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Transportation Infrastructure and Economic Growth: Empirical Insights from Bangladesh

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ABSTRACT

As one of the fastest-growing economies in the world, Bangladesh has upgraded and invested in its land transportation sector. The objective of this paper is to examine the causal relationship between land transportation (rail and road) and economic growth in Bangladesh over the period 1973 to 2020. The Johansen's Maximum Likelihood (ML) test and the Vector Error Correction Model (VECM) have been used in this study to look into the long-term equilibrium and short-term causation links between the variables. According to results from unit root tests, all the series under study are non-stationary at the level and stationary at their first difference. The study findings reveal that there is bidirectional causality between road transportation and economic growth. It also finds unidirectional causality running from rail transportation to economic growth. This study then applies Dynamic Ordinary Least Squares (DOLS) and Fully Modified Ordinary Least Squares (FMOLS) to examine the effects of land transportation on economic growth. The results of DOLS and FMOLS give evidence that both rail and road transportation have a statistically significant positive impact on economic growth in Bangladesh. Besides, economic growth in Bangladesh is positively and significantly influenced by both gross capital formation and the total population in the long run. Therefore, this study suggests that a solid transportation plan be kept up so that transportation infrastructure can be improved, and Bangladesh's economy can grow in the long run.

Keywords: DOLS, Economic Growth, FMOLS, Railways, Roadways, Transport, VECM.
JEL Code: L91, O18, R11, R42.

1.0 Introduction

Economic growth and a nation's development are intertwined, and a nation's economic growth largely determines its level of development (Van den Berg, 2016). In order to improve people's living conditions as well as their overall progress and well-being, economic development is essential. Despite the truth that economic

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growth is regarded as a component of economic development, it cannot alone lead to a nation's economic development (Van den Berg, 2016). It further includes the development of education, health, research, trade, manufacturing, and defense sector; and they are all affected by transportation infrastructure (Nenavath, 2023). However, transportation infrastructure, which contributes to a country's economic progress, is increasingly recognized (Nenavath, 2023; Peter et al., 2015).

The necessity and benefits of transportation systems for growth in the economy have long been acknowledged (Pradhan and Bagchi, 2013). A vital and crucial role is played by transportation in the economic growth and development of a country. It acts as an essential route for the movement of people, goods, and services between producers, consumers, and markets. A well-functioning transportation infrastructure increases a country's economic potential by increasing both the activation and efficiency of available resources (Magazzino and Mele, 2021). Transportation investments that are well-made reduce the cost of transporting people and goods. It can also facilitate the transportation of raw goods, energy, and equipment to production sites. Efficient transportation networks facilitate trade, market integration, investment, and services, thus enhancing productivity, efficiency, and regional development. Transportation infrastructure can be used as an immediate input and, in many circumstances, as a subsidized ingredient in the manufacturing process. Other existing inputs may be more efficient as a result of transportation infrastructure by luring resources from neighboring areas, infrastructure for transportation can serve as a catalyst for growth in the economy. By influencing aggregate demand, transportation infrastructure can influence the expansion of the economy (Pradhan and Bagchi, 2013). Construction of transportation infrastructure, for example, can boost multiplier effects in the economy by creating and increasing demand for raw materials from other sectors (Pradhan and Bagchi, 2013). To summarize, an economy's foundation is its transportation system. A healthy transportation system is crucial for a country's economic advancement. It acts as a catalyst to boost economic well-being (Pradhan and Bagchi, 2013; Ramanathan et al, 2001).

Bangladesh, an economy exhibiting rapid development at an approximate rate of 7%, sustains a population exceeding 160 million individuals (World Bank, 2021). Over the past five decades, the transportation industry has undergone remarkable growth. In the year 1947, the total length of paved roads in Bangladesh amounted to 461.8 kilometers. However, as of 2021, the Roads and Highways Department (RHD) of Bangladesh has significantly expanded the road network, resulting in a substantial increase to approximately 22,428 kilometers (RHD, 2021). Following the nation's emancipation, there has been a notable upsurge in the advancement of infrastructure, resulting in a proliferation of various transportation options encompassing land, water, and air domains. Over the course of time, there has been a significant expansion in the road network that is capable of accommodating automobiles. According to the RHD (2021), the volume of passenger traffic in 1975 amounted to 9.18 billion tons per kilometer, while freight traffic accounted for 0.91 billion tons per kilometer. In the year 2021, the volume of passenger traffic amounted to 46 billion per kilometer, while the volume of freight traffic reached 31.0 billion tons per kilometer.

The impact of transportation infrastructure on economic growth can be observed through the existing data and literature, highlighting the interconnectedness between transportation and the economy. Nevertheless, the causal relationship remains ambiguous. This research study aims to examine the causal association between transportation and economic growth in the context of Bangladesh.

2.0 Literature review

Since the early 1990s, economists, policymakers, and politicians have devoted significant research and attention to the relationship between transportation infrastructure and economic growth. As stated by Lenz et al (2018) transport infrastructure may be a necessity for economic development, while transportation and the sustaining communications infrastructure can act as a catalyst for economic expansion. By enhancing both the utilization of available resources and their productivity, a clean transportation infrastructure can boost a nation's potential for production (Pradhan and Bagchi, 2013). Nistor et al (2014) iterated that investment in transportation infrastructure is an instrument for local economies, especially in underdeveloped nations, particularly in the road sector. As a result, the complexity of the relationship between transportation and economic development lies in the variety of possible outcomes: increased development of economic exchanges between economic agents, establishment of trade relations with distant trade areas, and positive indirect influence on the development of other economic sectors.

A plethora of investigations have been done on the link between transportation infrastructure and economic development (Banerjee et al., 2020; Magazzino and Mele, 2021). Pradhan and Bagchi (2013) use the Vector Error Correction Model (VECM) to look at the impact of transportation (road and rail) infrastructure on India's economic growth from 1970 to 2010. They discover a two-way causal association between road transportation and capital formation, a two-way relationship between gross domestic product and economic growth, and a one-way relationship between rail transportation and both gross and economic capital formation.

In India, Tripathi and Gautam (2010) looked at the long-term connection between network dynamic externalities and macroeconomic variables originating from road transport networks. Utilizing the VAR model and data from 1970 to 2007, the study's findings show that network dynamic externalities that are caused by road transport networks have a long-term association with GDP as well as Gross Public Capital Formation, but no such relationship exists between network dynamic externalities that are driven by road transport networks and Gross Private Capital Formation. Moreover, Nenavath (2023) looks into the correlation between India's infrastructure for transportation and growth in the economy using ARDL models between the years 1990 and 2020. The study's findings show that in India, economic growth is influenced favorably by infrastructure over time, demonstrating a one-way causal relationship between investment in transportation infrastructure and economic advancement. Choudhary and Sultana (2018) also evaluated transportation infrastructure's effect on economic growth in Pakistan from 1991 to 2015, based on many empirical studies on emerging countries. The findings suggest that the economic growth of the country is positively associated with road infrastructure, whereas railways have a negative impact.

Using panel data from 31 Chinese provinces between 1998 and 2007, Hong et al (2011) create a multi-dimensional transportation infrastructure assessment and investigate the relationship between transportation infrastructure and regional economic growth. The study findings demonstrate that both land and water transportation infrastructures have considerable and positive impacts, whereas aviation transportation infrastructure has a minor impact. Furthermore, in regions with deficient land transport infrastructure, the growth of the economy is more heavily influenced by land transportation infrastructure, but investment in water transport infrastructure contributes favorably to economic growth only once the amount invested surpasses a certain amount. In China, Banerjee et al. (2020) analyzed the effects of over-transportation on regional economic production. The variables used were the wage rate, GDP, labor endowment, and capital. According to the results of a theoretical framework with empirical techniques, GDP per capita is impacted by transportation, whereas there is no impact on per capita GDP growth.

In addition to that, Xueliang (2013) proposes a model of the geographical spillover effects of transportation infrastructure on economic growth at the Chinese regional level that thoroughly explains how various elements contribute to China's regional economic growth. His empirical research showed that the transport infrastructure's overall production elasticity for regional economic growth is strong and that its spatial spillover effects on regional economic growth are very unique, using regional panel data between 1993 and 2009. Recently, by utilizing data from the years 1985 to 2015 using the Lotka-Volterra model, Sun et al. (2018) finds that increased highway traffic, highway passenger travel, and rail freight transit had all considerably contributed to the expansion of the country's economy in Xinjiang. Despite the fact that his research reveals that highway passenger transportation has a favorable impact on the growth of railway passenger transportation and that railway freight transportation has had a similar contribution to the growth of highway passenger transportation, there is no discernible correlation between investments in transportation and the economy.

Besides, Canning and Fay (1993) estimate the 96 countries' marginal product of their transportation networks from 1960 to 1985 at 5-year intervals, based on much empirical research on developing countries. The findings reveal that the return on investment for transportation infrastructure is "standard" in wealthy nations, considerably high in industrializing nations, and modest in developing nations. The findings also suggest that infrastructure has a modest but long-lasting influence on production: an increase in infrastructure has a minimal impact on output in the near run but leads to a greater growth rate and output in the long run. Peter et al (2015) uncover the positive influence of government expenditure on road transportation on gross domestic product as well as the economic growth of Nigeria in the long run by using the Probit Model and the Multivariate Model.

In Bangladesh, only Alom et al. (2018) explored the impact of multimodal transportation accessibility on aggregate production efficiency in separate regions. In numerous regions of the country, the technical efficacy of investments in the construction of transportation infrastructure has been evaluated using the Data Envelopment Analysis (DEA) technique. The findings revealed that investing in less-efficient regions' infrastructure development yielded a higher rate of return.

Mentionable that, the impact of transportation infrastructure on Central and Eastern European Member States's (C.E.M.S.) economic growth between 1995 and 2016 were empirically investigated by Lenz et al. (2018). This study's goal was to assess the contributions of transportation infrastructure (road and rail) to economic growth while adjusting for other factors including gross fixed capital formation, population growth, and trade openness. They use the three conventional estimators for panel data research: pooled ordinary least squares, fixed effects, and random effects. Except for the railroad infrastructure, where it appears that the effects are adverse, the results reveal positive effects for all estimated factors.

The importance of transportation has been highlighted by the essential relationship between prices and economies of scale, leading to the inclusion of transportation activity in economic policy debates (Nistor and Popa, 2014). Specific transport market advancements have been followed by research on simultaneous economic, environmental, and social impacts in order to transition the transportation industry to a higher degree of development. The study identifies the importance of transportation in establishing a sustainable economy that will deliver new services in the near future, as well as better traffic management and real-time traffic capacities to protect the environment and provide safety. Boopen (2006) also evaluated whether transport capital contributed to the national income of a selection of African nations between 1980 and 2000.

The results of the cross-sectional, pooled OLS, and panel data assessments of the investigation illustrate the relevance of transportation capital as an element of these countries' development. Furthermore, it has been discovered that this form of capital may have been more effective than the whole investment. Investment in transportation infrastructure is a regional development tool, especially in emerging nations, particularly in the road sector (Nistor et al, 2014).

Moreover, Deng (2013) furnished an update on the survey of recent advances and research challenges on how economic growth and productivity were impacted by transportation infrastructure. He showed ten possible important factors for the controversial results of the output elasticity of transportation infrastructure investment, despite the widespread perception that 'roads lead to prosperity'. Deng (2013) came to the conclusion that the output elasticity of investments in transport infrastructure still differs greatly depending on various circumstances, various phenomena that are being assessed, and various methods of assessing a similar phenomenon. Sturm et al (1999) uncover adequate proof of a beneficial impact on Dutch GDP in the latter half of the nineteenth century as a result of investments in transportation. They utilized Granger-Causality tests in a Vector Auto Regression (VAR) framework. Demurger (2001) looked into the relationship between Chinese infrastructure spending and economic expansion. He employed panel data from 24 Chinese provinces (excluding municipalities) collected between 1985 and 1998. According to the results of their growth equation, a significant percentage of the observed variation in provincial development performances can be attributed to changes in geographic position, transportation infrastructure, and telecommunication facilities. Over the period 1970–2007, Pradhan (2010) investigated the relationship between transportation infrastructure (road and rail), energy consumption (oil and electricity), and economic growth in India. The paper demonstrated unidirectional causality from transportation infrastructure to economic growth, unidirectional causality from economic growth to energy consumption, and unidirectional causality from transportation infrastructure to energy consumption employing cointegration and the Granger causality test. The direction of causality between land transportation and economic growth in Bangladesh remains unclear, as there is a lack of existing research on this specific relationship for the country.

3.0 Data and econometric modelling

The goal of this article is to look at the causal relationship between land transportation and Bangladesh's economic growth from 1973 to 2020. In this instance, having the right data set from the most trustworthy sources is crucial. Except for railways and highways, the majority of the data for this study has come from the World Development Indicators (WDI). For this study, data on railways and roads is obtained from the Bangladesh Economic Review (BER) as well as World Development Indicators (WDI) and Roads and Highways Department (RHD) respectively (See Table 1).

3.1 Data

The following study investigates the impact of total transport infrastructure on economic growth (GDP) as well as the role of gross domestic capital formation (GCF), population growth rate, and official exchange rate in Bangladesh using data spanning between 1973 and 2020. Furthermore, the current study, makes use of road and rail lengths to better understand the relationship between transportation infrastructure and economic growth. This is due to the fact that drivable roads and serviced train tracks are Bangladesh's primary forms of transportation. The relationship between the state of the transportation system and economic growth is examined in the function that follows:

$$EG = f\,(TINF, GCF, POP, OXCR) \qquad (1)$$

Where EG is for economic growth and TINF stands for all transportation infrastructure. We also use the following three variables: A variable measure of infrastructure investment is gross fixed capital formation (GCF), followed by a variable total population (POP), and another variable official exchange rate (OXCR). For the present empirical analysis, road and rail transportation are used as proxy for infrastructure in the transportation sector, while real gross domestic product (GDP) per capita is used as a proxy for economic growth. The factors included in this study are chosen based on prior research and data availability. As infrastructures on roads and railroads are both measured in kilometers, integrating them would not be technically deficient despite the fact that their capacities are not equivalent. Furthermore, we merged these two through a standardization process, which is statistically plausible and can be traced back to previous research that combined rail and road. All data are expressed logarithmically except OXCR throughout the analysis to account for the proliferative effect of time series. The annual data used in this analysis spans the years 1973 through 2020. Table 1 provides information of variables and Table 2 provides summary data for all variables included in this investigation.

Table 1.
Variables and sources.

Variable	Description	Units	Sources
GDP	Economic Growth	Real GDP per capita $US constant, 2015	WDI (2020)
RAIL	Rail Infrastructure	Length of rail in KM	WDI (2020),(BER,2021)
ROAD	Road Infrastructure	Length of road in KM	RHD (2021)
GCF	Infrastructure investment	Current US$	WDI (2021)
OXCR	Official Exchange Rate	LCU per US$, period average	WDI (2021)

Table 2.
Summary statistics.

Statistics	GDP	RAIL	ROAD	GCF	OXCR	POP
Mean	25.05697	7.953001	9.404929	22.93705	46.97212	18.54509
Median	24.97802	7.957947	9.845337	23.03242	42.84314	18.59378
Maximum	26.32426	8.008602	10.01583	25.35069	84.87139	18.91957
Minimum	24.04243	7.902857	8.299873	20.37302	7.849816	18.02967
Std. Dev	0.672417	0.024161	0.682119	1.349071	24.34857	.277975
Skewness	.283879	-559028	-0.670873	0.019211	0.050684	-.379777
Kurtosis	1.910787	3.098473	1.752814	2.112256	1.680730	1.837866
Jarque-Bera	3.017468	2.519489	6.711507	1.579130	3.501498	3.85495
Probability	.221190	0.283727	0.034883	.454042	.173644	0.145515
Sum	1202.734	381.7440	451.4366	1100.978	2254.662	890.1642
Sum Sq. Dev	21.25079	0.027435	21.86847	85.53966	27864.09	3.631694

Note: GDP: Per Capita Real Gross Domestic Product, RAIL: Rail Infrastructure, ROAD: Road Infrastructure, GCF: Gross Capital Formation, OXCR: Official Exchange Rate, POP: Population.

3.2 Methodology

This study has used a model similar to that of Pradhan and Bagchi (2013) to find out the relationship between transport infrastructure and economic growth in the presence of investment, total population, and the official exchange rate. All of the data in our assessment is represented in logarithmic form except OXCR in order to maintain the sharpness of time series data. In line with the above explanation, the following is a description of the model utilized in this investigation:

$$LNGDP_T = \alpha_1 + \alpha_2 LNRAIL_T + \alpha_3 LNROAD_T + \alpha_4 LNGCF_T + \alpha_5 OXCR_T + \alpha_6 LNPOP_T + u_T \quad (2)$$

Where LNGDP is real GDP per capita as an indicator of economic growth, LNRAIL is total rail length as a proxy for rail infrastructure, LNROAD is the length of the entire road as a proxy for road infrastructure, LNGCF is gross capital formation measured in current USD, which indicates total investment, LNPOP is total population, and OXCR is the official exchange rate. T and u indicate time and residual terms with a presumed normal distribution. Here are the long-run elasticity of railways, roadways, investment, the official exchange rate, and population, respectively.

The Granger causality test (Granger, 1988), which is based on the Vector Auto Regression (VAR), is used to investigate the relationship between transportation infrastructure and economic growth in this study. This test, on the other hand, is highly dependent on the stationarity of the time series variables in question. The stability criterion of VAR is not met in the event that the underpinning time series are non-stationary, suggesting that the Granger causality test statistic is invalid. Cointegration and the Vector Error Correction Model (VECM) are recommended to study the correlation between non-stationary variables. As a result, the initial and crucial criterion for employing VAR is to ensure that the variables are stationary. Numerous macroeconomic time series have unit roots that are dominated by stochastic patterns that Nelson and Plosser (1982) may detect using their method. When deciding whether to first difference or regress trending data on deterministic functions of time in order to make the data stable, unit root tests can be utilized. A stochastic trend can be inferred from the appearance of unit roots in time series data.

3.2.1 Unit root test

Johansen and Julieus (1990) recommended using the co-integration test, which calls for stationary pre-testing, to look at the long-term relationships between groups of variables. Integration of the series must be done in the same order as one another for the time series to cointegrate. Alternatively put, in order to restore stationarity, each series must be differenced d times once if two series are co-integrated in order d. Each of the series would be level-stationary for d = 0, but for d = 1, stationarity requires first differencing. If a series' mean, variance, and auto-covariance are not constant across time, it is considered non-stationary (Johansen and Juselius, 1990). Non-stationary variables must be incorporated into stationary processes. If not, neither of them converges to long-term equilibrium. The research effort has adopted the Phillips-Perron (PP) unit root technique and the Augmented Dickey-Fuller (ADF) technique.

3.2.2 Augmented Dickey Fuller (ADF) test

A frequently employed statistical test for determining whether or not a time series is stationary is the ADF (Augmented Dickey Fuller Test) technique (Provakaran, 2019). When it comes to examining the stationary of a series, it is one of the most widely employed statistical tests. This approach was devised by Dickey and Fuller (1979). A simple AR (1) model for time series can be represented as:

$$Y_t = \rho Y_{t-1} + e_t \quad (3)$$

Where, e_t~iid (0, σ_e^2). If |ρ| = 1 then Y_t is the non-stationary random walk process and $Y_t = \rho Y_{t-1} + e_t$ and it is said to have unit root. Again, if |ρ| < 1 then Y_t is stationary.

In differences, $$Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + e_t$$

$$\Delta Y_t = (\rho - 1)Y_{t-1} + e_t$$

Or $$\Delta Y_t = \lambda Y_{t-1} + e_t. \quad (4)$$

So the unit root test becomes H0: λ= 0 vs. H1: λ < 0. If λ = 0 then Y_t follows a random walk and therefore it is non-stationary. Similarly, If λ < 0, then Y_t is stationary.

The assessment unit root based on the (Dickey & Fuller, 1979) is stated as:

$$\Delta Y_t = \alpha + \delta_1 t + \lambda Y_{t-1} + e_t \quad (5)$$

However, such a regression model is not free from serial correlation. The augmented dickey-fuller test is a refinement of the dickey-fuller test that suppresses autocorrelation from the set before performing tests similar to the dickey-fuller technique. It can be represented mathematically as:

$$\Delta Yt = \alpha + \delta t + \lambda Y_{t-1} + \sum_{i=1}^{p} \beta \Delta Y_{t-1} + \mathcal{E}t \quad (6)$$

Where, $\mathcal{E}t$ is an independently and identically distributed zero-mean term, p is the number lags. Testing λ = 0 is equivalent to testing |ρ| = 1. Thus, ADF regression looks for the unit root of Yt, all model variables' logarithmic values at time t. Here, H0: $\lambda = 0$ against H1: $\lambda \neq 0$ is the null and alternative hypothesis for determining whether the variable Yt has a unit root. Since Campbell and Perron (1991) demonstrated that ADF tests are subject to lag lengths we employ Akaike's Information Criterion (AIC) to determine the optimum lag lengths. Our study has estimated the following equations to check the unit root:

$$\Delta LNGDP_t = \alpha + \delta t + \lambda LNGDP_{t-1} + \beta_1 \Delta LNRAIL_{t-1} + \beta_2 \Delta LNROAD_{t-1} + \beta_3 \Delta LNGCF_{t-1} + \beta_4 \Delta OXCR_{t-1} + \beta_5 \Delta LNPOP_{t-1} + \mathcal{E}t \quad (7)$$

The null hypothesis of unit root, H0 ; λ= 0 can be rejected and inferred that the time series is being test is stationary if the estimated absolute t-statistic is greater than the absolute value of the critical value at a preset significance level.

3.2.3 Phillips-Perron (PP) test

Unlike the ADF test another method used to determine whether such a variable has a unit root or not is developed by Phillips–Perron, (1988). Although using the Dickey Fuller test as a foundation of the null hypothesis of equation (4), $\Delta Y_t = \lambda Y_{t-1} + e_t$, the unit root tests Phillips-Perron (PP) and ADF differ primarily in how they handle serial correlation and heteroskedasticity in error. In contrast to the alternative method of stationarity, these methods test the unit root null hypothesis. The test regression for the PP tests is as follows:

$$\Delta Y_t = \alpha \quad + \delta_1 t + \lambda Y_{t-1} + e_t. \tag{8}$$

Where, e_t is I (0) and may be heteroskedastic. Any serial correlation and heteroskedasticity in the test regression's errors are adjusted by the PP tests. Our study has estimated the subsequent equations to check the unit root.

$$\Delta LNGDP_t = \alpha \quad + \delta_1 t + \lambda LNGDP_{t-1} + e_t. \tag{9}$$

It is possible to reject the unit root null hypothesis, H0 ;λ= 0 and infer that the time series is being test is stationary if the estimated absolute t-statistic is greater than the absolute value of the critical value at a preset significance level.

3.2.4 Cointegration Test

Time series systems must not be stationary at all levels in order to use the co-integration process. The correlation analysis is performed to confirm the correlation between two time series data sets. The following is a definition of the relationship:

$$Corr\ (X,Y) = \frac{Cov\ (X,Y)}{\sqrt{Var\ (X) Var\ (Y)}} \tag{10}$$

Where the covariance is indicated by Cov (X, Y) between the two time series (X, Y), and the two time series X and Y's values are denoted by the variables Var (X) and Var (Y), respectively.

Developed with VAR and VECM representations, the presence of co-integration and causation is indicated by the type of stationarity. Engel and Granger (1987) demonstrated that if two variables are independently integrated of order one and co-integrated, at least one causal link exists between them. As a result, it's also required to look for cointegration between the time series variables (Yoo& Ku, 2009). The cointegration test's goal is to figure out whether or not the variables are connected in a long-term equilibrium state. In the absence of cointegration, such variables lack a long-term equilibrium relationship and can, in theory, drift arbitrarily far apart. Cointegration does not, however, reveal the direction of cause-and-effect relationships between variables, only whether Granger causality exists or not. It is possible to figure out the direction of the Granger Causality by employing the Vector Error Correction Model, which is constructed from long-run co-integrating vectors. Hence, in this study, the maximum likelihood ratio test of Johansen (1988) is used, and two test statistics are examined: the maximum eigenvalue statistics (Johansen & Juselius, 1990) and the trace statistics. In contrast to the alternative hypothesis of cointegration, the null hypothesis of non-cointegration is presented.

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} Log\ (1 - \hat{\lambda}_i) \tag{11}$$

$$\lambda_{max} = -T\ Log\ (1 - \hat{\lambda}_{r+1}) \tag{12}$$

Where, $\hat{\lambda}_{r+1}, \ldots . \hat{\lambda}_n$ are (n + r) smallest estimated eigen values. In this study, the null hypothesis of r cointegrating vectors is contrasted with the alternative hypothesis of r + 1 cointegrating vectors. As previously stated, cointegration determines the sorts of models (VAR/ VECM) that can be used to determine the causality direction between transportation infrastructure and economic growth. The specified lag will have an impact on the co-integration test's outcome. In our study this co-integration test was conducted using the Johansen (1988) co-integration test, and we choose the appropriate lag profile based on the AIC process. The appearance of causality, at least in one direction, between the variables, is implied if they are co-integrated.

3.2.5 Vector Error Correction Model (VECM):

The Granger representation theorem asserts that an Error Correction Model (ECM) explains the dynamic relationship if the series are co-integrated. For use with non-stationary series that have been found to be co-integrated, the VECM is a constrained VAR. The specification of the VECM includes cointegration relations that prevent the endogenous variables' long-run behavior from converging to their cointegrating relationships while permitting the dynamics of short-run adjustment. The co-integration component is additionally referred to as the error correction term, as the deviation from long-term equilibrium is gradually addressed by a series of partial short-run corrections. The strength of the ECM framework resides in its capacity to accurately represent both the long-term equilibrium relationship and the short-term dynamics between two series.

If two variables are non-stationary and co-integrated, it's therefore possible that there may exist a long-run relationship between them, at least from one direction (Engel and Granger, 1987). Further, Sims and Watson (1993) looked into and came up with a method for analyzing multivariate models with unit root variables. The VECM was explicitly proposed as a result of this. The VECM model is commonly used to investigate long-run and short-run equilibrium relationships by combining co-integration variables (Jian, Fan,He et al., 2019). Asari and Baharuddin (2011) used the Vector Error Correction Model (VECM) approach in an attempt to elucidate how interest rates and inflation relate to exchange rate volatility in Malaysia. The following is a representation of the VECM regression equation form:

$$\Delta GDP_T = \eta_0 + \sum_{i=1}^{p} \eta_{1i} \Delta GDP_{t-i} + \sum_{j=1}^{p} \eta_{2j} \Delta ROAD_{t-j} + \sum_{k=1}^{p} \eta_{3k} \Delta RAIL_{t-k} + \sum_{l=1}^{p} \eta_{4l} \Delta GCF_{t-l} + \sum_{m=1}^{p} \eta_{5m} \Delta OXCR_{t-m} + \sum_{n=1}^{p} \eta_{6n} \Delta POP_{t-n} + \theta_1 ECT_{t-1} + \varsigma_{1t} \quad (13)$$

Where, η is the coefficients of the polynomial; p represents the optimal lag; ECTt−1 represents the correction term. The optimal length of the first differenced regression is calculated by Akaike Information Criteria (AIC) to avoid the issue with serial correlation in Equations (13). The null hypothesis in Equation 13 is as bellow:

$$\eta_{1i} = \eta_{2j} = \eta_{3k} = \eta_{4l} = \eta_{5m} = \eta_{6n} = 0$$

Where, the alternative hypothesis is as follows:

$$\eta_{1i} \neq \eta_{2j} \neq \eta_{3k} \neq \eta_{4l} \neq \eta_{5m} \neq \eta_{6n} \neq 0$$

As for example, equation (13) illustrates the causality test model from ROAD, RAIL, GCF, OXCR, POP to GDP. If the null hypothesis (H0: $\eta_{1i} = \eta_{2j} = \eta_{3k} = \eta_{4l} = \eta_{5m} = \eta_{6n} = 0$) is rejected in Equation (13), there exists a short-run Granger causality from ROAD, RAIL, GCF, OXCR, POP to GDP. The speed of adjustment towards equilibrium is expressed by the coefficient, θ of the error correction term. Long-term Granger causality from right to left is established if the null hypothesis (H0: 1 = 0) is rejected. If the ECM coefficient is negative and significant, any short-term oscillations between the response variables and the predictor variable will result in a steady long-term relationship between them.

3.2.6 Dynamic Ordinary Least Square (DOLS)

The Dynamic Ordinary Least Squares (DOLS) estimator is a parametric approach that has been proposed by Stock and Watson (1993) and has certain advantages over both OLS and maximum likelihood processes. Because a linear combination of the response and predictor variables generates a stationary error term in finite samples, this error term is found to correlate with the regressors, exacerbating an endogeneity problem and bias, which would be stated by second order bias because the estimator's consistency is unaffected by the regressors' endogeneity. Along with the asymptotic optimality features of the Johansen distribution dynamic OLS estimator, the latter adds some additional control variables in an effort to address the small sample bias that results in an endogeneity issue. The method has been applied to the estimation of the United States' market's demand for Mexican crude imports by (Camacho-Gutiérrez, 2010), and we adapt and broaden their strategy here.

3.2.7 Fully Modified Ordinary Least Square (FMOLS) Model

To determine whether there is a long-term association among the variables, this study uses a modern econometric technique introduced by and developed by Phillips and Hansen (1990) named the Fully Modified Ordinary Least Squares Method (FMOLS). Bashier and Siam (2014) use FMOLS approaches for estimating a single co-integrating relationship between immigration and Economic Growth in Jordan. According to Khan et al. (2019), it benefits from addressing serial correlation and endogeneity bias. The FMOLS approach ensures that small sample sizes are reliably estimated and that the results are robust (Mahmood et al., 2019). This measures and improves the least squares method to account for the sequence correlation effect and examines for the presence of cointegration among the predictors in order to obtain asymptotic efficiency (Mahmood et al. 2019).

Many academics have used the FMOLS technique to conduct time series investigations (Bashier and Siam, 2014; Aljebrin, 2012; Bashier and Wahban, 2013; Yahyaoui and Bouchoucha, 2021). FMOLS is only applicable when, following initial differencing, all the variables simultaneously achieve stationarity and cointegration (Babarinde, 2021). Our study has considered FMOLS suitable for the analysis because of the evidence of a cointegrating relationship between the study's variables, which are the I (1) series. The asymptotic distribution of the FMOLS estimator was the same as that of the dynamic OLS estimation developed by (Pedroni, 1996). While DOLS remains a parametric test, FMOLS addresses the autocorrelation issue with non-parametric methods. However, this method's drawback is the degree of freedom problem brought on by leads and lags (Maeso, Fernandez, Osbat, &Schnatz, 2006).

4. Empirical results

4.1 Unit root test

Since a requirement for cointegration and causality testing is that the time series variables be stationary, which helps with policy formulation, the current empirical analysis begins by checking stationarity. The ADF unit root test and the Phillips-Perron Unit Root test have been applied to look at the stationarity of the time series data. We have applied both of these two tests to check the robustness of the unit root test. It has been noticed that all of the variables show a trend except railways. So a unit root being observed in a sample of a time series and the series being non-stationary is the null hypothesis for both unit root tests. The time series characteristics of the 1973–2020 data utilized in the ADF and PP unit root tests are examined in this section. Both levels and the initial differences of the ADF and PP tests for all variables were subjected to these unit-root tests. The estimated outcomes of the unit root test are reported in Table 3.

Table 3.

Unit root test.

	At level I(0) Intercept and trend	First difference I(1) Intercept and trend	Conclusion
ADF UNIT ROOT TEST			
GDP	0.230	-12.983***	I(1)
RAIL	-2.449	-7.093***	I(1)
ROAD	-0.842	-10.339***	I(1)
OXCR	-3.404	-6.200***	I(1)
POP	3.052	-8.783***	I(1)
GCF	-1.854	-5.570***	I(1)
PP UNIT ROOT TEST			
GDP	0.494	-13.497***	I(1)
RAIL	-2.500	-7.112***	I(1)
ROAD	-1.380	-10.938***	I(1)
OXCR	-2.622	-7.811***	I(1)
POP	1.467	-5.785***	I(1)
GCF	-2.650	-5.518***	I(1)

Note: 1% level of significance is illustrated by ***

It is clear from Table 3 that the null hypothesis of non-stationarity could not be rejected by the ADF or PP test statistics. The study findings demonstrate that no time series variable has a tendency to be stationary in its levels of variation. This indicates that in their level data, the variables are non-stationary, and stationarity should be confirmed at a higher order of differencing. In this example, when the first differences of the variables are taken into account, the unit root null hypothesis is rejected at the 5% level of significance since the ADF and PP critical values are less than test statistic values. As a result, the differences become stationary, and the corresponding variables are designated as integrated of first order, 1 (1).

4.2 Cointergration test

The optimal lag length for cointegration is 2. Johansen's maximum likelihood (ML) test is then used to determine the cointegration connection between the time series after ensuring that they have been integrated to order zero. Due to the trace statistics and maximum eigenvalue above the crucial values at a 5 percent level, Table 4 clearly rejects the null hypothesis (there is no cointegration, r = 0). As a result, it can be said that the variables only have one cointegrating relationship. Therefore, the cointegration test outcomes (ltra and lmax) demonstrate that the time series variables (transport infrastructure, economic growth and gross capital formation, official exchange rate, and population) are cointegrated (see Table 4). Consequently, a long-term equilibrium relationship between both is possible.

Table 4.
Cointegration test.

Null hypothesis	Trace statistics	5% critical value	Max Eigen value	5% critical value
H0 : r = 0	226.6422	95.75366*	113.3595	40.07757*
H0 : r ≤ 1	113.2826	69.81889*	72.03982	33.87687*
H0 : r ≤ 2	41.24281	47.85613	24.97896	27.58434

Note: The cointegration between GDP, ROAD, RAIL, GCF, OXCR and POP; r denotes the number of cointegrating vectors; and * indicates statistically significant at 5%.

4.3 VECM estimation and analysis

4.3.1 Short run result

A Granger causality test is performed after identifying the cointegration connection between variables. We employ the VECM framework outlined in the preceding section because the variables are cointegrated. To assess the causal chain's direction between railways, roadways, economic growth, gross capital formation, the official exchange rate, and population, we employ the VECM Granger causality test set up by Engle and Granger (1987). The optimal lag length is chosen four by AIC.

Table 5 contains the results of the paper's investigation into both long- and short-term causation. The investigation reveals that a bidirectional causal relationship exists between economic growth and road transportation. According to the short-term causality test, road transportation significantly influences economic growth at a level of 0.10, and at the same time, per capita real GDP is the cause of road infrastructure at a significant level of 0.01. That is, an increase in the road sector will lead to an improvement in economic growth, and expanding economic growth will lead an improvement in the road sector. There are a variety of causes behind this.

Table 5.
Results of causality tests.

Dependent variables	ΔGDP	ΔRAIL	ΔROAD	Δ GCF	ΔOXCR	Δ POP	ECM
Δ GDP		0.24*	0.04*	0.20***	0.005*	58.79***	-0.04***
Δ RALI	.030		-0.002	0.068	0.068	50.150	-0.031
Δ ROAD	-.0987***	1.74**		0.54	0.01	652.594**	-0.419**
Δ GCF	0.176	0.252	0.076		0.001	-36.82***	-0.117
Δ OXCR	-4.991	-12.96	-1.188	0.336		9328.59	0.364
Δ POP	0.003*	0.002	0.0001**	0.0001	1.27E-05		-0.0003*

Note: Intercept and trend in CE and no trend in VAR, lag 4; *, **, and *** express 10%, 5% and 1% level of significance respectively.

For starters, one of the most important inputs in the manufacturing process is transportation. Increased road transportation improves public mobility and saves travel time. It contributes to the creation of more work opportunities. Road, highway, and bridge construction and upkeep are facilitated by investments in road infrastructure. This change improves regional connections, makes it easier to move goods and services, and lowers the price of transportation. Infrastructure improvements attract investments and boost economic activity. Through the construction of infrastructure, commercial facilities, support for manufacturing and other businesses, tourism promotion, agricultural development, job creation, regional development, and other activities, the road sector greatly contributes to economic growth. As a result, a rise in road transportation would be anticipated to boost economic growth. This is congruent with what Pradhan and Bagchi (2013) found. Similarly, there are numerous reasons why Bangladesh's road transport development has been encouraged by economic expansion. First off, economic expansion frequently results in higher tax revenues, which give governments more money to spend on improving infrastructure, particularly the road sector. Once more, economic expansion draws both domestic and foreign investment into a variety of economic areas. This additional investment is going directly toward building roads and other infrastructure. Additionally, there is a rising need for effective transportation infrastructure as economies develop. For businesses to carry goods and services to markets, there has to be a dependable and well-connected road network. Governments are under pressure to invest in the road industry due to the rising demand for better transportation infrastructure. Economic progress has resulted in an increase in the industrial and service sectors, particularly in the construction sector, which would necessitate the use of road transportation. Along with that increased job opportunities necessitate more people moving about, necessitating road improvements. The desire for better road infrastructure for domestic amusement has also increased as disposable income has increased. In summary, economic growth spurs road sector development by bringing in more tax income for governments, luring infrastructure, increasing demand for improved transportation, boosting technological developments, fostering public-private partnerships, and fostering regional development.

According to Table 5, there is a unidirectional Granger causality in Bangladesh that runs from railways to economic growth at the 10% significant level. In other words, a rise in railway development will result in an increase in real GDP per capita, not the other way around. This result's explanation is: Railways are the most common means of freight and passenger transportation. It connects the country's economic life since railways in Bangladesh transport a wide range of goods, including metal ores, chemicals, petroleum products, iron, and steel. The transportation of agricultural produce, completed goods, and raw materials from production hubs to markets, ports, and factories is made easier by improved railways. This boosts supply chain effectiveness and boosts industry competition. It allows people to connect at a lower cost and makes it easier for them to carry commodities. Opportunities for employment in construction, maintenance, and operation are created by railway development and expansion projects. Businesses also grow and hire more staff as a result of improved mobility, which helps to create jobs and boost the economy. In general, upgraded railroads have the potential to provide a positive feedback loop that promotes economic expansion, job creation, and development across a range of economic sectors. All these work as catalysts for economic growth in Bangladesh. So the finding indicates that reducing railway infrastructure as part of the country's transportation mix would result in lower economic growth. As an outcome, increasing economic growth in Bangladesh will necessitate massive railway infrastructure.

On the other hand, since India's 1947 partition, the railway network has barely expanded while the number of roads has greatly increased (Hasan, 2009). Since 1947, BR has been unable to expand. In the past 50 years, just an 80-kilometer rail route has been built. However, due to carelessness, poor maintenance, and inadequate funding, more than 1,200 kilometers of rail lines are at risk of not operating. One of the major problems may be inadequate locomotive routes. Given the lack of routes, the trains must endure an overabundance of traffic.

It is noticed that although the road network has grown tremendously, the rail network has not been similarly expanded. Roads have received special attention and the most funding (on average, 76 percent of the entire transportation sector). Due to decades of mismanagement, the railroad industry now has very little capacity to serve the public. Therefore, the main issue for the development of the railroad track is a lack of funding for further railroad modernization. The primary burdens taken into account in this scenario are safety concerns, age-related jointed tracks, weight restrictions, and speed limitations (Hasan, 2009). Recent field investigations have revealed that joints are typically old or worn out. Another significant issue is that the fastenings are old and rusty. The majority of instances are tracked manually. These factors prevent BR from operating well and cause it to lag behind many contemporary technologies. Overcoming these limitations has emerged as Bangladesh Railway's main challenge. The government's lack of investment led to less development in this sector than in roads and highways (RHD); ineffective management made it difficult to make decisions quickly; widespread corruption sapped employee commitment; and outdated technology were just a few of the many issues Bangladesh Railway is currently dealing with.

However, the BR has continued to take on these huge projects without boosting the effectiveness of its employees or hiring the qualified personnel necessary for such massive initiatives. The BR authorities have stated that the sluggish progress of the projects is due to challenges with land acquisition, the timely availability of foreign funding, a lack of labor, and COVID-19 disruptions. The primary obstacles to timely project completion, according to transportation experts, are inadequate planning, flawed feasibility studies, and political pressure to start projects before they are ready. In two of the previous six fiscal years, the Implementation Monitoring and Evaluation Division said in a report that it had been unable to even reach the average ADP implementation rate. Along with project implementation difficulties, the BR consistently suffers enormous losses. It had lost Tk 13,492.70 crore between FY 2008–09 and FY 2019–20, according to BR documents, despite the fact that the agency has been profitable since the fiscal year 2008–09, according to data from the Bangladesh Railway Information Book–2020. There are no significant measures being taken to regain the land, despite the fact that the BR could make millions of taka if it could be used for commercial reasons.

In the economic growth equation, gross capital formation, official exchange rate, and population are statistically significant at the 1%, 10%, and 1% levels, respectively, which indicate the association between gross capital formation, official exchange rate, population, and economic growth. Table 5 also provides evidence of unidirectional causality resulting from gross capital formation and the official exchange rate relative to per capita real GDP. It is possible to use rising gross domestic capital formation to boost socioeconomic investment, which has a number of consequences for economic development. In the railway equation, all the selected variables are not statistically significant at the 1%, 5%, or 10% level. So no relationship exists among the variables in the short run.

4.3.2 Long run results

The study also looked at the results of Table 5's long-term causality analysis. The table reveals that the railways, roadways, gross capital formation, official exchange rate, and population growth cause per capita GDP. There is a long-term causal relationship between the GDP and the roads, the railways, the gross capital formation, the official exchange rate, and the population, as shown by the negative coefficient of the error correction model and the significant factor in the GDP equation. The output of Table 5 illustrates how, over the long term, the factors chosen have had an advantageous effect on Bangladesh's GDP growth.

4.3.3 FMOLS and DOLS

This study tries to examine the impact of transport infrastructure (railways and roadways) and macro-specific factors (GCF, POP, and OXCR) on Economic growth. Many researchers have explored economic growth and its relationship with transport infrastructure factors and macro-specific factors. According to the standard unit root tests on time series, all of the series included in our investigation are integrated in the same order. The cointegration test, on the other hand, confirmed the presence of a long-term relationship in our model. Consequently, the following step is to calculate the long-term elasticity using FMOLS as well as DOLS models.

Table 6 displays the estimation results for the FMOLS and DOLS models. Furthermore, the coefficients derived from these two models can be utilized to calculate long-term elasticity. The coefficients derived by the two models, FMOLS and DOLS, are clearly highly comparable and exhibit identical signs. In fact, based on the findings shown in Table 6, we discover that, with the exception of the cases of railroads and roads in the FMOLS model, the coefficients derived from the regression are statistically significant at the 1% level of significance.

Table 6.

FMOLS and DOLS Outcomes.

Variable	FMOLS			DOLS		
	Coefficient	T statistic	Prob.	Coefficient	tstatistic	Prob.
RAIL	0.815605	2.022643	0.0497	1.178943	.127304	0.0000
ROAD	0.122493	2.125103	0.0397	0.132159	.058386	0.0054
GCF	0.036457	8.829763	0.0000	0.439337	.07782	0.0000
OXCR	0.018895	7.699961	0.0000	0.00759	.922713	0.0000
POP	2.301546	6.759689	0.0000	1.875903	6.436017	0.0000
R2	0.98			0.99		
AdJ R2	0.98			0.99		

Again, all the variables have a positive impact on economic growth (Table 6). Regarding investment in railways, in the FMOLS and DOLS models, it has a positive and significant coefficient at a 5% and 1% level, respectively. Therefore, we can assert that in the long term, railways have a positive effect on economic growth in the case of Bangladesh, where 1% increases in railway infrastructure result in a 0.81% and 1.17% increase in per capita real GDP for the two models, FMOLS and DOLS, respectively. Additionally, our experiential research demonstrates that roadways have a significant positive effect on economic growth at 5% and 1% levels for the two models. Indeed, the coefficient of roadways shows that long-term economic growth via FMOLS and DOLS will rise by 0.122493 percent to 0.132159 percent for every 1% increase.

Table 6 reports that GCF is positively related to economic growth (GDP) at the 1% level of significance for both FMOLS and DOLS models, where a 1% increase in GCF results in a 0.0364577% and 0.439337% increase in per capita real GDP via FMOLS and DOLS models, respectively. The GCF's positive coefficient indicates that, over time, it significantly boosts economic growth. The fact that GCF, a type of investment, can result in increased output and employment helps to explain how GCF and economic growth are positively correlated. Turning to the official exchange rate variable, it is apparent that it has a positive and significant impact on economic growth. When the OXCR increases by 1%, economic growth rises by 0.018895% and 0.007590%, respectively, for the two distinct models, FMOLS and DOLS. Thus, on a net basis, a decline in the value of the currency encourages the nation to boost its output. Increased output would satisfy both domestic and international market demands. As a result of their perceived low cost by their developed trading partners, the countries' exports are anticipated to rise. Likewise, the labor force measured by total population positively effects per capita real GDP. Generally, the FMOLS and DOLS coefficients indicate that all of the independent variables (Rail, Road, GCF, OXCR, and POP) are positively signed and statistically significant with economic growth. The R-squared value of 0.98 and the adjusted R-squared of 0.98 both point to the model having a good fit. The study shows that there is Hervey homoscedasticity, and the null hypothesis of homoskedasticity is accepted. The results of the normality test concluded that the data set is well described by a normal distribution.

5.0 Conclusion and policy recommendations

This research aims to investigate the relationship between land transportation and economic growth in Bangladesh over the period 1973–2020. The empirical literature served as a guide for the economic model used in this study, while the lack of data in Bangladesh restricted the selection of explanatory variables. Per capita real GDP is commonly utilized as a proxy variable to measure economic growth, whereas the extent of railways and roadways is often employed as a proxy variable to assess the state of transport infrastructure. Based on previous scholarly investigations, three additional variables: This study effort incorporates the variable of gross fixed capital formation as a model for infrastructure investment. Additionally, the variables of total population and official exchange rate are included in the analysis. We have found the error correction term (ECT) to be negative and less than one, indicating a long-run relationship among the variables of economic growth, railways, roadways, gross capital formation, the official exchange rate, and population. Estimation outcomes of both DOLS and FMOLS reveal the positive and significant impact of railways and roadways on per capita real GDP.

According to the results of this investigation, the increasing importance of transportation infrastructure and increasing levels of economic activity are likely to be connected in some way over the long run. There is a correlation in both directions between improvements to the nation's road transportation infrastructure and overall economic expansion. This is consistent with Pradhan and Bagchi's (2013) findings. Rail infrastructure directly contributes to economic expansion, but this only works in one direction. It is believed that the owners of intercity buses have historically utilized political lobbying as a way to impede the proliferation of railroad construction and timetables. This is due to the fact that the profit made by bus routes may decrease if the railway sector becomes more efficient. Gross capital formation, the official currency rate, and population all have a causal effect on economic development, but only in one direction. Aside from that, the results of the regression analysis demonstrate that highways and railways both have positive effects on the expansion of the economy. As a consequence of this, it is hypothesized that enhancing transportation infrastructure (including both roads and railways) will lead to more widespread economic expansion.

When compared to other developed nations, it is obvious that Bangladesh's transportation infrastructure level, both in terms of quantity and quality, is not up to the standards set by developed nations. Because of the numerous direct and indirect benefits that transportation infrastructure provides to the economy, it would be possible to achieve higher economic growth through its implementation. In light of the fact that improvements to the nation's transportation infrastructure have been pinpointed as more substantial than most other factors of economic advancement, it is imperative that an appropriate transportation strategy be upheld in order to guarantee the country's continued contribution to the global economy. To maintain its position in the competition, the Bangladesh Railways must also undergo significant remodeling and modernization. In this context, the relevant authorities are required to accord the utmost importance to any projects that the BR undertakes. The truth is, however, that projects frequently run behind schedule for no discernible reason. Besides, corruption and inefficiencies in work is posing a great hamper in allocating necessary budget, as the cost of building roads in Bangladesh is too high compared to other contemporary countries. In this context, it is necessary to increase surveillance and assessment to curb corruption tendencies, besides import of advanced technologies in building roads could be cost effective and efficient. Moreover, given the population density of Bangladesh if people get the buying power like western countries it can induce tremendous rise in private transport like cars. Increasing number of cars in cities are becoming a great concern as they are causing traffic jams. If more and more people start affording private cars in Bangladesh no amount of roads and highways would be enough to support them. In this context it is better to improve public transportation, projects could be taken to improve bus, Metrorail transportation. And, to reduce the number of private cars, a quota system could be initiated so that a controlled number of cars are sold in Bangladesh each year, as well tax should be further increased in order to disincentives the buyers and importers.

The scope of future research into economic growth and transportation is very broad. The availability of data was one of the most significant challenges and constraints faced by this research. When attempting to explain the connection between economic growth and transportation, data sets with a longer time period and district-specific panel data can be more helpful. More indicator variables on both sides can be included for further analysis. The study might be improved by the inclusion of data on road transportation at a more disaggregated level. There are a variety of models that can be used to investigate the ways in which a predictor variable reacts to a dependent variable.

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