Road Transportation Infrastructure, Industrial Evolution And Economic Growth: Evidence From Bangladesh

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Abstract: This paper sheds some light on the interaction among road transportation infrastructure, industrial evolution and economic growth in Bangladesh and further the study have worked out how they are interrelated by using Autoregressive Distributed Lag (ARDL) and Vector Error Correction Model (VECM) methods. Empirical findings in this study suggest that, economic growth is strongly co-integrated with industrial evolution and road transport infrastructure in Bangladesh, indicating the presence of long-run relationship among them. The study reflects a significant positive long-run impact of industrial evolution and a significant negative long-run impact of road transportation infrastructure on economic growth in Bangladesh. Further, the causality test confirms the presence of bidirectional causality between industrial evolution and economic growth in the short-run. But the study couldn't find any causal effect flowing from road transportation infrastructure to economic growth & vice-versa. The policy recommendations of this study are straightforward. If Bangladesh needs to retain a stable and smooth economic growth, gradual improvement of road transport infrastructure and build up more industries alongside improve the efficiency of the industrial sector is urgently needed.

Keywords: Bangladesh, Road Transportation, Industrial Evolution, GDP, Economic Growth, ARDL, VECM

1 INTRODUCTION

Rapid growth process enabled Bangladesh to fulfill the criterion of lower middle-income country in 2015. In 2018, Bangladesh fulfilled the criterion for graduation from United Nation's Least Developed Countries (LDC) and is on the right track for graduation to a middle-income country by 2024 (Bangladesh overview- World Bank, 2019). Average GDP growth in the last decade was 6.5% according to official estimates despite poor infrastructure, insufficient power supplies, and slow implementation of economic reforms. Bangladesh has also done a remarkable progress on socio-economic indicators. Per capita GDP growth of Bangladesh is expected at 6.6% in 2020 according to Asian Development Bank (ADB) report. Bangladesh continues to be one of the fastest growing economies in the world. Robust growth in industrial and service sectors, supported by higher public and private consumption, have boosted growth of the country. Bangladesh will celebrate her 50th birthday on 2021 and by then she is expecting to retain the rapid economic growth and give her people a wealthy life. Road transportation infrastructure and industrialization has always been a key factor in this development process. Sustained economic growth also increases the demand for transportation, industrialization and urbanization. Road transport system has put a great impact to the country's trade and commerce in recent periods. Besides, rapid growth rate of added values from the industrial sector is remarkable rather than other sectors of the economy. Both factors are contributing significantly to the country's growth process.

Infrastructure of road transportation in Bangladesh developed in a very slow pace because of the predominance of the water transportation system. Historically, road infrastructures are very weak and vulnerable to the natural disasters. But in recent years, road transportation infrastructure and its impact on the national economy has increased conspicuously. In such a developing country like Bangladesh, roads and highways can play a vital role in the root level development. Sustainable road infrastructure can attract direct investment from home and abroad, which accelerates the growth process of the country. Road transportation has access to wider market base where economies of scale in production, consumption and distribution can be improved. Road infrastructure is a very essential structural element of a country like Bangladesh as it connects one region to another region, one city to another city, one village to another village. A strong road infrastructural network can put a positive influence on social, commercial and demographic problems like rural to urban population migration, corruption, weak medical support, educational barriers, poverty, unemployment and others. So, it is essential to build up more sustainable road transportation infrastructure to connect the main economic hubs of the country to strengthen the socio-economic structure of Bangladesh. In this context, Bangladesh government's policy for the transport sector is spelt out in the 'National Land Transport Policy' approved in 2004. The policy objectives include provision of safe and dependable transportation services, and improving the regulatory and legal framework. The rate of production of the industrial sector can be increased more rapidly than the other core sectors like agriculture or service sector. So, industrialization is more essential for impetuous prosperity of a nation. Besides, industrialization is considered as a pre-requisite for the economic development. Industrialization play a vital role in the increment of standard of living and per capita income. Through introducing with various technologies, the industrial sector is playing a role of pioneer in the modern economy of the nations. Industrialization is the period of social and economic transformation that switches a human group from an agrarian society into an industrial one, based on the manufacturing of various goods and services. This happens in countries when they start to use machines to do work that was once done by people. Technological invention and innovation, modernization, urbanization, structural transformation of the economy and diversification of the

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economic basement accelerate economic growth and employment creation to the worldwide nations. Increase in per capita income and improvement in standard of living of the people are the universally recognized dynamic benefits obtaining from industrial development. Industrialization introduces a form of discreet change where people obtain a different attitude towards a sociological process of widespread rationalization and their perception of nature. Modernization of the industrial sector through developed science and technology is necessary for modernization of the other core sectors of the economy. Furthermore, industrial development encourages development of new technologies, capital formation for investment, planned urbanization, expanding international trade, use of natural resources, alleviation of poverty and unemployment, fast growth of per capita and national aggregate income of a country. The industrial sector in Bangladesh makes a huge contribution to the country's economic growth since 1971. Industrialization and specialization in manufacturing is the ultimate path in which Bangladesh can raise its per capita income and social structure. Furthermore, in order to accelerate the pace of industrialization of the country the government announced the 'National Industrial Policy' in 2016. However, Bangladesh is a densely populated, agro-based developing South Asian economy has a real per capita GDP of US$ 1,203 (June, 2018). For retaining current economic growth of this country, road transportation infrastructure and industrial evolution can play a vital role and can enhance the economy to achieve the ultimate goal.

2 THEORITICAL FRAMEWORK

2.1 The Classical Theory

Adam Smith considered the natural course of economic development as agriculture, industry and commerce sequentially. He said, agricultural sector creates surplus which increases the purchasing power of people and that creates demand for industrial products. It also provides the raw materials for the industrial sector. The most important contribution of smith to the growth theories is that he emphasize on the growth of industry and agriculture, as capital accumulation or investment depends on savings out of profit generated by these sectors. Adam Smith based his theory of economic growth on the socio-economic conditions at his time in Europe, when the seed of industrialization has already been implanted on the economy. Smith described industrial enterprises as one of the agent of economic growth. As a classical economist, Professor W. Arthur Lewis's 'systematic theory of economic development' mainly focuses on the structural transformation of a subsistence economy into a modern industrial economy to obtain sustainable economic growth. Later the dual economy model developed by John Fei and Gustav Renis. This model was a flaw in Lewis model. It explains how the increased productivity in agricultural sector would become helpful in promoting industrial sector. As one of the fathers of classical development economics, Ragnar Nurkse gave importance to reduce transport costs to promoting international cooperation in importing and exporting in his balanced growth theory. According to Fredrick list the theory of balanced growth has a great significance by which a balance could be achieved between agriculture, industry and trade. Adam Smith's view on infrastructure was also eminent. He described road and bridge infrastructures as public infrastructures and as an important accelerator of trade and commerce. According to his thought, well planned infrastructures like road, railways and other modes of communication provides basic services and lead to economic growth. Adam Smith seemed to very keen about government provide for public infrastructure like roads, canals and bridges and also keen to have those factors that make use of the infrastructure contribute to its preservation (Wealth of Nations, Book v, Part 3).

2.2 The Keynesian Economics

During the Great Depression the theories forming the basement of the Keynesian economics were first presented by John Maynard Keynes (1936) in his book named "The General Theory of Employment, Interest and Money". Though Keynes was not a development economist, but the interaction of some relevant economic agents can be found in his theory. The other Keynesian economists supported circular and cumulative process about economic growth. Keynesian economics is a theory that says, government should increase demand to boost up the economic growth. Keynesian economists thought that, demand is the preliminary driving force for the economy. One of the key concept of Keynesian economics was, government spending on infrastructure, unemployment benefits and educational support will increase consumer demand. Hence, it will lead to economic growth. Keynes predicted that, public infrastructure deficit spending could result in a multiplier effect on economic growth. This especially might be true when the real interest rates are low. Nicholas Kaldor (1966, 1967) provided a high level of correlation between the level of industrial activities and economic growth to some level income. Kaldor proposed three laws which are related to the causation of economic growth. Firstly he said that, the growth of GDP and the growth of manufacturing sector are positively correlated. The first law of Kaldor states that, 'manufacturing sector is the engine of growth'. Besides that, as a Keynesian economist, Petrus Johannes Verdoorn (1949) thought that, the productivity growth rate is endogenous and it depends on the output growth rate, endogeneity of the factors, understanding dynamic contexts and increasing economies of scale, namely in the industry. This relationship later considered as the second law of Kaldor (1966, 1967). The second law (also known as Verdoorn's Law) reflects that, there is a positive causal relationship between output and labor productivity in manufacturing sector. Which derives from static and dynamic increasing returns to scale. The simplest form of Verdoorn law can be specified as below:

$$P_{it} = a + bq_{it}$$

Where, P_{it}= Growth rate of labor productivity
Bq_{it}= Output in the industrial sector
i= specification of the economy
t= time

At the last law, Kaldor said that, the positive correlation of productivity of the non-manufacturing sector to the prosperity of the manufacturing sector is predicted on the assumption of the diminishing returns of the non-industrial sector.

2.3 The Austrian School Concepts

The originator of the "Big Push" growth theory is Paul Rosenstein-Rodan, who was trained in the Austrian tradition. This theory is a modern version of an old idea of external economics. It is based on an idea that industrial economy enjoys many external economies. The theory emphasize on planned industrialization of under developed countries where agriculture is the dominant sector. He thought agriculture as a backward sector which riddled with poverty. He said, a big push to industrialization is expected to place the system on strong rooting and to prevent the uncertainties arising from the agricultural sector. Austrian thinkers unlike many other same economists believe that, the free market can function in sectors such as infrastructure (road and electricity) and dealing with externalities.

2.4 The Neoclassical Growth Theory

Solow's neoclassical growth model of economic growth presents a relationship between the total output and the aggregate inputs of the factors of production of a country. The model is based on the basic assumption of constant capital-output ratio with no government intervention, full employment at all times, constant labor force growth rate and constant technology. The Solow's model assumes that, physical capital is the standard measure of capital in the economy. From the economic definition point of view, road transportation infrastructure can be considered as a capital good because it is used in the production of other goods and services by necessitating the mobility of goods and services within an economy. Therefore in this scenario, the amount of capital stock within the economy will affect the economic growth rate. Which implies that, the road infrastructure network being part of the physical capital affects the economic growth. This is therefore the link between the road transportation infrastructure and economic growth as plotted by the Solow's model of economic growth. Professor Solow considers, the most important feature of an underdeveloped economy is the dual economy. This economy consists of two sectors. One is the capital sector or industrial sector and another is the labor sector or agricultural sector. In industrial sector, the rate of accumulation of capital is more than rate of exploitation of labor. According to Solow, for attaining long-run growth an assumption can be made that, capital and labor both increase but capital increases at a faster rate than labor. So that, the capital-labor ratio is high. As a result, if the capital-labor ratio increases, the output per worker declines and national income falls. Solow assumed that, technical coefficients of production is variable. So, that the capital-labor ratio may adjust itself to the equilibrium ratio. If the capital labor ratio is higher than the equilibrium ratio, then as a result the growth of capital and output capital would be lesser than the labor force. In this contrary, many employment opportunities can be created with the help of variable technical coefficients. In agricultural sector, real wages and productivity per worker is very low. To achieve sustained economic growth, the capital-labor ratio must be high as the improvement of industrial sector is obvious. So, the underdeveloped economies must follow Solow's theory to attain a steady economic growth.

3 LITERATURE REVIEW

Empirical studies related to this study area in the context of Bangladesh are very few. This study can be considered as almost new empirical analysis of road transportation infrastructure and industrial evolution relating to the economic growth in the perspective of Bangladesh. A study on impact of new road on rural livelihood in Bangladesh by Ali, M. Y. et al. (2016) was conducted to understand the impact of new roads on the inhabitant of rural areas in Bangladesh. The shortcomings from the study are a new road dramatically change people's lifestyle with local economy and socio-cultural environments, transport development, trade and commerce, infrastructural expansion, establishment of small to medium scale industries. Due to establishment of new highway, urbanization occurs rapidly. In that case, they suggested that the government should make more highways to improve the country's economic condition. An empirical study of Amin and Sonobe (2013) on the success of the industrial development policy in the pharmaceutical industry in Bangladesh reflects a case study on the success of governmental policy in the pharmaceutical industry. In this path, other industrial policies need to be implemented properly for robust growth of the industrial sector in Bangladesh. Ahaduzzaman et al. (2017) showed the major industrial growth of Bangladesh and their contribution to the country's development. They presented the prospects and recommendations for major industrial sectors in their study to achieve a smooth and sustainable industrial growth which can further lead to economic growth in Bangladesh. Radhia and Bouzid (2017) deployed a study on transport infrastructure and economic growth in the case of Tunisia for the period from 1980 to 2013 by using ARDL bounds testing approach and found that, transport infrastructure and transport infrastructure investment in Tunisia has a positive significant impact on economic growth. They also suggested to design an economic policy that will improve transport infrastructure and increase transport investment for making the sector suitable for sustainable economic growth in Tunisia. Junwook and Baek (2016) tried to assess the short-run and long-run effect of the transport and non-transport infrastructure on economic growth by using ARDL bounds testing approach in the context of USA. They found a long-run bidirectional relationship between transport infrastructure and GDP. Which suggests that, transport infrastructure improves aggregate economic output in the long-run and enhanced economic output increases public investment in the transportation sector. An extensive econometric study of Pradhan (2013) examined the role of transportation (road and rail) infrastructure on economic growth in India over the period 1970-2010 by using ARDL bounds testing and Vector Error Correction Model (VECM) approach and found that, expansion of transportation infrastructure along with the gross capital formation will lead to substantial growth in the Indian economy. The study also founded a bidirectional causality between road transportation infrastructure and economic growth. From his study, he suggested a suitable transport policy should be retained to boost up transportation infrastructure and hence sustainable economic growth in India. A study on public transportation investment and economic growth in Turkey was completed by Merter (2017). He found, regarding public railway and highway investments, the net impact of

public railway investments has been positive only in the short-run and the net impact of public highway investments has been positive both in the short-run and long-run on the economic growth of Turkey. Yu (2012), Liu and Zhao (2005), Zhang (2012), Ma and Li (2001) discovered that, transportation infrastructure is the key factor to both foreign direct investment and economic growth in China and it also causes poverty alleviation. By using Generalized Methods of Moment and Autoregressive distributed lag model investigated the role of infrastructure in promoting economic growth in China for the period 1975 to 2007, Pravakar et al. (2010) found that, infrastructure and investment have played an important role in economic growth in the Chinese economy. Brunel (2005) examined the correlation between freight transport and economic growth. The study aimed to give an empirical explanation of the coupling by deploying a panel data estimation approach in the case of European Union. The results of the study revealed two factors of coupling and other two factors of decoupling. Factors of coupling found in that study are the increasing distance of transport and the growing modal share of road transport. Inversely, two factors of decoupling were the declining share of the industry in the GDP and the decreasing weight of the industrial production. The study also suggested to apply this model to other countries from other continents of the world to investigate the evolution of the key factors. Chakraborty and Nandi (2011), Khandker and koolwal (2011) concluded that, the impact of the transport and communication infrastructure is a topic that has drawn a lot of attention in the literature along the few last years. Boopen (2006) analyzed the contribution of transport capital to growth in Sub-Saharan Africa and a sample of Small Island Developing States by using both cross sectional and panel data analysis. The study concludes that, transport capital is a major contributor to the economic progress of the Sub-Saharan African countries. On the basis of the Spanish case, an empirical study was conducted by Cantos et al. (2005) to find out the impact of transportation infrastructure on regional economic growth. The results from the study indicates that, it is road infrastructures that explain with some extent the economic growth of the regions in Spain (Cantos et al., 2005). A paper on "Industrialization: Panacea for Economic Growth" by Odeleye and Olunkwa (2019) examined the relationship between industrialization and economic growth in Nigeria for the time period 1981-2005 by employing ARDL approach. The empirical results of the study confirmed that, and a long-run relationship exists between industrialization and economic growth in Nigeria. Comparing with the Asian tigers, they suggested the policymakers to rigorously stay in the path of industrialization to achieve a sustainable economic growth. Cherniwehan (2012) argued on the compositional shift from agriculture to industrialization is a main determinant of changes in environmental quality as economies develop. He also examined the effect of sulfur emission emerged from the industries in the case of 157 countries of the world. A study on "contribution of industrial structure to economic growth: the case of ECOWAS" by Sarpe and Manga (2017) proposed to determine the weight of industry in the economic growth in the ECOWAS region. The findings from the study indicate that, improvement in the regional industrial infrastructure increases its growth rate.

Zhao and Tang (2018) conducted an empirical study to find out industrial structural change and economic growth by comparing Russia-China case. They found that, Chinese economy was concentrated more in the industrial sector and less in the service sector than Russia. The acceleration of economic growth in China in the middle of 2000s was mainly due to manufacturing sector. In the other hand, in Russia the acceleration was mainly due to service sector followed by the mining and oil-gas industry. Karami et al. (2019) examined the effect of manufacturing value added on economic growth in the case of Europe for the time period 1995-2016. The result of this study revealed that, the economic growth has a significantly positive relationship with manufacturing, labor force, and technology. The unexpected interesting result from the study is that, the relationship between economic growth and investment is significantly negative. Su and Yao (2016) effectuated a study named "manufacturing as the key engine of economic growth for middle income economies". From the study the found that, manufacturing industrial development can not only improve the incentives of further savings, but also improve the technological accumulation. Lastly they proved that, manufacturing industrial sector can better utilize human capital and economic institutions compared to other sectors. According to their study, the most important policy implication drawn is on the necessary industrial policies for the middle income economies. It seems that governments in developing economies should play an important role in preventing a country from premature deindustrialization, especially in this era of globalization. The poor performance of manufacturing industries and the relatively strong performance of services in some developing economies may not be a good for maintaining sustainable long-run economic growth. Anaman and Amponsah (2007) analyzed the causal linkage between the growth of the construction industry and the growth of the macro-economy in Ghana. The empirical finding of this paper shows that, growth in the construction industry Granger causes economic growth in Ghana. The also suggest a policy implication of considering construction industry as one of the major drivers of economic growth in Ghana.

4 DATABASE AND METHODOLOGY

This article looks into secondary datasets obtained from different sources. Annual time series data from 1976 to 2018 are used for this empirical investigation. The data were obtained from World Development Indicators (WDI) reported by World Bank and from Road Condition Survey (RCS) report compiled by Roads and Highways Department (RHD) under the Ministry of Road Transport and Bridges, Government of the People's Republic of Bangladesh. Besides, various national and international data sources have been considered to obtain relevant information. In this study, all data are used in logarithm form in order to include the proliferative effect of time series. The core variables of the study are economic growth (GDP), road transportation infrastructure (RTR) and industrial evolution (IND). The main purpose of the study is to investigate if these variables interacts with each other in the growth process and to find out if there any causal relationship exist among them. The aim of the study is to answering the following questions:

- ✓ Is there any relationship among road transportation infrastructure, industrial evolution and economic growth in Bangladesh?
- ✓ Does any short-run or long-run relationship exist among these variables?

Finally this study will test the following hypothesis:

- ✓ H1: Road transportation infrastructure Granger-causes economic growth.
- ✓ H2: Industrial evolution Granger-causes economic growth.
- ✓ H3: Road transport infrastructure Granger-causes industrial evolution.

Some econometric analysis and diagnostic tests have been performed in this study to find out the results to answer the research questions and to test the validity of econometric model. These are:

- ✓ Descriptive statistics
- ✓ Correlation analysis
- ✓ Unit root test
- ✓ ARDL bounds test for co-integration
- ✓ Optimum lag selection
- ✓ Vector error correction estimates
- ✓ Spuriousness test
- ✓ Autocorrelation test
- ✓ Heteroscedasticity test
- ✓ Stability test
- ✓ VECM Granger causality test
- ✓ The Econometric Model

After verifying by the theoretical framework, the structural equation to determine the relation between dependent and independent variables in this study is:

$$LGDP = f(LRTR, LIND) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Considering the above function in the context of multiple regression, the evaluation of the function can be done on the basis of following equation:

$$LGDP_t = \beta_0 + \beta_1 LRTR_t + \beta_2 LIND_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

To complete the specification of the econometric model, the form of algebraic or linear relationship among the economic variables might be considered. In this relationship a log-linear econometric model is as follows:

$$LGDP_t = \beta_0 + \beta_1 LRTR_t + \beta_2 LIND_t + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where,
β_0 = Intercept term
β_1 = Slope coefficient of LRTR
β_2 = Slope coefficient of LIND
ε_t = Random disturbance term
LGDP = Natural logarithm of GDP
LRTR = Natural logarithm of road transportation infrastructure
LIND= Natural logarithm of industrial evolution

The disturbance term counts for many factors which affect GDP that has omitted from this simple model and it also includes the intrinsic and random behavior in the economic activities.

4.1 ARDL BOUNDS TEST FOR CO-INTEGRATION

Co-integration concept was first introduced by Granger (1988). It is a multivariate problem that focuses on how to determine a long-run relationship between variables. From statistical point of view, a long-run relationship describes that the variables move together over time so that the short-term disturbances arising from the long-term trend are corrected. The ARDL bounds testing framework is used in this research to identify the existence of any long-run relationships among road transportation infrastructure, industrial evolution and economic growth in Bangladesh. This technique for the test of co-integration is chosen because this method has a number of advantages compared to other traditional methods such as Engle and Granger (1987) and Johansen (1988) co-integration methods. These two traditional methods estimate long-run relationships in the context of a system of the equations. But the ARDL method uses only a single reduced form equation (Pesaran and Shin, 1999). The Autoregressive Distributive Lag (ARDL) bounds testing approach was originally introduced by Pesaran and Shin (1999) and further extended by Pesaran, Shin and Smith (2001). ARDL model is an Ordinary Least Square (OLS) based model which is applicable for both non-stationary time series and time series with mixed order of integration and this technique does not require pretests for unit roots unlike other techniques (Peasaran et al., 2001; Nkoro and Uko, 2016). But it is must to make sure that none of the variables is integrated stochastic trend of I(2). ARDL approach is superior to other co-integration tests as it gives more authentic results in the case of a small sample study like this. Another advantage of ARDL bounds testing approach is that Unrestricted Error Correction Model (UECM) has flexibility to take satisfactory lags that captures the data generating process with agenda (in a general to specific framework) of specification (Laurenceson and Chai, 2003). The ARDL model involves in estimating the following equations of UECM used in this study:

$$\Delta LGDP_t = \beta_0 + \sum_{i=1}^{p} \lambda_i \Delta LGDP_{t-i} + \sum_{i=1}^{q1} \delta_{1i} \Delta RTR_{t-i} + \sum_{i=1}^{q2} \delta_{2i} \Delta LIND_{t-i} + \varphi_1 LGDP_{t-1} + \varphi_2 LRTR_{t-1} + \varphi_3 LIND_{t-1} + V_{1t} \quad \ldots\ldots\ldots \quad (4)$$

$$\Delta LRTR_t = \beta_0 + \sum_{i=1}^{p} \lambda_i \Delta RTR_{t-i} + \sum_{i=1}^{q1} \delta_{1i} \Delta LGDP_{t-i} + \sum_{i=1}^{q2} \delta_{2i} \Delta LIND_{t-i} + \varphi_1 LRTR_{t-1} + \varphi_2 LGDP_{t-1} + \varphi_3 LIND_{t-1} + V_{2t} \quad \ldots\ldots\ldots \quad (5)$$

$$\Delta LIND_t = \beta_0 + \sum_{i=1}^{p} \lambda_i \Delta LIND_{t-i} + \sum_{i=1}^{q1} \delta_{1i} \Delta LGDP_{t-i} + \sum_{i=1}^{q2} \delta_{2i} \Delta RTR_{t-i} + \varphi_1 LIND_{t-1} + \varphi_2 LGDP_{t-1} + \varphi_3 LRTR_{t-1} + V_{3t} \quad \ldots\ldots\ldots \quad (6)$$

Where,
LGDP = Natural logarithm of Gross Domestic Product (GDP)
LRTR= Natural logarithm of road transportation infrastructure

LIND= Natural logarithm of Industrial evolution
Δ= The difference operator

4.2 THE ERROR CORRECTION MODEL SPECIFICATION AND LONG-RUN AND SHORT-RUN ELASTICITIES

Once there have evidence of co-integration in the ARDL bounds testing framework, the ARDL model can be re-parameterize into the error correction model. Then the study will proceed to specify the error correction specification as follows:

$$\Delta LGDPt=\beta_0+\sum_{i=1}^{p}\lambda_1\Delta LGDP_{t-i}+\sum_{i=0}^{q1}\delta_{1i}\Delta LRTR_{t-i}+\sum_{i=0}^{q2}\delta_{2i}\Delta LIND_{t-i}+\varphi ECT_{t-1}+\varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Error correction term (ECTt-1) is the lagged OLS residuals obtained from running the long-run model (LGDPt=β0+ β1LRTRt + β2LINDt+εt). So the error correction term can be defined the as follows:

$$ECT_{t-1}= \varepsilon_{t-1}= LGDP_{t-1} - (\beta_0 + \beta_1 LRTR_{t-1} + \beta_2 LIND_{t-1})$$

If co-integration exists in the ARDL bounds co-integration test, the error correction term represents the speed of adjustment to long-run equilibrium after a deviation in the short-run model. The coefficient of error correction term (φ) is the speed of adjustment and it also means the independent variables Granger causes the dependent variable in the long-run. Significance of φ is determined by its t-statistic. To ensure convergence toward long-run equilibrium φ should be negative and statistically significant. Significance of φ is determined by its t-statistic. If φ is positive, the model will be considered as unstable and explosive.

4.3 VECM GRANGER CAUSALITY ANALYSIS

The Granger test suggests that, Granger Causality exists at least in one direction if there is co-integration among the variables in equation (2) providing that the series are integrated order of one or I(1). Enger and Granger (1987) caution that, in the first difference of the variables and in the existence of any long-run relationship, the Granger Causality test based on the Vector Auto Regressive (VAR) technique may produce inconsistent results. So, by adding a variable called the Error Correction Term (ECT), it will be helpful to check the long-run connection. The VECM analysis investigates the long-run and short-run causality running from each other among the variables. After confirming the existence of co-integration among road transportation infrastructure, industrial evolution and economic growth the study might proceed the conduct the Granger causality test under VECM. The VECM framework for Granger causality test is:

$$\Delta LGDP_t=\alpha_{10}+\sum_{i=1}^{q}\alpha_{11}\Delta LGDP_{t-i}+\sum_{i=1}^{r}\alpha_{12}\Delta LRTR_{t-i}+\sum_{i=1}^{s}\alpha_{13}\Delta LIND_{t-i}+\eta_1 ECT_{t-1}+\varepsilon_{1t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$\Delta LRTR_t=\alpha_{20}+\sum_{i=1}^{q}\alpha_{21}\Delta LGDP_{t-i}+\sum_{i=1}^{r}\alpha_{22}\Delta LRTR_{t-i}+\sum_{i=1}^{s}\alpha_{23}\Delta LIND_{t-i}+\eta_2 ECT_{t-1}+\varepsilon_{2t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

$$\Delta LIND_t=\alpha_{30}+\sum_{i=1}^{q}\alpha_{31}\Delta LGDP_{t-i}+\sum_{i=1}^{r}\alpha_{32}\Delta LRTR_{t-i}+\sum_{i=1}^{s}\alpha_{33}\Delta LIND_{t-i}+\eta_3 ECT_{t-1}+\varepsilon 3t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where,
Δ = The difference operator
α_{it} = The constant term

ECT represents the Error Correction Term, which is derived from the long-run co-integrating relationships. The t-statistic is deployed here to test the significance of the speed of adjustment in ECT terms. The statistical significance of ECTt-1 with a negative sign validates the existence of a long-run causality flowing among the variables of the study. The Wald test is applied here to examine the short-run causality.

5 RESULTS AND DISCUSSIONS

5.1 DESCRIPTIVE STATISICS

Logarithm forms of data are used in this summary statistics. Here, LGDP has the largest unconditional average of 24.84. Median tells about the middle values of each of three variables. These are called measures of central tendency. Standard deviation reflects the deviation from sample mean. It shows the level of volatility in the variables. These are the measures of dispersion or how data is spread out. Here, LIND is the most volatile at 0.86% while LGDP is less volatile at 0.60%.

***Table 1**. Descriptive Statistics*

Variables	LGDP	LRTR	LIND
Mean	24.8468	9.568504	23.21573
Median	24.78046	9.941843	23.1679
Maximum	25.99188	9.969509	24.83827
Minimum	23.92783	8.393216	21.76964
Std. Dev.	0.603747	0.514286	0.865965
Skewness	0.263139	-1.136765	0.18071
Kurtosis	1.896818	2.977149	1.897693
Jarque-Bera	2.676713	9.261953	2.411056
Probability	0.262276	0.009745	0.299534
Sum	1068.412	411.4457	998.2765
Sum Sq. Dev.	15.30944	11.10856	31.49561

Skewness measures the degree of asymmetry of the series. According to the rule of thumb, RTR is highly skewed (skewness value is less than -1). LGDP and LIND are fairly symmetrical (skewness values are between -0.5 and 0.5). Kurtosis is the measure of outliers present in the distribution. High kurtosis in a data set indicates that data has heavy tails or outliers. It is a measure of 'tailedness' of the probability distribution of a real valued random variable. Where low kurtosis indicates data has light tails or lack of outliers. A standard normal distribution has a kurtosis of 3; which is called mesokurtic. Here, kurtosis values of LGDP, LRTR and LIND indicate that their distributions are shorter and tails are thinner than the normal distribution. It is called platykurtic (kurtosis<3).

5.2 CORRELATION ANALYSIS

From the table 2 according to the guide that Evans (1996) suggests, it can be seen that the correlation between LRTR

and LGDP is 0.839938; which indicates very strong correlation between them.

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***Table 2**. Correlation Matrix*

Correlation / Probability	LGDP	LRTR	LIND
LGDP	1		

LRTR	0.839938	1	
	0	-----	
LIND	0.999049	0.854692	1
	0	0	-----

Again, the correlation between LIND and LGDP is 0.999049; which is also a very strong correlation. Furthermore, the correlation between LIND and LRTR is 0.854692; that also indicates a very strong correlation between them. Correlation estimation among three variables shows significant level of probability value less than 5% level of significance, indicates there is a strong and significant relationship among them.

5.3 UNIT ROOT TEST

Following the correlation results, unit root test is also reported here to know the order of integration of the variables. Unit root is basically required whether the time series is non-stationary and the number of times the variable has to be differenced to be stationary. This is also essential for knowing the validity of ARDL model. Augmented Dickey-Fuller (ADF: Dickey and Fuller, 1981) and Phillips-Perron (PP: Philips and Perron, 1988) tests have deployed here for the same.

***Table 3**. Unit Root Test Results*

ADF and PP tests for Unit root					
Series	Level		First Difference		Decision
	ADF	PP	ADF	PP	
LGDP	0.95971	1.57115	-7.7934*	-7.7329*	I(1)
LRTR	-0.8168	-0.8665	-4.3194*	-4.1381*	I(1)
LIND	1.90352	-0.4676	-4.7205*	-10.37*	I(1)

Note:

- ✓ *= stationary at 5% significance level.
- ✓ All t-statistics are calculated with trend and intercept.

5.4 LAG SELECTION CRITERION

Based on Akaike information criterion [AIC] (Akaike, 1974) optimum lag length of the model is 3, shown in table 4. AIC has chosen here because, according to Monte Carlo experiment of Liew (2004), AIC criterion is superior to other criterions; particularly when time span is less than 60 observations. The smaller value of AIC is a better result.

***Table 4**. Lag Order Selection: VAR Lag Order Selection Criterion*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	58.24844	NA	1.27E-05	-2.762422	-2.635756	-2.716624
1	308.9891	451.3332	7.15E-11	-14.84945	-14.34279	-14.66626
2	330.2107	35.01571	3.92E-11	-15.46054	-14.57387*	-15.13995
3	346.7792	24.85264*	2.74e-11*	-15.83896*	-14.5723	-15.38097*

5.5 ARDL BOUNDS TEST FOR CO-INTEGRATION

ARDL bounds testing approach has been employed to examine both short-run and long-run elasticities among the variables. In the first step of ARDL estimation, a test for long-run association among the variables has conducted. The table shows the results of ARDL bounds test for co-integration, taking each variable as dependent variable. The estimated models presented here are based on minimizing the Akaike Information Criterion.

***Table 5**. ARDL Bounds Test Results*

Model	Variables	F-statistic	Co-integration
1	F(LGDP|LRTR,LIND)	10.57509	Co-integrated
2	F(LRTR|LGDP,LIND)	4.832522	Inconclusive
3	F(LIND|LGDP,LRTR)	10.21681	Co-integrated
Critical Values (Finite Sample: n=30)			
Significance		Lower Bound, I(0)	Upper Bound, I(1)
1%		5.893	7.337
5%		4.133	5.26
10%		3.373	4.377

Note:

- ✓ Critical values are obtained from surface response procedure.
- ✓ Critical values are for 5% significance level.
- ✓ Tests are performed with unrestricted constant and no trend.

Table 5 reflects, when economic growth is used as the dependent variable, the computed F-statistic is higher than the upper critical value bound at 5% level of significance. This implies, when economic growth is the dependent variable, there exists a long-run relationship in the model 1. On the contrary, when industrial evolution is the dependent variable, the computed F-statistic is also higher than the upper critical value bound at 5% significance level. That also shows a long-run association among the variables in model 3. But in model 2, where road transportation infrastructure is the dependent variable, the computed F-statistic falls between the lower and the upper critical value bound. That means co-integration among the variables in model 2 is inconclusive. This means there are two absolute co-integration equations in total.

5.6 LONG-RUN MODEL ESTIMATES

Since the empirical results indicate a long-run relationship among the variables, the next step is to conduct an estimation of long-run relationship among the variables. The results of long-run analysis reflect that, industrial evolution has a positive and significant impact on economic growth and road transportation infrastructure has negative significant effect on economic growth in Bangladesh. More specifically, 1% increase in industrial evolution leads to increase in economic growth by 8.54% in the long-run. But in the long-run, 1% increase in road transportation infrastructure decreases economic growth by 0.06% beneath the road transportation infrastructure framework remaining over the past four decades in Bangladesh; that is inconsistent with the growth theory. The reason behind this negative relationship may be the lack of sufficient number of control variables in the model. According to the expression of rule of thumb, if the value of R-squared is greater than the Durbin-Watson Statistic, then it may be considered that the deliberated regression estimation is

meaningless. Table 6 clearly indicates that the R-squared value is lower than the Durbin-Watson statistic. Thus, the OLS estimation of the long-run model is free from spurious regression. But, the long-run model shows the evidence of autocorrelation and heteroscedasticity.

***Table 6**. Long-run Analysis*

Dependent Variable: LGDP			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C*	8.541748	0.092106	92.73786
LRTR*	-0.060725	0.012285	-4.942892
LIND*	0.727356	0.007296	99.69158
R-squared=0.998819			
Durbin-Watson statistic=1.306373			
Diagnostic Test Statistics			
Serial Correlation[Chi-square(p-value)]=0.0269			
Heteroscedasticity[Chi-square(p-value)]=0.0007			

Note:

- ✓ *=Statistical significance at 5% level.

5.7 SHORT-RUN MODEL ESTIMATES

The short-run dynamics are displayed in table 7. The empirical findings suggest that, road transportation infrastructure has a positive but insignificant impact on economic growth in Bangladesh. A 1% increase in road transportation infrastructure increases the economic growth by 0.023% in the short-run, ceteris paribus. On the contrary, an increase in the industrial evolution by 1% causes an increases in the economic growth by 0.40% in the short-run, ceteris paribus. Furthermore, to determine the robustness of the short-run dynamics obtained from the ARDL model and to verify the existence of the long-run relationship previously obtained in the ARDL model, estimation of the error correction model is essential in this case. Optimal lag length of 3 is used in this estimation which was determined earlier. The estimated results are displayed in the table below. From the table, the estimated coefficient of the error correction term ECTt-1 is -0.26, which is negative and statistically significant at 5% significance level. As the error correction term is the speed of adjustment, it reflects the correction of the previous errors in the subsequent periods.

***Table 7**. Short-run Dynamics*

Dependent Variable: ΔLGDP			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C	0.008646	0.008936	0.967591
ΔLRTR	0.023156	0.034172	0.677649
ΔLIND*	0.402232	0.075055	5.359127
ECTt-1*	-0.262195	0.109864	-2.38654
R-squared=0.873789			
Durbin-Watson statistic=1.48288			
Diagnostic Test Statistics			
Serial Correlation [Chi-square(p-value)]=0.0592			
Heteroskedasticity [Chi-square(p-value)]=0.3281			
Normality [Jarque-Bera(p-value)]=0.827363			
CUSUM=Stable			
CUSUMSQ=Stable			

Note:

- ✓ *=Statistical significance at 5% level.

The value of ECTt-1 describes that the whole system can get back to the long-run equilibrium at the speed of 26%. The coefficient of statistically significant error correction term also reflects that the independent variables in the model Granger cause the dependent variable, which will be presented in the next step.

5.8 GRANGER CAUSALITY TEST

Although a long-run association has consisted through the co-integration analysis, it doesn't ascertain the direction of causality among the variables. The existence of co-integration among road transportation infrastructure, industrial evolution and economic growth leads the study to proceed the multivariate Granger causality test under VECM framework, to get a clear view of causality relationship among the variables.

***Table 8**. Granger Causality Test Results*

Dependent Variable	Short-run Causality			Long-run Causality
	ΣΔLGDP	ΣΔLRTR	ΣΔLIND	ECT_{t-1}
ΔLGDP	…	0.681 (0.570)	4.435* (0.011)	0.028 (0.765)
ΔLRTR	1.54 (0.22)	…	0.584 (0.630)	-0.144* (0.007)
ΔLIND	2.627** (0.067)	0.595 (0.623)	…	-0.438* (0.0008)

Note:

- ✓ *= Statistical significance at 5% significance level.
- ✓ **= Statistical significance at 10% significance level.

Table 8 shows the multivariate Granger causalities between road transportation infrastructure, industrial evolution and economic growth. Commencing with the short-run results, it is confirmed that there is a strong causality flowing from industrial evolution to economic growth. The results further confirm that, economic growth Granger-causes industrial evolution. That is, a bidirectional causality exists between industrial evolution and economic growth (LIND⇔LGDP). There is no evidence of any short-run causal relationship flowing from road transportation infrastructure to industrial evolution or to economic growth and vice-versa. When road transportation infrastructure is used as the dependent variable, the results validate the existence of a strong long-run causality flowing from industrial evolution and economic growth to road transportation infrastructure. This is on account that, the error correction term (-0.144) is negative and significant at 5% level of significance. Again, when industrial evolution is the dependent variable, there exists a strong long-run causal effect flowing from road transportation infrastructure and economic growth. The error correction then also negative (-0.438) and statistically significant.

6. CONCLUSION AND POLICY RECOMMENDATIONS

The major findings from the study can be summarized as follows:

- ✓ From the unit root test, both Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests confirm

that, the time series variables are non-stationary at level. But after taking their first difference, all of them become stationary. Thus, they are integrated of order one or I(1).

- ✓ The results of ARDL bounds test method for co-integration established that, road transportation infrastructure, industrial evolution and economic growth are co-integrated; indicating a long-run association among them. The error correction term is also significant and fulfills the criterions for theoretical validity. The results also indicate the existence of a significant negative long-run impact of road transportation infrastructure on economic growth whereas, a significant positive long-run impact of industrial evolution on the economic growth in the context of Bangladesh.
- ✓ At last, the results of Granger causality test under VECM framework validate the existence of a bidirectional causality between industrial evolution and economic growth in Bangladesh in the short-run.

On the basis of empirical findings, it can be concluded that industrial evolution plays a major role in boosting the economic growth in Bangladesh. Moreover, a smooth and sustainable economic growth can also boost up industrial evolution in this country. But, Bangladesh is yet to fully derive the benefits of road transportation system, as it has a negative impact on economic growth.

Some recommendations from the study for the policymakers can be proposed as follows:

- ✓ The results above may be a concern for the government. As a rising economy, Bangladesh can't ignore the importance of road transportation infrastructure as a mode of infrastructure to develop further socio-economic condition and to sustain current prosperity. The administrative system of the road transportation sector should be reformed. Both public and private sector should take more initiatives to improve road infrastructures.
- ✓ More projects should be implicated under Public-Private Partnership (PPP). More roads should built to connect the remote regions of the country with the major cities. This will help to decentralize the facilities and to reduce rising pressure on the capital. More road transport facilities will help the industry sector to spread out all over the country. That will open the door of new opportunities such as employment, more trade & business, build up more industries, technological advancement and educational efficiency to the nation.
- ✓ According to the study, the rapid growth process of Bangladesh enable the industrial sector to spread out further. Improved socio-economic condition of the country lead the macroeconomic variables to flourish. More savings will come out from households, as a result increased capital formation will lead to further investment on all the core sectors of the economy. Thus, it will lead to a sustainable economic growth.
- ✓ Government should make industrial policy easier and give more dictation to invest in various industrial sector and should give more concern to improve supplementary facilities to boost up industrialization, give more facilities and expedite bank loan system for the Small and Medium Entrepreneurs (SMEs). With the effective initiatives of public and private sectors industrialization can grow up very fast.
- ✓ Based on the results of this research, industrial sector is a key factor to the economic growth in Bangladesh and its rising share to GDP helps the country to spreading up industrialization alongside urbanization. For low cost of production and low labor cost, Bangladesh has earned much potential on Ready Made Garments sector considering as the backbone of the country's economy. Government should take proper and feasible policies to handle the private industries. By facilitating the labors of this sector, industrialists of this country should look forward to raise efficiency of this sector. More technologies should be introduce to simplify the production process and manufacture more from the industries.
- ✓ Introducing proper technology and making more skilled labor by training will bring blessing to the industrial sector. As the structural transformation has been seeing since 1980s, it is high time the country built an industry based economy to prevent the detrimental effect of landslides of the other economic sectors in Bangladesh. Hence, the circulation flow between industrial evolution and economic growth will lead the country and her people to economic prosperity.

7. LIMITATIONS OF THE STUDY

The study has some shortfalls. As it has been conducted with annual time series data, the study shows the evidence of autocorrelation and heteroscedasticity in the long-run model estimates. It might be occurred in the case that the standard errors of a variable, monitored over a certain period of time, are non-constant or more similar the values of a variable that occurred farther apart in time. Besides, in the long run model the coefficient of road transportation infrastructure reflects negative significant impact on the economic growth in Bangladesh. This might be occurred because of frugality of sufficient control variables in this simplistic model using only three variables. Economic growth not only influenced only by such limited prominent. It depends on other various human and natural resources or other factors. It is hoped that, further researches in this study area by purifying the model or by using more control variables will eliminate these problems.

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APPENDICES

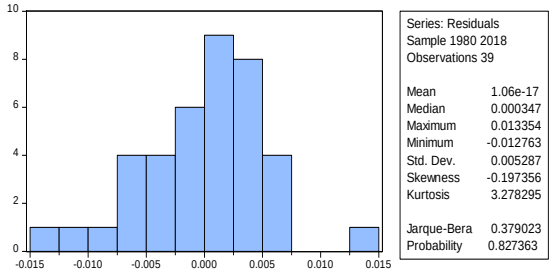

***Figure 1**: Diagnostic Tests for Short-run Model (Normality)*

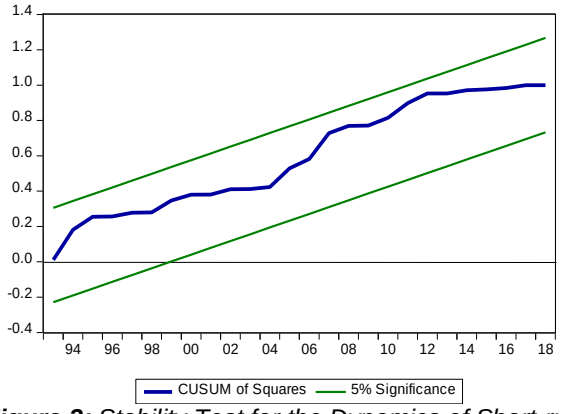

***Figure 2:** Stability Test for the Dynamics of Short-run Model*