.

¹Although the ARDL bounds testing approach can be used for a data series without knowing the order of integration (i.e., it can be applied to a mixture of $I(1)$ and $I(0)$ series), it is inappropriate for a series of $I(2)$. See, for example, Pesaran et al. (2001) for more details.

Unit root tests

To test for stationarity of the time-series data, FDI, and GDP, we applied augmented Dickey-Fuller (ADF), augmented Dickey-Fuller generalized least square (DF-GLS), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and Lee-Strazicich (LS) unit root tests. We applied the KPSS test because some series are, in fact, trend stationary instead of having unit roots (Kwiatkowski et al. 1992). Figure 1 shows some broken trends in the FDI series. Hence, we applied the Lee and Strazicich (2013) unit root test, which allowed for one structural break in both the null and alternative hypotheses, to see whether there were any structural breaks in the data series.

Augmented Dickey-Fuller test

This ADF test is conducted by augmenting the equation in which the lagged difference form of the dependent variable ΔY_{t-i} is added as an explanatory variable to capture any serial autocorrelation (Dickey and Fuller 1981). Following are the three variants of the ADF test.

No constant and no trend:

$$\Delta Y_t = \gamma_1 Y_{t-1} + \sum_{i=1}^m \alpha_i \Delta Y_{t-i} + \mu_t. \quad (1)$$

Constant and no trend:

$$\Delta Y_t = \gamma_0 + \gamma_1 Y_{t-1} + \sum_{i=1}^m \alpha_i \Delta Y_{t-i} + \mu_t. \quad (2)$$

Constant and trend:

$$\Delta Y_t = \gamma_0 + \gamma_1 Y_{t-1} + \gamma_2 t + \sum_{i=1}^m \alpha_i \Delta Y_{t-i} + \mu_t, \quad (3)$$

where μ_t is a pure white noise error term and ΔY_t is the first difference of the dependent variable. To use a particular model, we need to verify the pattern of the time-series data by observing its diagrammatic representation. If the data series exhibits neither drift nor trend, we can apply Eq. (1); if the data series exhibits drift but no trend, we have to apply Eq. (2); finally, if data series exhibits both drift and trend, we need to apply Eq. (3) (Harris 1992).²

DF-GLS unit root test

The Elliott et al. (1996) study modified the ADF unit root test and termed it the DF-GLS test. Before performing this test, the data are transformed using a generalized least squares (GLS) regression. The test has two steps. First, the test de-trends (de-means) the data utilizing the GLS approach; second, the test uses an ADF test to identify a unit root. The DF-GLS test also allows for a linear time trend that is based on the following regression:

²To have knowledge about the particular pattern of the data series, we had to plot them in a figure (as in Figure 1). Here both series exhibit the trend; hence, we had to use model 3.

$$\Delta y_t^d = \alpha y_{t-1}^d + \sum_{j=1}^p \beta_j \Delta y_{t-j}^d + v_t, \quad (4)$$

where y_t^d is the de-trended (de-measured) data series and v_t is a white noise error term. In addition to the DF-GLS test, the Elliott et al. (1996) study computed a second unit root test, which was termed the point-optimal test. The null hypothesis is the unit root against the alternative stationary.

KPSS test

Kwiatkowski et al. (1992) proposed a unit root test in which the presence of a unit root is not in the null but in the alternative hypothesis. This test, known as KPSS test, argues that the absence of a unit root is not a necessary proof for the data to be stationary but, by design, may be trend stationary (Lipsey and Sjöholm 2011). The test takes the following time-series model:

$$y_t = \beta_0 + \beta_1 t + \gamma_t + \varepsilon_t, \text{ and} \quad (5)$$

$$\gamma_t = \gamma_{t-1} + \mu_t. \quad (6)$$

Equation (5) has three different components. First, β_0 and $\beta_1 t$ are deterministic components in the form of a constant term and a linear time trend. Second, γ_t is either a random walk component or a constant term, which depends on whether or not the variance of μ_t , denoted σ_μ^2 , takes on a nonzero value.³ Finally, ε_t is a disturbance term, that in the current context is assumed to fulfill $\varepsilon_t = \omega(L)\xi_t$, where $\omega(L) = \sum_{i=0}^{\infty} \theta_i L^i$ such that $0 < \omega(1) < \infty$ and $\sum_{i=1}^{\infty} i|\theta_i| < \infty$, while $\sigma_\xi^2 = E(\xi_1^2)$. Assumptions on the error process amounts to assuming that the disturbance follows a linear process, as in Phillips and Solo (1992).

To test the null hypothesis that y_t is covariance stationary or that is $I(0)$, Kwiatkowski et al. (1992) suggested that whether or not σ_μ^2 is equal to zero should be tested by employing the following test statistic:

$$LM = \frac{1}{T^2} \frac{\sum_{t=1}^T M_t^2}{\hat{\sigma}^2}, \quad (7)$$

where $M_t = \sum_{i=1}^t e_i$ is the least squares residual obtained by de-trending the time-series y_t with either an intercept or an intercept and a time trend. In addition, $\hat{\sigma}^2$ in Eq. (7) is a variance estimator that can relieve the asymptotic distribution of the Lagrange multiplier (LM) statistic from nuisance parameters under the null hypothesis.

Lee-Strazicich test

The conventional methods for testing unit roots cannot account for breaks in the data series. Some data series actually may contain breaks either in the intercept or in the slope or in both. Therefore, it is essential to apply a unit root test that allows for structural breaks in the data series. Lee and Strazicich (2013) proposed the minimum LM unit root test, which allows for one structural break under both the null and alternative

³When the variance is zero, the random walk term will take on the value γ_0 for all t , which will alter the constant term of y_t to $\beta_0 + \gamma_t$.

hypotheses in a consistent manner. This test can detect structural break in the data series, if any, endogenously. The test considers the following data-generating process:

$$y_t = \alpha^E X_t + \varepsilon_t, \quad \varepsilon_t = \theta \varepsilon_{t-1} + e_t, \quad (8)$$

where X_t includes exogenous variables. Two models of structural change are considered here: Model A, which is known as the crash model, allows for a one-time change in the intercept under the alternative hypothesis; and Model C, which is known as the break model, allows for a shift in the intercept and a change in trend slope under the alternative hypothesis. The crash model can be described by $X_t = [1, t, D_t]^E$, where $D_t = 1$ for $t \geq T_B + 1$ and zero otherwise, whereas the break model can be described by $X_t = [1, t, D_t, DT_t]^E$, where $DT_t = t - T_B$ for $t \geq T_B + 1$, and zero otherwise. The minimum LM principle says that a unit root test statistic comes from the following regression:

$$\Delta y_t = \alpha^E \Delta X_t + \beta \tilde{S}_{t-1} + \mu_t, \quad (9)$$

where the de-trended series \tilde{S}_t is defined as follows: $\tilde{S}_t = y_t - \tilde{\delta}_m - X_t \tilde{\alpha}$, $t = 2, \dots, T$; $\tilde{\alpha}$ equals the coefficients in the regression of Δy_t onto ΔX_t , and $\tilde{\delta}_m$ equals $y_1 - X_1 \tilde{\alpha}$, where y_1 and X_1 correspond to the first observations of y_t and X_t respectively.

Augmented ARDL bounds testing approach to Cointegration analysis

To analyze the relationship between GDP and FDI, this study applied an augmented ARDL bounds testing approach to the cointegration proposed by McNown et al. (2018). Although there are various cointegration approaches, such as Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990), the data series must have a unique order of integration for these models to be applied. Thus, the ARDL model is more flexible in terms of its application when the data series do not have unique order of integration. This model can be applied to variables that have different order of integration—that is, $I(0)$ or $I(1)$. It is not applicable, however, if any of the variables are $I(2)$. Moreover, for a small dataset, it can be reliably applied to obtain consistent results (Haug 2002). Furthermore, in the case of a lag selection for both the dependent and independent variables, it gives more options and can handle the endogeneity phenomenon in variables, if any exist.

The ARDL model proposed by Pesaran et al. (2001) was upgraded by McNown et al. (2018) and was named the augmented ARDL. This version of the model necessitated an extra t -test or F -test on the coefficients of lagged independent variables. For our framework, this model is specified in Eq. (10), which we used to reveal the long-run relationship between the considered variables: GDP and FDI.

$$\begin{aligned} \Delta \ln GDP_t = & \alpha_1 + \sum_{i=1}^p \beta_1 \Delta \ln GDP_{t-i} + \sum_{i=0}^q \beta_2 \Delta \ln FDI_{t-i} + \gamma_1 \ln GDP_{t-1} \\ & + \gamma_2 \ln FDI_{t-1} + \sigma_1 D_t + \varepsilon_t, \end{aligned} \quad (10)$$

where ε_t is a white noise error term and Δ is a first difference operator. In Eq. (10), the terms with summation represented short-run dynamics, whereas the terms with γ_s indicated long-run relationships. D_t is included to account for possible structural break in the dataset. Here, the null hypothesis is $\gamma_1 = \gamma_2 = 0$, which indicated that no long-run relationship existed. The first test in the ARDL modeling analysis is an F -test for the joint

significance of the coefficients on the level (Pesaran and Shin 1999; Pesaran et al. 2001). The second test is a t -test for the lagged dependent variables. The statistics have a nonstandard distribution under the null hypothesis in the sense that no level relationship exists regardless of whether the regressors are $I(0)$ or $I(1)$.

In the case of the ARDL test, however, Goh and McNown (2015) demonstrated that it was insufficient to report only the value of the F -test statistic for the overall test and for the t -test statistic on a lagged dependent variable. To avoid the degenerate case 1 identified by Pesaran et al. (2001), McNown et al. (2018) proposed an additional t -test or F -test on the lagged independent variables to complement the ARDL test by Pesaran et al. (2001). The use of all three tests was necessary to distinguish between cases of cointegration or degenerate cases.

Instead of conventional critical values, Pesaran et al. (2001) and Sam et al. (2019) provided two sets of asymptotic critical values: one for purely $I(1)$ and another for purely $I(0)$ regressors. If the value of the F -test statistic was smaller than the lower bound critical value or the absolute value of the t -test statistic was lower than the absolute lower bound critical value, then the null hypothesis of “no long-run relationship” could not be rejected. This implied that no long-run relationship existed between the variables. In contrast, if the value of the F -test statistic was greater than the upper bound critical value or the absolute value of the t -test statistic was greater than the absolute upper bound critical value, then the null hypothesis could be rejected. This implied that long-run relationships did exist between the variables. Finally, if the value of the test statistic was neither lower nor greater than the two critical values, that is, the value fell between the two critical values, then the decision regarding the long-run relationships between the variables was inconclusive.

To analyze the short-run dynamics, we applied the following error correction model (ECM):

$$\Delta \ln GDP = \alpha_2 + \sum_{i=1}^p \theta_1 \Delta \ln GDP_{t-i} + \sum_{i=0}^q \theta_2 \Delta \ln FDI_{t-i} + \omega ECT_{t-1} + \mu_t, \quad (11)$$

where θ_s indicates the short-run dynamics, ECT is the error correction term measuring the speed of adjustment each period toward equilibrium after a shock, and ω is the corresponding parameter that gives this measure. The expected value of the corresponding parameter of ECT ranges from -1 to 0 , where 0 implies no convergence toward equilibrium and -1 implies perfect convergence, that is, any shock this period is perfectly adjusted the next period if the value is -1 .

We applied several diagnostic tests. First, we applied the Harvey test to check for the heteroscedasticity of the residuals of the augmented ARDL model. Second, we applied the Breusch-Godfrey Serial Correlation LM test to check for serial correlation of the residuals. Third, we used the Ramsey RESET test as a model specification test. Fourth, we utilized the Jarque-Bera normality test to test for the normality of the residuals of the models. Finally, we used the cumulative sum (CUSUM) test and the CUSUM of square test to check for model stability.⁴

⁴See Brown et al. (1975) for more details. These tests are developed to test the stability of the estimated parameters, which depend on the cumulative sum of the recursive residuals. These tests find parameters to be stable if the cumulative sum lies between the two 5% critical straight lines, but if the cumulative sum goes outside the critical lines, the parameters are unstable.

Granger causality

The cointegration technique can test only whether any relationships exist between the variables, but it cannot give the direction of causality. A unidirectional or bidirectional causality may exist between the variables. To test for the direction of causality, we needed to apply a causality test technique. The Granger representation theorem (Engle and Granger 1987) suggests the direction of causality of two or more variables when they are cointegrated with the error correction being used. The linear regression modeling of the stochastic processes is used as its mathematical basis (Granger 1969). For our two-variable case, FDI and GDP, we can frame the model as follows:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \dots + \alpha_p Y_{t-p} + \beta_1 X_{t-1} + \dots + \beta_p X_{t-p} + v_{1,t}, \text{ and} \quad (12)$$

$$X_t = a_0 + a_1 X_{t-1} + \dots + a_p X_{t-p} + B_1 Y_{t-1} + \dots + B_p Y_{t-p} + v_{2,t}. \quad (13)$$

where α_1 to α_p and a_1 to a_p are coefficients for the lagged dependent variables, and β_1 to β_p and B_1 to B_p are coefficients for the lagged independent variables. First, for both time series, we took the maximum order of integration (d); second, we selected the maximum number of lags by applying the vector autoregression (VAR) lag selection technique; and, third, we added the maximum order of integration (d) for both series to the lags selected by the VAR technique to obtain the total number of lags to be used while applying the Granger causality technique (Granger 1969). The hypotheses are as follows:

$$H_0: \beta_1 = \dots = \beta_p = 0 \text{ and indicates } X \text{ does not Granger cause } Y.$$

$$H_0: B_1 = \dots = B_p = 0 \text{ and indicates } Y \text{ does not Granger cause } X.$$

If we reject the null hypothesis, it suggests that one variable Granger causes another variable—that is, the rejection of the null hypothesis “ X does not Granger cause Y ” indicates that X does Granger cause Y . The same logic holds for the second null hypothesis.

Empirical results

Table 1 shows basic descriptive statistics of lnGDP and lnFDI. The columns display the variables’ mean, standard error, minimum value, maximum value, skewness, kurtosis, and Jarque-Bera test for normality check with its corresponding significance values.

Results of unit root

Although the augmented ARDL bounds test can be applied to variables that have a different order of integration, it must be ensured that no variable is $I(2)$. To check for the order of integration of the FDI and GDP data series, we estimated the unit root tests. A stationary process is one in which the mean and variance are constant over time (Gujarati 2003).

Table 1 Descriptive statistics of the data series

Series	Mean	Std. Error	Minimum	Maximum	Skewness	Kurtosis	J.B.	P-value
GDP	10.9197	0.6219	9.9746	12.1006	0.2708	− 1.0788	2.7930	0.2474
FDI	4.2798	2.14281	0.5044	7.3681	−0.0776	−1.2999	3.2850	0.1934

Data are expressed in natural logarithm

Table 2 Results of unit root tests

Variables	ADF, DF-GLS, and KPSS test							
	ADF		DF-GLS				KPSS	
			P _T		GLS			
	Level	First Dif.	Level	First Dif.	Level	First Dif.	Level	First Diff.
GDP	2.264	-11.109***	74.853	5.529**	0.164	-7.772***	0.1577**	0.1435*
FDI	-1.711	-7.434***	7.828	4.385**	-2.764	-4.598***	0.1179	0.1005

LS (one break model)					
	Model	Level		First Dif.	
		T-Stat	Break	T-Stat	Break
GDP	Crash	-0.376	D: 1980	-3.651**	D: 1987
	Break	-2.648	D: 1997	-7.150***	D: 1985
			DT: 1997		DT: 1985***
FDI	Crash	-3.921**	D: 1982**	-2.415	D: 1982*
	Break	-3.437	D: 1995	-6.784***	D: 1981
			DT: 1995		DT: 1981

***, **, and * denote significance at the 1%, 5%, and 10% level respectively. The 1%, 5% and 10% critical values are -4.15, -3.50 and -3.18 respectively for ADF; 3.96, 5.62, and 6.89 respectively for P_T and -3.48, -2.89, and -2.57 for GLS of DF-GLS test; 0.216, 0.146 and 0.119 respectively for KPSS; and -4.084, -3.487 and -3.1850 respectively for LS crash model and -4.907, -4.345 and -4.068 respectively for break model. The variables are in natural logarithm form. D stands for break in the intercept and DT break in the slope

Table 2 (upper panel) shows the results of the unit roots of the time-series data on FDI and GDP based on ADF, DF-GLS, and KPSS unit root tests.⁵ The results showed that the GDP series was nonstationary at level but stationary at first difference according to ADF, DF-GLS, and KPSS⁶ unit root tests. The same results held in both the crash and break model⁷ of the LS test (lower panel). This allowed for one endogenously determined structural break. Thus, in the GDP series, we could not say there was structural break, either in intercept or slope. The FDI series also was nonstationary at level but stationary at first difference (except for the KPSS test in which it was stationary at both level and first difference). The FDI series was stationary at level (at the 5% level) with a structural break in the intercept in 1982, according to the crash model. It was nonstationary, however, at first difference with the same structural break, which implied that the structural break in 1982 was significant in the series. This break was consistent with the fact that the existing military government in Bangladesh was replaced in 1982 with another military-backed government. This change in power in state administration led to a decline in foreign capital inflows in several subsequent years starting from 1982.

⁵Figure 1 exhibits the trend in the original data series; hence, we applied only the trend model (model 3) of the ADF and KPSS unit root tests. The maximum lag length used are 4 for both the ADF and LS tests and 10 for KPSS test.

⁶The null hypothesis for KPSS test is “stationarity” and the alternative is “unit root.” See Kwiatkowski et al. (1992) for more details.

⁷The unit root test proposed by Lee and Strazicich (2003) utilized two models to test for the unit root, crash, and break models. We applied the crash model when the data series did not exhibit the trend, and break model was appropriate for the data series that did exhibit the trend.

Therefore, the unit root results gave a mixture of $I(1)$ and $I(0)$ series. Hence, the usual Engle-Granger and Johansen cointegration technique were not appropriate and required a data series to have a unique order of integration. The features of the data series necessitated the use of the augmented ARDL model proposed by McNown et al. (2018). This model could be applied to variables with a different order of integration, that is, a combination of $I(0)$ and $I(1)$.

Augmented ARDL bounds test for Cointegration

To select the optimal lag length for each variable, we estimated the number of regressions $(p + 1)^k$ by the ARDL model, where p was the maximum lag length and k was the number of explanatory variables (Shrestha and Chowdhury 2007). Therefore, the number of regressions estimated by ARDL model was $(4 + 1)^2 = 25$.⁸

The long-run Cointegration analysis

To test for the long-run relationships between the considered variables, we estimated the augmented ARDL bounds test model, as in Eq. (10). The estimated results confirmed whether any long-run relationship existed between GDP and FDI.

The estimated results are displayed in Table 3. We applied the Akaike information criterion to select the appropriate lag length to be used in the augmented ARDL bounds test from a maximum of four lags for both series. The results of the bounds test confirmed that there was a long-run relationship between the variables because the coefficients were significant. Dum_FDI was dummy variable accounting for possible structural break in the data series. It had a value of 1 for the year 1982 and 0 for all other years (as indicated by LS unit root test). The dummy variable (Dum_FDI), however, was not statistically significant. This lack of significance implied that the structural break identified by the unit root test (LS test) did not affect the independent variable (GDP) significantly.

Table 4 shows the bounds test results of the F -test and t -test to show the long-run relationships between the variables. The augmented ARDL model was “unrestricted intercepts and no trend” because this was best fit by the diagnostic tests. We have reported the critical values of Pesaran et al. (2001), Narayan (2005), and Sam et al. (2019). We reported the Narayan (2005) critical values because we had a small sample size. The values of the F -statistic exceeded all three of the critical values at the 5% level for the GDP equation and at the 10% for the FDI equation. Therefore, the results of the F -bound test revealed that long-run relationships existed between the variables.

We also reported the t -statistic (on the lagged dependent variables) whose absolute values also exceeded the absolute upper bound critical value at the 1% level for GDP equation and at the 10% for FDI equation, which implied the existence of a long-run relationship. In addition, to avoid the degenerate case 1 identified by Pesaran et al. (2001), we reported the t -test statistic associated with the coefficients on the lagged independent variables. The values of these t -test statistics exceeded the absolute upper bound critical value at the 10% level for both the GDP and FDI equations. Hence, the results removed the possibility of the degenerate cases identified by Pesaran et al. (2001). Therefore, all three test statistics confirmed the evidence of cointegration between the variables.

⁸We calculated p as the “number of observation $(46)^{0.3333} = 3.58$,” which was rounded up to 4.

Table 3 Augmented ARDL model estimation results

Dependent variable	Regressors	Coefficient	Standard Error	T-Statistic
$\Delta \ln GDP$	$\ln GDP_{-1}$	0.0685	0.0158	4.91***
	$\ln FDI_{-1}$	0.5346	0.1400	3.82**
	Dum_FDI	-0.0149	0.0127	-1.17
	R-squared: 0.9997 Adjusted R-squared: 0.9996 F-stat: 11076.80			
$\Delta \ln FDI$	$\ln FDI_{-1}$	-0.3316	0.1017	-3.26**
	$\ln GDP_{-1}$	0.2753	0.0793	3.47*
	R-squared: 0.8494 Adjusted R-squared: 0.8071 F-stat: 20.06			

***, ** and * denote significance at the 1%, 5%, and 10% level respectively. The variables are in natural logarithm

Analysis of short-run dynamics with augmented ARDL bounds test

We found evidence in favor of short-run dynamics as shown by the signs and values of the coefficients of the first-difference lagged variables, GDP and FDI, and of ECT with their corresponding significant *t*-statistic (Table 5). The coefficient of ECT was positive significant but was very close to zero when the dependent variable was GDP. This result implied that no adjustment was made toward a long-run equilibrium relationship for this equation if there was a shock in the short run. However, the coefficient of ECT was negative significant when the dependent variable was FDI, which implied that there was an adjustment toward a long-run equilibrium relationship for this equation if there was a shock in the short run.

Diagnostic tests

Table 6 shows the results of different diagnostic tests. To check the heteroscedasticity of the residuals of the augmented ARDL model, we used the Harvey test, and for the correlation check, we used the Breusch-Godfrey test. The results on these two tests revealed

Table 4 Long-run augmented ARDL bounds testing with *F*-statistic and *t*-statistic

Critical Values	Dependent variable: $\Delta \ln GDP$	<i>F</i> -Statistic: 5.63**							
		<i>t</i> -statistic on lagged dependent variable: 4.91***							
		<i>t</i> -statistic on lagged independent variable: 3.82*							
	Dependent variable: $\Delta \ln FDI$	<i>F</i> -Statistic: 4.48*							
		<i>t</i> -statistic on lagged dependent variable: −3.26*							
		<i>t</i> -statistic on lagged independent variable: 3.47*							
Pesaran et al. (2001)					Narayan (2005)		Sam et al. (2019)		
<i>F</i> -test		<i>t</i> -test							
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
1 percentage	5.15	6.36	−3.43	−4.10	5.8784	6.870	5.06	8.38	
5 percentage	3.79	4.85	−2.86	−3.53	4.335	5.078	3.21	5.62	
10 percentage	3.17	4.14	−2.57	−3.21	3.625	4.330	2.41	4.43	

***, ** and * denote significance at the 1%, 5% and 10% level respectively

Table 5 Augmented ARDL short-run and ECM results

Dependent variable	Regressors	Coefficients	Standard Error	T-Statistic
$\Delta \ln GDP$	$\Delta \ln GDP_{-1}$	-0.3169	0.1458	-2.17**
	$\Delta \ln FDI$	0.0418	0.0206	2.023**
	$\Delta \ln FDI_{-1}$	-0.0024	0.0014	1.74*
	ECT	0.0046	0.0008	5.7586***
$\Delta \ln FDI$	$\Delta \ln FDI_{-1}$	-0.0237	0.1419	-0.1670
	$\Delta \ln FDI_{-2}$	-0.2875	0.1149	-2.5022**
	$\Delta \ln GDP$	0.0859	0.0475	1.8084*
	ECT	-0.2160	0.0985	-2.1936**

***, **, and * denote significance at the 1%, 5%, and 10% level respectively. The variables are in natural logarithm

that the residuals obtained from the augmented ARDL model were homoscedastic and uncorrelated. For the normality test, the study utilized the Jarque-Bera test, which showed that the residuals of the test employed were normally distributed. Moreover, to check for the appropriate functional form, the study used the Ramsey RESET test. The probability values of 0.5391 and 0.7582 suggested that the models are well specified.

Furthermore, to ensure the stability of the estimated parameters of the long-run relationship of our results, we employed CUSUM and CUSUM of squares tests based on the recursive residuals developed by Brown et al. (1975).

Parameter constancy and model stability were significant if both plots, CUSUM and CUSUM of squares, remained between the 5% critical bounds. The plots of CUSUM and CUSUM of squares in Fig. 2 (for regression with GDP being the dependent variable) remained between the 5% critical bounds, thereby indicating “parameter constancy” and “no identified systematic change” in the coefficients at the 5% significance level in the data series.

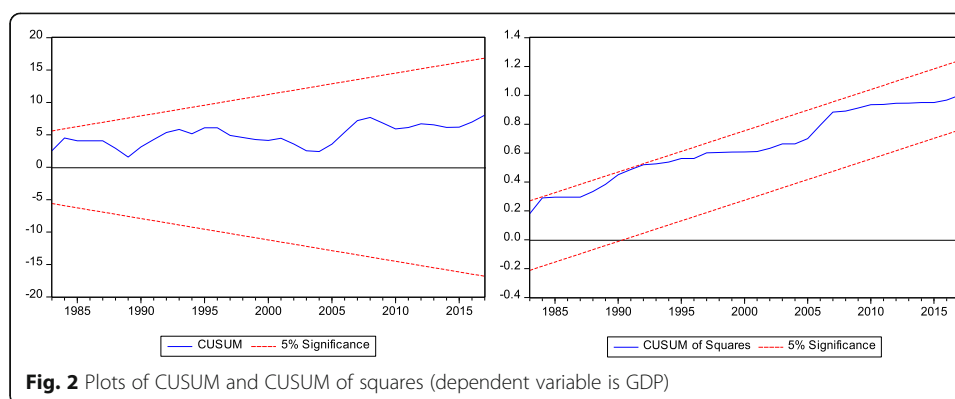
Figure 3 shows parameter constancy and model stability. The plots of CUSUM and CUSUM of squares remained between the 5% critical bounds.

Results of Granger causality

The results of Granger causality based on Granger (1969) provided evidence to reject the null hypothesis that “GDP does not Granger cause FDI” at the 5% significance level (Table 7). This result confirmed that GDP Granger caused FDI at the 5% significance level. The null hypothesis “FDI does not Granger cause GDP,” however, cannot be rejected because the probability of the test statistic was 0.1431, which was greater than even the 10% significance level. This indicated that GDP was not Granger caused by FDI in the short run. Therefore, there was a short-run unidirectional causality running

Table 6 Results from different diagnostic tests

Dep. variable	Harvey		Breusch-Godfrey		Ramsey		Jarque-Bera	
	F-Stat	Sig.	F-Stat	Sig.	F-Stat	Sig.	Stat	Sig.
$\Delta \ln GDP$	1.2183	0.3168	1.3245	0.2598	0.8267	0.6064	2.3189	0.3137
$\Delta \ln FDI$	0.6361	0.7580	0.7264	0.6816	0.1254	0.9987	1.6738	0.4331



from GDP to FDI in Bangladesh. These results supported the finding that the steady GDP growth rate could help the Bangladesh economy to attract steady FDI inflows in the long run.

The results of this study, in terms of causality, were similar to that of Chakraborty and Mukherjee (2012), Kiviyiro and Arminen (2014), Ozyigit and Eminer (2011), Goh et al. (2017), and Basu et al. (2003). In terms of causality, however, these results were in contrast to the results of Katircioglu (2009), Sunde (2017), Azman-Saini et al. (2010), Shahbaz and Rahman (2010), Ibrahim (2015), and Wang (2009).

Conclusion and policy recommendations

This study conducted an empirical analysis of the nexus between FDI and GDP. The empirical results of the augmented ARDL bounds testing approach to cointegration with structural breaks suggested that there was a long-run relationship between GDP and FDI in Bangladesh. The signs and values of ECT coefficients and the values of corresponding t -statistic confirmed the existence of this long-run relationship. The ECT results also confirmed the finding that the disequilibrium for the FDI equation converged. The disequilibrium for the GDP equation did not converge if there was any shock in the equilibrium position. This meant that the long-run causality was unidirectional, and it ran from GDP to FDI. Having confirmed that there was a long-run relationship between GDP and FDI through a cointegration analysis, the study applied a Granger causality test, which also indicated the presence of short-run unidirectional causality running from GDP to FDI. These results were consistent, as Bangladesh has

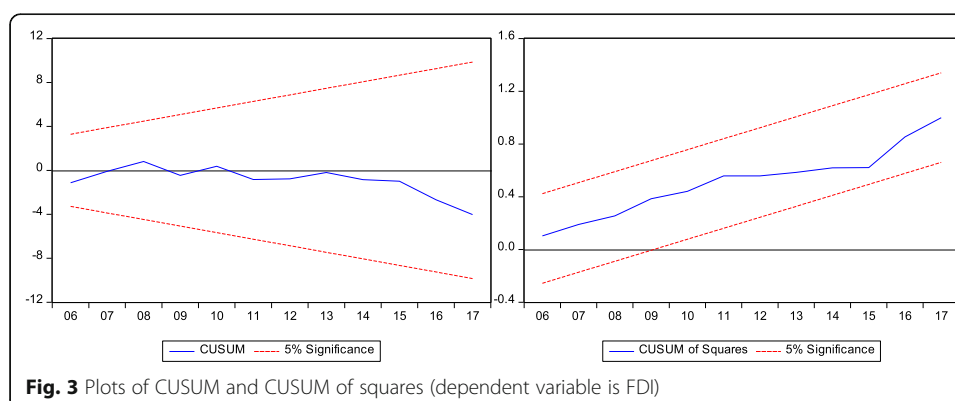


Table 7 Results of Granger Causality

Null Hypothesis	F-test	Probability	Decision
FDI does not Granger Cause GDP	2.0446	0.1431	Accepted
GDP does not Granger Cause FDI	3.0319*	0.0497	Rejected

* denote rejection of the null hypothesis at the 1%, 5%, and 10% level respectively

been experiencing stable economic growth over the past few decades and the volume of FDI also has increased to a significant extent with little fluctuation.

Therefore, the findings of this study have some crucial policy implications. The findings of the presence of short-run and long-run relationships and the causality running from GDP (economic growth) to FDI advocate for placing greater emphasis on policies that are appropriate to maintain a steady growth rate of GDP. Notably, if possible, policy makers in Bangladesh should induce policies required for sound macroeconomic position, develop a socioeconomic infrastructure for the economy, further liberalize the financial sector, and maintain an environment for sound international trade and smooth utilization of foreign investment in Bangladesh. Moreover, policy makers should ensure policies that support the development of human capital, which determines how much manpower the economy is capable of absorbing, and should maintain a sound macroeconomic position. Furthermore, political stability is crucial for a sound macroeconomic position, which is required for the GDP growth rate to be maintained at a steady rate. Finally, the government should ensure that all of the important steps for FDI are utilized fairly and effectively, which is essential in a capital-scarce country like Bangladesh.

Abbreviations

ADF: Augmented Dickey-Fuller; ARDL: Autoregressive distributed lag; CUSUM: Cumulative sum; DF-GLS: Augmented Dickey-Fuller Generalized Least Square; ECM: Error correction model; ECT: Error correction term; FDI: Foreign direct investment; GDP: Gross domestic product; KPSS: Kwiatkowski Phillips Schmidt Shin; LM: Lagrange Multiplier; LS: Lee–Strazich; VAR: Vector autoregression

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Authors' contributions

BS was the major contributor in designing and writing the manuscript. FK provided BS with valuable suggestions and comments in every steps including modeling the econometric framework and result analysis and finally reviewed the manuscript. Both authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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