International Journal of Business and Technopreneurship
Volume 6, No. 2, June 2016 [209-232]

Cointegration and VAR Causality Testing of the Infrastructure - FDI Relationship: A Case of Bangladesh

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ABSTRACT

This study explores the role of infrastructure availability, particularly with respect to transportation, information and communication technology and energy consumption in determining the attractiveness of foreign direct investment (FDI) inflows in Bangladesh. The infrastructure of a country not only encourages its local investment to develop its socio-economic condition but also attracts the foreign direct investment. For the empirical analysis this paper uses data for the period 1975-2011 from the World Development Indicators (WDI) (on FDI, per capita energy consumption and GDP) (WDI 2014). The long term relationships between infrastructure and FDI are explored by using cointegration analysis for Bangladesh. The data sets are found to be integrated of the same order. It is also found that they move together in the long run by Johansen Cointegration Test. Using VAR Granger causality/Block exogeneity Wald causality test the study has revealed some interesting causal relationships between foreign direct investment and different infrastructure indicators in Bangladesh. Bi-directional causality is observed only from LNICT to LNFDI in Bangladesh.

Keywords: FDI, Infrastructure, Johansen's Co-integration, VAR, Causality

1. INTRODUCTION

Infrastructure plays an important role in promoting rapid economic growth and making this growth more inclusive, by sharing the benefits of growth with poorer groups and communities, particularly in remote and isolated areas and small and landlocked countries. Infrastructure facilitates the poor's access to basic services and helps increase their income generating capacity. Physical connectivity through cross-border infrastructure (CBI) development is crucial for enhanced regional cooperation and economic integration (Kuroda, 2006). In economic

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terms, infrastructure can be seen as a structure which allows for the production and exchange of goods and services. Broadly defined, the concept of infrastructure is not limited to public utilities, but may also refer to information technology, informal and formal channels of communication, software development tools, and political and social networks which support the economic system (such as a city or a country). It also encompasses the soft aspects of infrastructure such as operating procedures, management practices, and development policies that interact with societal demand and the physical world to facilitate the transport of people and goods, and energy, among others (National Research Council, 1987).

Ample supply of transport infrastructure at no or low costs to users is conjectured to have a positive impact on costs and productivity of firms. Indeed, the usefulness of privately owned and operated cars and trucks depends on a network of roads and bridges. For instance, good road designs, materials, and maintenance can reduce the wear and tear on vehicles, thus reducing transportation costs. The same is true for aircraft, which require good airports, and for private ships and barges, which need ports and navigable waterways. A freeway is faster than a washed out dirt road, email is faster than the post office, and time is money (Seetanah, 2007).

The World Economic Forum's Global Competitiveness Report 2015–2016 described infrastructure as the second pillar of a country's competitiveness (Schwab, 2015). The report pointed out several other elements that contribute to competitiveness and that should be made to reinforce each other, such as sound macroeconomic policies, stable political and legal institutions, sophistication of companies' operations and strategies, and the quality of the macroeconomic business environment. In Table 1, the overall infrastructure quality position of Bangladesh is 124 out of 140 countries.

Table 1: Infrastructure Indictors in South, East and Southeast Asia (2015-16)

Country	Overall Infrastructure Quality (Out of 140)	Rail Road Infrastructure Development	Port Infrastructure Development	Air Transport Infrastructure Development	Quality of electricity supply	Mobile telephone subscriptions/100 pop
Bangladesh	2.8 (124)	2.5	3.6	3.2	2.7	75.9
India	4.0 (74)	4.1	4.2	4.3	3.7	74.5
Sri Lanka	5.1 (26)	3.9	4.3	4.9	4.9	103.2
Pakistan	3.5 (98)	2.8	4.1	4.1	2.1	73.3
Nepal	2.7 (127)	N/A	1.6	2.8	1.9	82.5
P.R.China	4.5 (51)	5.0	4.5	4.8	5.3	92.3
Re. of Korea	5.6 (20)	5.6	5.2	5.5	5.7	115.5

Malaysia	5.6 (16)	5.1	5.6	5.7	5.8	148.8
Philippines	3.3 (106)	2.2	3.2	3.7	4.0	111.2
Iran, I.R of	3.9 (76)	3.4	3.9	3.2	5.0	87.8

Source: Global Competitiveness Report 2015-16, World Economic Forum.

Note: Overall Infrastructure Quality is (1= poorly developed and inefficient and 7= among the best in the world). The same applies to rail, port and air transport infrastructure.

It is observed that Bangladesh's overall infrastructure quality is lower than all of the countries mentioned in the table except Nepal. Out of five South Asian countries, Bangladesh posits four which indicates the present scenario of the infrastructure facilities of the country.

In order to encourage the inflows of FDI the government of Bangladesh offers one of the most liberal investment policies and attractive packages of fiscal, financial and other incentives to foreign entrepreneurs in South Asia. Foreign investment in Bangladesh is 100% safe and secured by the Foreign Private Investment (Promotion & Protection) Act 1980. We have a large number of young and energetic populations with about 59.3% economically active people. According to a recent study conducted by the Japan External Trade Organization (JETRO) factors of production like land, labour, fuel, vehicles, rental and hiring skilled management people etc. are very much competitive here in Bangladesh in comparison with 29 cities and region of Asia.

Table 2: FDI Inward Stock in South, East and Southeast Asia, (Millions of Dollars)

Country	1990	2000	2014
Bangladesh	477	2162	9355
India	1657	16339	252331
Iran, I.R. of	2039	2597	43047
Malaysia	10 318	52 747	133 767
Nepal	12	72	541
Pakistan	1892	6919	30892
P.R.China	20 691	193 348	1 085 293
Philippines	3 268	13 762	57 093
Re. of Korea	5 186	43 738	182 037
Sri Lanka	679	1596	10511

According to the World Investment Report 2015, Bangladesh received $ 9355 million inward stock of FDI in FY2014, $2162.00 million in 2000 and $477.00

million in 1990 which are the lowest amount of all countries mentioned in the Table 2 except Nepal.

The rest of the paper is organized as follows. The next section presents the elaborate literature review of the study. Section 3 shows the rationale of the study and the variables and the data analyses are presented in section 4. The econometric model and time series analysis are shown in section 5. Section 6 presents econometric results from cointegration and VAR causality testing of the infrastructure - FDI relationship. Some concluding remarks are offered in the final section 7.

2. LITERATURE REVIEW

Root and Ahmed (1979) analyzed the determinants of non-extractive direct investment inflows for 70 developing countries over the period 1966-70. Their analysis focused on testing the significance of the economic, social and political variables in explaining the determinants of FDI. They concluded that developing countries that have attracted the most non-extractive direct foreign investment were those that have substantial urbanization, a relatively advanced infrastructure, comparatively high growth rates in per capita GDP, and political stability. Studies by Wheeler and Mody (1992), Loree & Guisinger (1995), asserted that good infrastructure is a necessary pre-requisite for foreign investors to conduct its operations successfully. Poor infrastructure acts as a fetter to FDI as it increases its costs of operations. In other words, lack of proper infrastructure in the form of inadequate transport facilities, telecommunication services and electricity services decrease productivity and thereby increase cost of doing business in host country.

Loree and Guisinger (1995) were studying the determinants of foreign direct investment by the United States in 1977 and 1982 (both towards developed countries as well as toward developing countries), concluded that variables related to host country policy are significant in developed countries only when infrastructure is an important determinant in all regions.

Lansbury *et al.* (1996) the authors attempted to explain why foreign investors have moved into these markets so rapidly and why Hungary and the Czech Republic have attracted more FDI than Poland. They focused in particular on the organization of the privatization process in these economies and the trade linkages between them and those countries that have invested in the region. A number of country-specific factors such as human capital, technological endowments and economic infrastructure are found to influence the location of foreign investments. Asiedu (2002) studied that a higher return on investment and better infrastructure have a positive impact on FDI to non-Sub-Saharan Africa (SSA) countries, but have no significant impact on FDI to SSA.

A study by Qian *et al.* (2002) of 30 provinces from 1986 to 1998 of China reported that FDI determinants move through time. Labor quality and infrastructure are important determinants of the distribution of FDI. High labor quality and good infrastructure attract foreign investors. Also, China's political stability and openness to the foreign world is another important factor for attracting foreign capital. They also find that the cumulative FDI relative to cumulative domestic investment has a negative impact on the new FDI.

Asiedu (2003) examined the determinants of FDI to Africa. The results indicated that large local markets, natural resource endowments, good infrastructure, low inflation, an efficient legal system and a good investment framework promote FDI. In contrast, corruption and political instability have the opposite effect. Mondal (2003) found that FDI inflow to Bangladesh is constrained by six factors: (i) Political instability; (ii) Sluggish steps towards privatization; (iii) High business cost; (iv) Tax hazards; (v) Threats related to finance; and (vi) Incompetent or futile capital market. Sekkat and Veganzones-Varoudakis (2004), the results showed that trade and foreign exchange liberalization, infrastructure availability and sound economic and political conditions increase FDI inflows. Their effects are much higher for FDI in the manufacturing sector than for total FDI. Dollar *et al.* (2005) drawed on level surveys in Bangladesh, China, India, and Pakistan to investigate the relationship between investment climate and firm performance and concluded that accumulation and growth at the firm level are higher where the investment climate is better. Alam *et al* (2006) have empirically shown that the macroeconomic environment in Bangladesh is congenial for attracting foreign investment. Since the inception of BEPZA it has been playing a very important role for economic development of Bangladesh through export promotion, employment creation, technology transfer, and development of forward and backward linkages of industries and so on.

Sahoo (2006) concluded that the results of FDI impact on growth show that FDI has a positive and significant impact on growth for four south Asian countries including Bangladesh. Other significant factors that contribute to growth are exports, gross domestic capital formation and infrastructure. Therefore South Asian countries need to improve their domestic investment, exports and infrastructure facilities, along with more foreign investment, to achieve higher growth. The study by Seetanah and Khadaroo (2007) explained that infrastructure availability is an ingredient of foreign direct investment inflows in sampled 25 African economies. They particularly study transportation. Using dynamic panel data approach, transport infrastructure availability is seen to have been contributing to the relative attractiveness of the countries in the sample.
Nasrin et al. (2010) their study analyzed the major determinants and hindrances of FDI inflow in Bangladesh. In terms of barrier to FDI inflow the most significant barrier identified is infrastructural constraint. The study further revealed that in spite of having investment-friendly policies there are some implementation problems at the levels of facilitating agencies. As Bangladesh is

facing infrastructural constraints, special incentives packages can be offered as policy incentive to the investors for certain period who will invest in this sector. Babatunde (2011) the results showed that FDI depends on trade openness and GDP per capita. Further results show that the interaction between trade openness and infrastructure leads to a slight increase in FDI inflows. The results also indicate that FDI has a positive and significant effect on growth.

Ramirez and Komuves (2013) showed that in the short run, lagged changes in economic infrastructure, as well as lagged changes in private capital formation are positively associated with changes in FDI inflows; a dummy variable to capture the 2008 financial crisis and euro crisis has a negative and highly significant effect. In the long run, however, FDI inflows and private capital formation are substitutes for one another, while economic infrastructure crowds in private capital formation. Shaheena (2014) has traced the major determinants of FDI inflow in Bangladesh through establishing both the short run and long run equilibrium relationship between FDI and four selected determinants using ARDL approach. She finds that GDP per capita and infrastructure do not have any significant impact on accelerating FDI in Bangladesh. On the other hand, trade openness has positively influenced FDI and played the most important role in attracting FDI in Bangladesh. Low wage rate is also another driving force in attracting FDI in this country.

Shah and Faiz (2015) tried to find out the impact of terrorism along with other important location variables such as market size, economic growth, exchange rate, and infrastructure and trade openness on FDI inflows in five SAARC member nations, including Bangladesh. They are employed a panel econometric estimation model on annual data from 1980-2012 the results of the study showed a significant positive impact of market size, trade openness, infrastructure availability and economic growth on inward FDI in these SAARC countries. Whereas, exchange rate volatility exhibits negative relationship with FDI inflows, as in Sankaran (2015), "An Analysis of the Determinants of FDI Inflows: The Case of the Dominican Republic", the empirical analysis of the paper reveals that market size, infrastructure, trade openness, natural resource extraction, secondary education and labor force participation rate are statistically significant factors in attracting FDI inflows.

3. RATIONALE OF THE STUDY

As the review suggests though there are a number of studies the impact of infrastructure on FDI regarding global perspectives, to the best of my knowledge, there is no extensive time-series analysis on Bangladesh. The studies upon Bangladesh mainly emphasized on the political stability, inflation, exchange rate, market size of the economy, economic growth as determinants of FDI. However, those studies have overlooked the crucial determinants as the infrastructure, such as transport, information and communication technology and energy consumption which determine the FDI inflows in a host country like Bangladesh. Moreover, empirical analysis in those studies is rarely applied. In fact, no comprehensive research has been conducted upon the overall factors of FDI. The study will empirically investigate the relationship between infrastructure facilities and FDI inflows in Bangladesh.

4. METHODOLOGY

4.1 Data and the Variables

The study has attempted to explain why foreign direct investment inflow into Bangladesh is very low and why it doesn't attract more FDI than the rest of the countries in the region. This paper is used time-series approach of stationarity test, cointegration test, stability test and Granger causality test. Research on FDI determinants in Bangladesh is mainly focused on economic and policy factors like openness, market size, exchange rate, and inflation rate etc., discussed in the previous section. There exist a very few studies which acknowledges the importance of infrastructure on FDI in Bangladesh. The paper examines relationship between the infrastructures – FDI in Bangladesh perspective. The study includes the country infrastructure for transport, information and communication technology and energy consumption. This variable is expected to present a positive sign and a positive correlation, since better infrastructure allows for increased FDI flows through better roads, transportation links and logistics. The dependent variable, *FDI*, is measured as the net foreign direct investment inflow as a current US dollar. The main sources of data series are from World Development Indicators (2014) and from Bangladesh Bank.

4.2 Model Specification

The study uses the ordinary least squares (OLS) estimation. The choice of this model is based on the fact that OLS is the best suited for testing specific hypothesis about the nature of economic relationship (Guajarati 2004). The time series properties of the variables are examined in the process. The targets of this study are to investigate the relationship and impacts of infrastructure in Bangladesh, after considering other important macroeconomic determinants, on FDI inflows. The identified model is seven variables which hypothesize that foreign direct investment as a function of market size, openness, exchange rate, and transport infrastructure, information and communication technology infrastructure and energy consumption.

$$FDI = f(MKTSIZE,\ Openness, ExRate,\ TransInfra,\ ICT,\ Energy\ Cons) \tag{1}$$

The econometric form of the equation can be written thus:

$$FDI_t = \alpha_0 + \beta_1 MKTSIZE_t + \beta_2 Openness_t + \beta_3 ExR_t + \beta_4 Trans_t + \beta_5 ICT_t + \beta_6 Energy_t + \mu_t \quad (2)$$

The log-log linear form of the equation can also be presented as:

$$Ln(FDI)_t = \alpha_0 + \beta_1 Ln(MKTSIZE)_t + \beta_2 Ln(Openness)_t + \beta_3 Ln(ExR)_t + \beta_4 Ln(Trans)_t + \beta_5 Ln(ICT)_t + \beta_6 Ln(Energy)_t + \mu_t \quad (3)$$

Where, MKTSIZE = Gross Domestic product as a measure of market size of the country (Current $US), ExR = Average Nominal Exchange Rate (with US Dollar), Openness = Trade is measured as openness (% of GDP), Trans = transport Infrastructure, ICT = Information and Communication Technology Infrastructure, Energy= Energy consumption as a measure of energy use per capita (Kg of Oil Equivalent), μ = Error term of the model, and t = 1, 2, 3… 37 (time period is from 1975– 2011), $\alpha =$ Constant, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 =$ Coefficients to be estimated. Ln = Natural log.

5. EMPIRICAL ANALYSES

5.1 Unit Roots Test

Augmented Dickey-Fuller test is required to check the order of integration through unit root test. The ADF test is based on the following regression model that consists of running a regression of the first difference of the series against the series lagged once, sum of lagged difference terms, and a constant and a time trend.

$$\Delta Y_t = \beta_0 + \beta_1 t + \beta_2 Y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \mu_t \quad (4)$$

Where μ_t is the pure white noise error term that adjusts the errors of autocorrelation and is independently and identically distributed. $\Delta Y_{t-i} = Y_{t-i} - Y_{t-(i+1)}$. ΔY_{t-i} expresses the first differences with p lags. The coefficients of $\beta_0, \beta_1, \beta_2$ and $\boldsymbol{\alpha_i}$ are being estimated. Having found that all the four variables in examination have unit roots (that is, they are integrated of order one), our next step is to determine whether or not there exists at least one linear combination of the non-stationary variables (in level form) that is integrated of order zero (I(0)). In other words, do the involved variables have a stable and non-spurious, long run (cointegrating) relationship among themselves over the relevant time span.

5.2 Cointegration Tests

Cointegration, an econometric property of time series variables, is a precondition for the existence of a long run or, equilibrium economic relationship between two or more variables having unit roots (i.e. integrated of order one). Two or more random variables are said to be cointegrated if each of the series are themselves non-stationary, but a linear combination of them is stationary (Engle and Granger, 1987). The stationary linear combination is called the *cointegrating equation* and may be regarded as a long-run equilibrium relationship among the variables. The purpose of the cointegration test is to determine whether a group of non-stationary series is cointegrated or not. Apart from the Engle-Granger technique, there is the Johansen (1979) procedure of cointegration, which we have chosen to employ in this study. Johansen's approach that begins with an unrestricted VAR involving potentially non-stationary variables, allows us to deal with models with several endogenous variables. A key aspect of this approach is isolating and identifying the *r* cointegrating combinations among a set of *k* integrated variables and incorporating them into an empirical model. Johansen's system-based approach is robust, flexible and has the ability to test restricted versions of vectors and speeds of adjustment. The presence of a cointegrating relation forms the basis of the vector error correction model (VECM) specification. We estimate the following system of equations formulated in a VECM.

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \ldots + \mathit{\Gamma}_{t-k-1} + \Pi Z_{t-1} + \mu + \varepsilon_t \, ; t = 1, \ldots T \quad (5)$$

Where, Δ is the first difference operator, *Z* denotes vector of variables in natural logarithmic form, ε_t is a normal, independent and identically distributed random variable with mean zero and standard deviation Σ (ε_t ~ niid (0,Σ)), μ is a drift parameter, and Π is a (p x p) matrix of the form Π = αβÜ, where α and β are both (p x r) matrices of full rank, with β containing the r cointegrating relationships and α carrying the corresponding adjustment coefficients in each of the r vectors. Johansen proposes two different likelihood ratio tests of the significance of these canonical correlations and thereby the reduced rank of the Π matrix: the trace test and maximum eigenvalue test, shown in equations (6) and (7) respectively.

$$J_{trace} = -T \sum_{i=r+1}^{n} Ln(1 - \hat{\lambda}_i) \quad (6)$$

$$J_{max} = -T \, Ln(1 - \hat{\lambda}_{r+1}) \quad (7)$$

Here *T* is the sample size and $\hat{\lambda}_i$ is the *i:* th largest canonical correlation. The trace test tests the null hypothesis of *r* cointegrating vectors against the alternative hypothesis of *n* cointegrating vectors. The maximum eigenvalue test, on the other hand, tests the null hypothesis of *r* cointegrating vectors against the alternative hypothesis of *r* +1 cointegrating vectors. Neither of these test statistics follows a chi square distribution in general; asymptotic critical values can be found in Johansen and Juselius (1990) and are also given by most econometric software packages. Since the critical values used for the maximum eigenvalue and trace test statistics are based on a pure unit-root assumption, they will no longer be correct when the variables in the system are near-unit-root processes.

5.3 Causality Tests

According to Asteriou (2007), one of the good features of VAR models is that they allow us to test the direction of causality. Causality in econometrics is somewhat different to the concept in everyday use; it refers more to the ability of one variable to predict (and therefore cause) the other. Suppose two stationary variables, say Y_t and X_t, affect each other with distributed lags. The relationship between Y_t and X_t can be captured by a VAR model. In this case, it is possible to have that (a) Y_t causes X_t (Unidirectional Granger causality from Y to X), (b) X_t causes Y_t (Unidirectional Granger causality from X to Y), (c) there is a bi-directional feedback (causality among the variables), and finally (d) the two variables are independent. The problem is to find an appropriate procedure that allows us to test and statistically detect the cause and effect relationship among variables.

Granger (1969) developed a relatively simple test that defined causality as follows: a variable Y_t is said to Granger-cause X_t, if X_t can be predicted with greater accuracy by using past values of the Y_t variable rather than not using such past values, all other terms remaining unchanged. This test has been widely applied in economic policy analysis.

The Granger Causality Test

The Granger causality test for the two *stationary* variables, say, ΔY_t and ΔX_t involves as a first step the estimation of the following VAR model:

$$\Delta Y_t = \alpha_1 + \sum_{j=1}^{p} \beta_j \, \Delta Y_{t-j} + \sum_{j=1}^{p} \gamma_j \, \Delta X_{t-j} + \mu_{1t} \tag{8}$$

$$\Delta X_t = \alpha_2 + \sum_{j=1}^{p} \delta_j \, \Delta Y_{t-j} + \sum_{j=1}^{p} \theta_j \, \Delta X_{t-j} + \mu_{2t} \tag{9}$$

Where it is assumed that both μ_{1t} and $\mu_{2t}$are uncorrelated white-noise error terms, and Y_t and X_t are integrated of order 1.

6. EMPIRICAL RESULTS ANALYSIS

Table 3 shows the results of the descriptive statistics of the variables in the foreign direct investment model under study. The Jarque-Bera test statistics fails to reject the null hypothesis of normal distribution of most of the variables, which confirms that the series are normally distributed. Besides, the numeric of kurtosis for five variables is found below 3, which indicates the normality of distribution.

Table 3: Descriptive Statistics of the Variables

	LNFDI	LNMKTSIZE	LNOPEN	LNEXR	LNTRANS	LNICT	LNENERGY
Mean	2.10E+08	4.19E+10	28.14190	41.81828	14709.05	0.335149	131.9713
Median	8510000.	3.32E+10	23.12158	40.00090	15250.00	0.214058	121.7561
Std. Dev.	3.43E+08	2.94E+10	10.90583	19.29805	6312.904	0.256717	33.03804
Skewness	1.527612	1.403159	0.729065	0.213189	-0.368961	1.026658	0.817705
Kurtosis	3.957490	4.352790	2.501467	1.868171	1.687399	2.630094	2.532271
Jarque-Bera	15.80391	14.96258	3.660959	2.255204	3.495655	6.710775	4.460557
Probability	0.000370	0.000564	0.160337	0.323809	0.174152	0.034896	0.107498

Sources: Eviews output.

The figure for skewness of each variable is found to be mild and positively skewed, except for the LNTRANS, which is negatively skewed. The standard deviation of the series is found low when it is compared to the mean, which indicates a small coefficient of variation. In addition, the range of deviation between the maximum and minimum of each individual series is found to be reasonable in comparison to the mean. Finally, the mean over median ratio for the variable LNMKTSIZE and LNEXR are seen to be approximately one, five for the variable LNOPEN, ten for the variable LNICT and LNENERGY except for the variable LNFDI, which represents normality of distribution.

Table 4: The OLS of Foreign Direct Investment Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.31E+09	3.54E+08	3.714899	0.0008
LNMKTSIZE	0.015166	0.002623	5.782795	0.0000
LNOPEN	15138061	3912560.	3.869094	0.0005
LNEXR	12532966	5465302.	2.293188	0.0290
LNTRANS	-22075.93	9060.986	-2.436372	0.0210
LNICT	1.21E+09	2.15E+08	5.652355	0.0000
LNENERGY	-21008143	4842310.	-4.338455	0.0001

R-squared	0.965254	Mean dependent var	2.10E+08
Adjusted R-squared	0.958305	S.D. dependent var	3.43E+08
S.E. of regression	69985981	Akaike info criterion	39.13415
Sum squared resid	1.47E+17	Schwarz criterion	39.43891
Log likelihood	-716.9817	Hannan-Quinn criter.	39.24159
F-statistic	138.9009	Durbin-Watson stat	1.824152
Prob(F-statistic)	0.000000		

Normality	Jarque-Bera	Ho= Errors are normally distributed
F 0.052112 (0.974281)	Fail to reject Ho	
Serial Correlation	Breusch-Godfrey L.M	Ho= No serially correlated errors
F 1.632321 (0.2135)	Fail to reject Ho	
ARCH	F-Statistic	Ho= ARCH effect does not characterize model's errors
F 0.007718 (0.9305)	Fail to reject Ho	

Source: computed by author using the software.

Table 4 shows the regression results. The regression results of the model indicate that all of the explanatory variables are significant in attracting FDI inflow into Bangladesh. The result also reveals that market size, openness, exchange rate and information and communication technology infrastructure of the economy is positively related to FDI inflows into Bangladesh, and all the variables is highly significant. The results also reveal that transport infrastructure and energy use per capita of the economy has negative effect on FDI but found to be also significant. Overall, the regression results fail to reject the null hypothesis of the study. The adjusted R- squared is 0.965254, implying that 96% of the variation in the determinant of foreign direct investment is explained by the independent variables, which is an indication of the best fit of the model. In comparison to the R square, the adjusted R square is better and more precise good fit measure because it allows degree of freedom to sum of squares therefore even after addition of new independent variable(s) the residual variance does not change. The Durbin Watson statistic indicates the absence of autocorrelation among the variables.
The overall equation is highly statistically significant as shown by the probability value of the F-statistic (0.000000).

Thus the regression equation for the above model is given below:

$$LnFDI_t = 1.31 + 0.015166(LnMKTSIZE_t) + 15138061(LnOpenness_t) + 12532966(LnExR_t) - 22075.93\ (LnTrans_t) + 1.21\ LnICT_t - 21008143(LnEnergy_t)$$

To ascertain the goodness of fit of the estimated model, the diagnostic test was conducted. Diagnostic test suggests that the model passes the test of serial correlation, non-normality of the errors and heteroscedasticity associated with the model. The regression includes diagnostic statistics for testing against various alternative hypotheses: residual autocorrelation (DW and AR), skewness and excess kurtosis (Normality), autoregressive conditional heteroscedasticity (ARCH). The diagnostic test suggests that the model is the best fit. The model does not suffer from the problems of non-normality of the errors, ARCH effect, serially correlated errors and heteroscedasticity.

The table 5 presents that all the variables are not stationary in levels except foreign direct investment and the market size of the economy which is measure as gross domestic products. This can be seen as the observed values (in absolute terms) of ADF test statistics with the critical values (also in absolute terms) of the test statistics at the 1% and 5% level of significance. Result from the table provides strong evidence of non stationarity. Therefore, the null hypothesis is accepted and it is sufficient to conclude that there is a presence of unit root in the variables at levels, following from the above result, all the variables are differenced once and the ADF test is conducted on them, the result as shown in table below.

The unit root test result revealed that all the variables included in the model except FDI and MKTSIZE are found to be non-stationary at level but became stationary after first difference. Therefore the concept of co-integration is relevant. Since the co-integration test requires variables must be non-stationary at level but when they are converted to first difference, then they become stationary-integrated of same order we therefore considered only the variables that are integrated of the same order.

Table 5: ADF test for unit root

	Constant and No Trend		Constant and Trend		No Constant & No Trend	
	At Level	At 1st Differenced	At Level	At 1st Differenced	At Level	At 1st Differenced
LNFDI	3.376831	2.366261	3.623677	0.947809	3.217371	2.746515
LNMKTSIZE	7.689567	-0.666156	3.355673	-1.684612	2.826233	0.257887
LNOPEN	0.032081	-7.593736	-1.526435	-7.989803	2.015083	-6.835158
LNEXR	1.357004	-4.166409	-2.783906	-4.320242	3.874027	-1.335190
LNTRANS	-1.622553	-4.444157	-0.128760	-4.784910	1.425828	-3.495131
LNICT	1.304839	-4.109910	-2.791562	-3.721800	2.380430	-3.782307
LNENERGY	3.865710	-5.528877	-0.204984	-7.838624	6.233216	-0.793972

Source: Author's Envies output, Note: Test Critical Value at 1 and 5 percent level.

For obtaining an ideal lag for the model adopted in this study, we used a VAR lag order selection criteria. The optimal lag length of the level VAR system is determined using the Akaike's Information Criterion (AIC), Hernan-Quinn criterion (HQ) and Schwartz criterion (SC). However, five criteria of this manner exhibit that lag 3 is the optimal lag length, as shown in Table 6. In the Table 6, it can be seen obviously that the lag 3 represents the ideal selection due to the result of the criteria adopted via Eviews software. Therefore, the analysis of the specific model will be economically meaningful. So, we precede further tests with lags 3. Moreover, the Johansen trace test for cointegration is regressed to find out whether there is a long-run association amongst the variables of the study.

Table 6: VAR Lag Order Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2067.986	NA	2.41e+44	122.0580	122.3723	122.1652
1	-1813.926	388.5631	1.48e+39	109.9956	112.5096	110.8530
2	-1731.802	91.78546	3.12e+38	108.0472	112.7609	109.6547
3	-1624.467	75.76568*	3.59e+37*	104.6157*	111.5292*	106.9734*

* indicates lag order selected by the criterion

The result of the cointegration condition (that is the existence of a long term linear relation) is presented in Table 8 below using methodology proposed by Johansen (1990):

Table 7: Johansen Cointegration Tests

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.931722	255.8624	125.6154	0.0000
At most 1 *	0.849884	161.9166	95.75366	0.0000
At most 2 *	0.751926	95.54436	69.81889	0.0001
At most 3	0.525773	46.75335	47.85613	0.0632
At most 4	0.231016	20.64093	29.79707	0.3804
At most 5	0.156318	11.44697	15.49471	0.1855
At most 6 *	0.145362	5.497697	3.841466	0.0190
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.931722	93.94582	46.23142	0.0000
At most 1 *	0.849884	66.37222	40.07757	0.0000
At most 2 *	0.751926	48.79101	33.87687	0.0004
At most 3	0.525773	26.11242	27.58434	0.0762
At most 4	0.231016	9.193963	21.13162	0.8165
At most 5	0.156318	5.949271	14.26460	0.6197
At most 6 *	0.145362	5.497697	3.841466	0.0190

The results of the Johansen's cointegration test are presented in the table 5. Both the 'trace' statistic and 'maximum eigen value' test leads to the rejection of the null hypothesis of (no co-integrating vectors) against the alternative hypothesis (one or more cointegrating vectors) while the null of against the alternative cannot be rejected at 5% level of significance. The test indicates the presence of 3 cointegrating equations at 5 percent level of significance for the FDI model and therefore confirms the existence of long-run equilibrium relationship between FDI and explanatory variables.

Table 8: Result of the long run foreign direct investment model

Normalized cointegrating coefficients (standard error in parentheses)						
LNFDI	LNMKTSIZE	LNOPEN	LNEXR	LNTRANS	LNICT	LNENERGY
1.000000	0.019266	-21032236	-10512438	-10711.08	-2.23E+09	11349964
	(0.00304)	(4205912)	(7432660)	(11670.6)	(3.1E+08)	(4729273)
Adjustment coefficients (standard error in parentheses)						

The result of the long-run Foreign Direct Investment equation shows that market size and energy use per capita positive effects on foreign direct investment inflow in Bangladesh while openness, exchange rate, transport infrastructure and information and communication technology infrastructure have a negative effect on FDI. The elasticity shows that FDI inflow in Bangladesh is more positively responsive to energy use per capita of the economy than the market size while is more negatively responsive to exchange rate, openness than information and communication technology infrastructure. Table 8 also presents that the FDI inflow elasticity for market size, openness of the economy, exchange rate, transport infrastructure, information and communication technology infrastructure and energy use per capita are 0.02, -210, -105, -107, -2.23 and 113 respectively.

Now we also run Vector Autoregression (VAR) with the lag order of 3. The results of VAR are reported in Table 9. The results from the VAR residual normality test and the VAR residual serial correlation LM test are reported in Table 10 and Table 11, respectively. With the data from Table 10, we cannot reject the hypothesis of normality properties, since P-values are 0.1375, 0.8381 and 0.4133 for skewness, kurtosis and the Jarque-Bera test. This provides some support for the hypothesis that residuals from our VAR model have a normal distribution. Table 11 shows that we also cannot reject the null hypothesis of no autocorrelation up to lag 12, most of the lag shows that there is no serial correlation in the VAR model.

Table 9: Vector Autoregression Model

	LNFDI	LNMKTSIZE	LNOPEN	LNEXR	LNTRANS	LNICT	LNENERGY
LNFDI(-1)	-0.401861	2.225532	6.90E-09	2.19E-09	3.04E-06	-4.63E-11	6.13E-09
	(0.41789)	(5.93021)	(1.3E-08)	(6.1E-09)	(3.2E-06)	(1.1E-10)	(1.4E-08)
	[-0.96164]	[0.37529]	[0.52247]	[0.35735]	[0.96062]	[-0.40960]	[0.43131]
LNFDI(-2)	0.013462	18.10372	1.20E-08	-3.30E-09	-3.46E-06	-2.67E-10	-9.52E-09
	(0.40114)	(5.69250)	(1.3E-08)	(5.9E-09)	(3.0E-06)	(1.1E-10)	(1.4E-08)
	[0.03356]	[3.18028]	[0.94351]	[-0.56157]	[-1.14141]	[-2.46131]	[-0.69815]
LNMKTSIZE(-1)	-0.011385	0.800794	4.19E-11	-1.78E-11	8.87E-08	-9.56E-12	1.19E-10
	(0.00862)	(0.12236)	(2.7E-10)	(1.3E-10)	(6.5E-08)	(2.3E-12)	(2.9E-10)
	[-1.32042]	[6.54473]	[0.15382]	[-0.14068]	[1.35982]	[-4.10493]	[0.40746]
LNMKTSIZE(-2)	0.013006	0.032888	-1.49E-10	-1.03E-11	-1.13E-07	5.78E-13	4.02E-11
	(0.00848)	(0.12037)	(2.7E-10)	(1.2E-10)	(6.4E-08)	(2.3E-12)	(2.9E-10)
	[1.53337]	[0.27324]	[-0.55772]	[-0.08270]	[-1.75781]	[0.25236]	[0.13952]
LNOPEN(-1)	-12321765	-5.10E+08	0.453674	-0.262340	112.5380	0.001738	0.206361
	(8787025)	(1.2E+08)	(0.27759)	(0.12878)	(66.4881)	(0.00237)	(0.29874)
	[-1.40227]	[-4.09385]	[1.63431]	[-2.03707]	[1.69260]	[0.73185]	[0.69077]
LNOPEN(-2)	-5773551.	93510355	0.080080	0.056039	-51.11382	-0.000858	0.128881
	(8036392)	(1.1E+08)	(0.25388)	(0.11778)	(60.8084)	(0.00217)	(0.27322)
	[-0.71843]	[0.81996]	[0.31542]	[0.47579]	[-0.84057]	[-0.39504]	[0.47171]
LNEXR(-1)	-19957296	-1.13E+09	-0.259054	1.185757	253.4370	0.005240	0.402921
	(1.7E+07)	(2.5E+08)	(0.54730)	(0.25391)	(131.087)	(0.00468)	(0.58899)
	[-1.15198]	[-4.59027]	[-0.47333]	[4.67007]	[1.93335]	[1.11929]	[0.68409]
LNEXR(-2)	-21013811	8.44E+08	0.251763	-0.702350	-22.46749	-0.012746	0.113068
	(1.8E+07)	(2.6E+08)	(0.56840)	(0.26369)	(136.140)	(0.00486)	(0.61169)
	[-1.16794]	[3.30562]	[0.44294]	[-2.66351]	[-0.16503]	[-2.62189]	[0.18484]
LNTRANS(-1)	64488.41	327020.3	-0.000654	0.000601	0.784010	1.48E-05	-0.000723
	(27705.4)	(393161.)	(0.00088)	(0.00041)	(0.20964)	(7.5E-06)	(0.00094)
	[2.32765]	[0.83177]	[-0.74767]	[1.48016]	[3.73985]	[1.98124]	[-0.76767]
LNTRANS(-2)	-28494.01	-161285.1	0.000611	-3.82E-05	-0.265271	1.46E-06	0.000582
	(28976.3)	(411197.)	(0.00092)	(0.00042)	(0.21925)	(7.8E-06)	(0.00099)
	[-0.98335]	[-0.39223]	[0.66706]	[-0.08985]	[-1.20988]	[0.18681]	[0.59106]
LNICT(-1)	3.03E+09	4.41E+10	15.57379	-3.519845	-16956.28	0.241793	-16.47699
	(1.4E+09)	(2.0E+10)	(44.4337)	(20.6139)	(10642.6)	(0.38005)	(47.8183)
	[2.15548]	[2.20962]	[0.35049]	[-0.17075]	[-1.59325]	[0.63622]	[-0.34457]
LNICT(-2)	1.64E+08	-5.65E+10	-64.77335	3.168007	857.7978	1.925501	44.38495
	(1.4E+09)	(2.0E+10)	(44.4282)	(20.6113)	(10641.2)	(0.38000)	(47.8123)
	[0.11660]	[-2.83032]	[-1.45793]	[0.15370]	[0.08061]	[5.06711]	[0.92832]
LNENERGY(-1)	-322688.5	2.15E+08	0.174369	0.187177	11.88264	0.001503	0.307077
	(8807759)	(1.2E+08)	(0.27825)	(0.12909)	(66.6450)	(0.00238)	(0.29944)
	[-0.03664]	[1.71939]	[0.62667]	[1.45001]	[0.17830]	[0.63158]	[1.02549]
LNENERGY(-2)	12087992	2.21E+08	0.310117	0.128717	57.60866	0.001017	0.065891
	(9363796)	(1.3E+08)	(0.29582)	(0.13724)	(70.8523)	(0.00253)	(0.31835)
	[1.29093]	[1.66336]	[1.04835]	[0.93793]	[0.81308]	[0.40178]	[0.20698]
C	-6.81E+08	-2.44E+10	-31.20127	-19.98431	-6782.874	-0.219851	43.10499
	(8.6E+08)	(1.2E+10)	(27.2236)	(12.6297)	(6520.49)	(0.23285)	(29.2973)
	[-0.79041]	[-1.99537]	[-1.14611]	[-1.58232]	[-1.04024]	[-0.94419]	[1.47130]

Table 10: VAR Residual Normality Test

Component	Skewness	Chi-sq	df	Prob.
1	0.312751	0.570577	1	0.4500
2	0.202106	0.238274	1	0.6255
3	0.228558	0.304725	1	0.5809
4	0.737788	3.175268	1	0.0748
5	0.894465	4.667060	1	0.0307
6	-0.502411	1.472430	1	0.2250
7	-0.319786	0.596533	1	0.4399
Joint		11.02487	7	0.1375

Component	Kurtosis	Chi-sq	df	Prob.
1	3.314765	0.144488	1	0.7039
2	3.031493	0.001446	1	0.9697
3	2.342494	0.630458	1	0.4272
4	4.206188	2.121714	1	0.1452
5	3.461354	0.310402	1	0.5774
6	2.639151	0.189893	1	0.6630
7	2.774221	0.074340	1	0.7851
Joint		3.472741	7	0.8381

Component	Jarque-Bera	df	Prob.
1	0.715065	2	0.6994
2	0.239720	2	0.8870
3	0.935184	2	0.6265
4	5.296981	2	0.0708
5	4.977462	2	0.0830
6	1.662323	2	0.4355
7	0.670873	2	0.7150
Joint	14.49761	14	0.4133

Table 11: VAR Residual Serial Correlation LM Test

Lags	LM-Stat	Prob
1	78.25852	0.0050
2	66.83099	0.0460
3	68.95654	0.0315
4	57.20741	0.1967
5	64.40674	0.0690
6	70.84888	0.0222
7	46.18372	0.5880
8	47.27090	0.5435
9	75.62843	0.0086
10	60.48079	0.1259
11	64.06046	0.0729
12	47.63290	0.5286

Probs from chi-square with 49 df.

Table 12: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: LNFDI

Excluded	Chi-sq	df	Prob.
LNMKTSIZE	2.628154	2	0.2687
LNOPEN	4.106870	2	0.1283
LNEXR	6.158564	2	0.0460
LNTRANS	5.673570	2	0.0586
LNICT	7.235818	2	0.0268
LNENERGY	1.678084	2	0.4321
All	36.52310	12	0.0003

Dependent variable: LNMKTSIZE

Excluded	Chi-sq	df	Prob.
LNFDI	11.06751	2	0.0040
LNOPEN	17.84194	2	0.0001
LNEXR	21.83194	2	0.0000
LNTRANS	0.708686	2	0.7016
LNICT	8.566717	2	0.0138
LNENERGY	6.439075	2	0.0400
All	72.03192	12	0.0000

Dependent variable: LNOPEN

Excluded	Chi-sq	df	Prob.
LNFDI	1.391389	2	0.4987
LNMKTSIZE	0.355172	2	0.8373
LNEXR	0.269620	2	0.8739
LNTRANS	0.634783	2	0.7280
LNICT	2.449312	2	0.2939
LNENERGY	1.658438	2	0.4364
All	11.26706	12	0.5062

Dependent variable: LNEXR

Excluded	Chi-sq	df	Prob.
LNFDI	0.382211	2	0.8260
LNMKTSIZE	0.060758	2	0.9701
LNOPEN	4.345576	2	0.1139
LNTRANS	3.168660	2	0.2051
LNICT	0.034009	2	0.9831
LNENERGY	3.325985	2	0.1896
All	33.18891	12	0.0009

Dependent variable: LNTRANS

Excluded	Chi-sq	df	Prob.
LNFDI	1.886299	2	0.3894
LNMKTSIZE	3.261325	2	0.1958
LNOPEN	2.880614	2	0.2369
LNEXR	4.986614	2	0.0826
LNICT	3.513985	2	0.1726
LNENERGY	0.734232	2	0.6927
All	14.50944	12	0.2694

Dependent variable: LNICT

Excluded	Chi-sq	df	Prob.
LNFDI	6.826963	2	0.0329
LNMKTSIZE	23.75667	2	0.0000
LNOPEN	0.543564	2	0.7620
LNEXR	7.060853	2	0.0293
LNTRANS	6.836664	2	0.0328
LNENERGY	0.624513	2	0.7318
All	141.0394	12	0.0000

Dependent variable: LNENERGY

Excluded	Chi-sq	df	Prob.
LNFDI	0.582432	2	0.7474
LNMKTSIZE	0.380609	2	0.8267
LNOPEN	1.201689	2	0.5483
LNEXR	0.943707	2	0.6238
LNTRANS	0.616764	2	0.7346
LNICT	0.908167	2	0.6350
All	10.92590	12	0.5353

We have adopted the VAR Granger Causality/Block Exogeneity Wald Tests to examine the causal relationship among the variables. Under this system, an endogenous variable can be treated as exogenous. We used the chi-square (Wald) statistics to test the joint significance of each of the other lagged endogenous variables in each equation of the model & also for joint significance of *all* other lagged endogenous variables in each equation of the model. Results are reported in Table 10. A chi-square test statistics of 2.628154 for LNMKTSIZE with reference to LNFDI represents the hypothesis that lagged coefficients of LNMKTSIZE in the regression equation of LNFDI are equal to 0.2687 that means LNMKTSIZE does not granger cause LNFDI where null hypothesis is not rejected rather we accept the null hypothesis. Similarly, the lagged coefficients of LNOPEN and LNENERGY as well as block of all coefficients in the regression equation of LNFDI are equal to 0.1283 and 0.4321 respectively. Thus, LNMKTSIZE, LNOPEN and LNENERGY do not have Granger Cause for LNFDI at 0.2687 0.1283 and 0.4321 levels of significance respectively. The null hypothesis that LNEXR, LNTRANS and LNICT do not granger cause LNFDI is rejected. That means LNEXR, LNTRANS and LNICT do granger cause to LNFDI. Also, all the variables are Granger Causal for LNFDI at the 0.0003 significance level. The test results for LNFDI equation however indicates that null hypothesis cannot be rejected for individual lagged coefficient LNMKTSIZE, LNOPEN and LNENERGY. This suggests that LNFDI is not influenced by these three explanatory variables that mean market size, openness of the economy and energy infrastructure in Bangladesh.

The null hypothesis of block exogeneity is rejected for all equations in the model, except for LNOPEN, LNTRANS and LNENERGY. This indicates LNOPEN, LNTRANS and LNENERGY are not jointly influenced by the other variables. The evidence of uni-directional causality is observed among LNEXR, LNTRANS, LNICT and LNFDI. The uni-directional causality is also observed among LNFDI, LNOPEN, LNEXR, LNICT, LNENERGY and LNMKTSIZE. It is also seen in LNEXR and LNTRANS. From the equation in LNICT, the study shows that LNFDI, LNMKTSIZE, LNEXR, LNTRANS are uni-directional causality with LNICT which implies that these variables are influenced by each other. Bi-directional causality is observed only from LNICT to LNFDI in Bangladesh.

7. CONCLUSION

This study investigates the infrastructure factors enhancing the attractiveness of FDI recipient in Bangladesh over the period 1975-2011. The regression results of the model indicate that all of the explanatory variables are significant in attracting FDI inflow into Bangladesh. The result also reveals that market size, openness, exchange rate and information and communication technology infrastructure of the economy is positively related to FDI inflows into Bangladesh, and all the variables is highly significant. The results also reveal that transport infrastructure and energy use per capita of the economy has negative effect on FDI but found to be also significant. Overall, the regression results fail to reject the null hypothesis of the study. Analysis shows that there is a long-run relationship between foreign direct investment (FDI) and the level of the infrastructure. The empirical results further confirm the bi-directional causality from information and communication technology infrastructure to FDI.

The results of the study suggest that there is an implication for policy—governments should take a plan to develop the infrastructure in order to attract

FDI. Improving infrastructure such as ICT based infrastructure is a main objective of the trade facilitation agenda, which aims to increase the bureaucratic and administrative efficiency of customs, ports, and investment gateways and generally speed the movement of goods, services, and local investments as well as foreign direct investment.

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