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A Study of Innovative Transportation and its Effects on Economic Growth of a Nation - A Case Study of Saudi Arabia

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Abstract

The development of transport takes place in socio-economic context. Development does not take place without proper infrastructure. The transport sector is very important in the economy. It is used for development due to intensive use of infrastructure. Innovation in transport makes sure that transport is safer and well-coordinated. Especially, in global economy transportation gains importance due to increasing economic opportunities and mobility of people. Therefore, transport infrastructure and level of economic development are apparently related. An efficient transport system reduces costs in many sectors. The effects of transport are not always predicted and can have unforeseen consequences such as congestion. Transport system holds an important responsibility both economically and socially.
This study aims to investigate and analyze the causality relations between innovative road transport infrastructure and economic growth in Saudi Arabia. The study is mainly based on information from secondary data sources obtained from Saudi Arabia Monetary Agency and World Bank over the period of 1989 to 2018 and information from third-party respondents involved in the transport sector are included. Granger causality test is used in this study to find out the relationship between different variables with Akaike Lag Length Selection Information Criteria and Vector Autoregression (VAR) model is used to find the causality relation. The result shows single directional causality from real GDP to transport infrastructure. There is, however, no proof to support that road transportation infrastructure is the major cause of economic growth. The finding lies in the basic idea that economic growth is the basis to provide the required support for the development of transportation infrastructure.

Keywords: Transportation, infrastructure, innovation, causality, road, real gross domestic product, and economic growth.

Introduction

Transportation is important for the well being and growth of any nation. Healthy transportation provides strong support for economic growth both in rural and urban areas.

By innovation transportation, we mean digitalization, electrification, automation and the sharing of economy

Advancement in transportation includes autonomous cars (google cars, Telsa) lightweight vehicle materials (moving from cast iron and steel to magnesium-aluminum alloys and carbon fiber construction), on-demand ride services (uber have changed the way people find transportation) hyperloop (pneumatic tube that uses a series of induction motors and compressors to propel vehicles at super-fast speed)

Transport is very crucial for the economy. Especially road transport where in today’s global economy economic opportunities are directly related to the increasing mobility of people all over the world.

There is a strong and positive relationship between road infrastructure expenditure and real GDP growth.

Road transport is the transportation of goods and personnel from one place to another. It has more advantages than other modes of transport. Investment required is less as compared .to other modes of transport.

Saudi Arabia is a large country of 2,149,690 km^2. It is a member country of the "Group of Twenty" (G-20) world major economies. It has total growing population of approximately 32 million. Road transport using Motor vehicles is the major means of transportation within the country. The country is rich in natural resources These resources can be used for economic development. But these resources are not enough to be used for a well-developed transport system.

The transport sector of Saudi Arabia has emerged as a major driving force for both economic and social development of the Kingdom. The highway network is large with 56,000 km. It has increased road facilities and mobility of people as well as goods across the whole Kingdom. Ministry of Transport (MOT) of Saudi Arabia has collaborated with international organizations and drafted a National Transportation system for developing a sustainable transport system and improving road safety in the country.

The transportation system of Saudi Arabia is mainly dominated by land transport system with Private vehicles playing the dominant role as they represent the common transport means for most of the population. The study will try to analyze the causality between current transportation infrastructure and economic growth in Saudi Arabia over the period 1988-2018 to give further scope to policymakers and to fill the gap in literature. The importance of investment in infrastructure is growing fast with Saudi vision 2030 that highlights the need for research in line with the Saudi development process and improvement in road transport infrastructure. It is important to sustain growth, generate employment as it allows entrepreneurs to get in flow with economic activities and bring resources together to produce goods and services. Sustainable economic growth and growing markets are important in making the social and geographical growth process. The study takes into consideration the abundant resources of Saudi Arabia as it is crucial to identify how road transport infrastructure investment is optimized by making the country's infrastructure more efficient and effective. Also it is important to recognize the contribution of transport system to economic growth rates through export, imports and employment levels.

The study aims to achieve two broad, distinct and complementary objectives; Firstly, to analyze the role of the road transport sector in economic development of the country. Secondly, it aims to provide better decision making and planning through explanation of applied relationship between the transport system and the economic development in Saudi Arabia. These objectives are attained by testing the hypotheses whether there exists positive relationship between road transport infrastructure and economic growth?

Section two provides a literature review on the impact of transport system on overall economic growth. Section three gives outline of the data and methodology adopted. The Dickey-Fuller Unit Root Test is applied to test the stationary of the time series and Granger causality test was used to examine the causal relationship between the chosen variables. It further follows results and reports and policy implications of the findings. The last section concludes the paper.

Review of Literature

2.1. Review of the empirical literature

The transport sector has major contribution to economic development especially employment generation and derives economic activities (1).

Most of the analysis of Structural Adjustment Programs in Africa aimed to search lags and deficiencies in infrastructure. It is a major cause of poor response in economic reforms. Proper transport encourages farmers to increase their marketable surplus and to use more and more land to adopt more efficient techniques and modern inputs. It also examined the relationship between infrastructure and per capita GDP in terms of the contribution of infrastructure and its demand.

The evidence obtained from the Survey of African Businesses shows strong correlation between the quality of infrastructure and the sentiments of foreign business. The result shows the importance of infrastructure in business decision and operations; it ranks high on list of complaints about all business and third for foreign-owned firms. Firms overwhelmingly indicate that roads are the most important.

Cantos (11) tested the impact of transport infrastructure on the economic growth in Spain. He tried to obtain spillover effects associated with transport infrastructures. Two different methods were used. The first method used was an accounting approach based on a regression on indices of total factor productivity and the second used was econometric estimation of the production function. It obtained elasticity with both methods. The result confirmed the spillover effects associated with transport infrastructures.

Weiss (21) examined the effect of infrastructure on economic growth for a sample of 30 developing counties over the period of 1971 to 1993. He adopted a growth accounting approach with infrastructure proxies including two variables, power capacity per capita and road length per capita. The estimates revealed that infrastructure is positively related to growth output and per capita GDP was significant and has a positive sign. In contrast, in their attempt to explain Africa's growth using cross-section regression found no significant effect either on roads, railways or electricity generation on productivity. This cites the poor state of its infrastructure.

Aljoufie and Algounabaiet (7) had examined the interrelation between infrastructure and economic activity. They used two infrastructure datasets with county-level employment and wages from 1990 to2003. Vector autoregressions, error correction models, and directed acyclic graphs methods were adopted. It showed the weak relationship between infrastructure investment and economic activity and not uniform.

Altahgfy (8) investigated the relationship between infrastructure investments and economic activity in Jeddah for the period of 1980 to 2000. Independent time scales were used to analyze the relationship to avoid the problem of endogeneity. The result shows that there exists causality nexus between growth and transport infrastructure investment and is timescale- dependent but it reverses in a comparison of the short-run and the long-run dynamics.

Daniel (14) provided a survey on estimates of transport infrastructure contributions to productivity and economic growth. The questions addressed were based on the elasticity of economic output with respect to transport infrastructure investment. The study showed controversial results such as in the research period, geographical scale, and country's capability in enabling economic development.

Yao and Zhao (20,29) also examined the differences in study related to the same phenomena. It measured different economic sectors, different types of transport and different quality levels of transport infrastructure. Dependent variables, functional specifications and estimation method of the econometric model were used. The result was inconclusive due to spatial concerns on the impact of infrastructure.

Yousif and Mohammad (30,31) analyzed the impact of transport infrastructure on economic growth in Pakistan. The findings suggested that there exists no causality between the two variables but there exists a unidirectional causality between economic development and infrastructure investment.

2.2. The transport sector in Saudi Arabia

Saudi Arabia is a vast country, where the population is scattered all over the country, separated by deserts, sand dunes, valleys, and mountains. In such case, fast and reliable means of transportation become very significant and essential. The main aim of road construction in Saudi Arabia is to connect major urban centers with surrounding villages and towns, thereby giving scope to development and improvement in the quality of life by providing citizens with better means of mobility. Construction of roads has been an important feature in the Kingdom's development and has dictated patterns of traffic movement. Most development projects, including for public services, religious purposes, agriculture or industry, requires construction of new roads for better connectivity.

The transport sector of Saudi Arabia has emerged as a driving force for economic and social development. The highway network length is approximate of 56,000 km. It has facilitated the movement of goods and people across the whole country. To develop transportation in the major cities of the Kingdom, it is necessary to develop integrated public transport including rail and bus services. The railway network is expanding thereby facilitating high-speed passenger trains and supporting multi-modal transport of goods. Also, private sector is increasing their investment in air transport services.

The massive growth in the use of motor transport worldwide witnessed in the early 20th century has transformed almost every country on the planet. However, road transport in Saudi Arabia has changed drastically is the world's leading oil producer. Earlier, population of Saudi Arabia was less, and the country had only few industries, but presently, it has become a highly industrialized economy due to its dominant oil production fulfilling fuel needs of almost the entire world. Saudi government is now investing more to develop its transport infrastructure system thereby introducing innovative transport system. Both Public and private transport will benefit from its massive investment program. Its plan to implement a multimodal transportation system includes new railways, metros, traffic systems, buses, bridges, and roads. Government has made huge investment in infrastructure development in the capital city, Riyadh. The multimodal transportation system of metros and buses will be ready to use by the end of 2019 (39).

Table (1): Contribution of Transport Sector in Saudi's GDP

Years	Share of Transport Sector in GDP as %	The budget for the transport sector in million (SR)
1990-1995	2.11	8,268.1
1996-2000	1.99	6,652.2
2005 – 2001	1.36	6,458.4

2006-- 2010	4.02	11,951.3
2011–2015	5.46	47,261.4

Source: Saudi General Authority for Statistics (2015).

If we observe the Saudi budget for the period of 1990 to 2015, a huge amount of funds and resources are allocated for the transport and communication sector as shown in the Table (1a). It is observed that as the transport sector budget increases, the contribution to GDP also increases. It shows that the transport sector is highly productive in terms of its growing contribution to the GDP growth of the country. But the country is facing many challenges to achieve its one of the prime objectives of Saudi vision 2030 to connect all the three continents through better transport. The government expenditure on infrastructure and transportation increased 87% from SR 29bn ($7.7bn) to SR 55bn ($14.4bn) in 2018 budget.

Saudi Vision 2030 clearly emphasizes on the improvement of the business environment and logistics systems of the nation and increasing global trade. For this it must make improvements in commercial environment and logistics systems.

According to the World Bank survey report, among 190 countries Saudi Arabia ranked 161st out of the 190 countries in terms of ease of doing business. For transport infrastructure, it ranked 53rd for railways, 46th for air transport and 42nd for the quality of its ports, while its roads were ranked 34th – this reflects the improvement in each category. Also, the reforms outlined in Saudi Vision 2030 would help Saudi Arabia to improve its ranking in all these international indices and comparisons.

Methodology and Data

To achieve the objectives and to validate the hypotheses, the study utilized econometric Granger (13) causality test and Akaike Lag Length Selection information criteria. The study also used Vector Autoregressive Model (VAR) to interpret the dynamic relationship between the variables. Since Granger test and (VAR) Model were performed between the stationary time series, the stationary (unit root) test was used. To make this reliable, a time series secondary macroeconomic dataset comprising annual observations for the periods from 1988 to 2017 was generated from World Bank reports and Saudi Arabian Monetary Agency.

The unit root test is a commonly used statistical test to determine whether each data series is non-stationary or stationary. The importance of this test arises from the fact that it forms the basis for econometric analysis of long-run equilibrium relationships proposed by economic theory. On economic grounds, there exists the belief that certain economic variables should not wander freely or be independent of each other. In fact, they are expected to move, so that, they do not drift apart. Therefore, to develop a meaningful relationship between the underlying variables, the stationary properties of the data were examined by implementing the Augmented Dickey-Fuller (ADF) test for the unit root (non- stationary) Pair of time series of paved roads and real gross domestic product are denoted as ROAD and RGDP, respectively.

The stationary VAR allows interpretations on the dynamic relationship between the variables.

The VAR model for paved roads and real gross domestic product, formulated as:

$$RGDP_t=\delta_1+\sum_{i=1}^{P}\beta_{1i}\,RGDP_{t-i}+\sum_{i=1}^{P}\beta_{2i}\,Road_{t-i}+U_{1t} \qquad (1)$$

$$Road_t=\delta_2+\sum_{i=1}^{P}\alpha_{1i}\,RGDP_{t-i}+\sum_{i=1}^{P}\alpha_{2i}\,Road_{t-i}+U_{2t} \qquad (2)$$

Where:

δ, β, α, are parameters.

RGDP: Real Gross Domestic Product.

Road: Paved Roads.

U_t: are the stochastic error terms.

Assumptions about the error terms:

1. The expected residuals are zero: E (U_{1T}) =E (U_{2t})= 0

2. The vector error terms are not autocorrelated:

E $(U_t U_s)$ $=\sigma_i^2$ if s= t and

E $(U_t U_s)$ =0 if s≠t

Different tests are conducted using equations (1) and (2), in order to analyze the dynamic relationship between those variables.

The selected order is lag one (1) according to the criteria of Akaike information criterion, implies that we have VAR (1). The equations (1) and (2) of VAR is shown as:

$RGDP_t=\delta_1+\beta_1 RGDP_{t-1}+\beta_2 Road_{t-1}+U_{1t}$ -(3)

$Road_t=\delta_2+\alpha_1 RGDP_{t-1}+\alpha_2 Road_{t-1}+U_{2t}$ -(4)

In 1969, The Granger causality test was proposed for determining whether one-time series is useful in forecasting another. Clive Granger argued that causality in economics is tested for measuring the ability to predict the future values of a time series using prior values of another time series. True causality It is absolutely philosophical therefore many econometricians assert that the Granger test finds only "predictive causality".

A time series X is said to Granger-cause Y if it can be shown, usually through a series of t-tests and F-tests on lagged values of X (and with lagged values of Y also included), that those X values provide statistically significant information about future values of Y.

To examine the causal relationship between road transport infrastructure and economic activity, Granger (13) causality test was used. Granger's definition of causality is based on two ideas. The first is that the future cannot cause the past, while the past and present cause the future. The second idea is that causality exists only between two stochastic variables. Causality is not possible when the two variables are deterministic. Granger's test utilizes a one-sided distributed lag method, which is based on the incremental forecasting value of the past (or past plus present) history of one variable on another. A time series X is said to Granger-cause Y if it can be shown, usually through a series of F-tests on lagged values of X that those X values provide statistically significant information about future values of Y. By effective method, the test can be done by first doing a regression of ΔY on lagged values of ΔY. As the appropriate lag interval for Y is proved significant (t-stat or p-value), subsequent regressions for lagged levels of ΔX are performed and added to the regression if they are significant and add explanatory power to the model.

The above exercise repeated for multiple ΔX's (with each ΔX tested independently of other ΔX's, but in conjunction with the proven lag level of ΔY). More than one lag level of a variable can be included in the final regression model if it is statistically significant and provides explanatory power.

The Granger causality test estimates the following pair of regressions:

$y_t= \sum_{i-1}^{n} \alpha_i x_{t-i} +\sum_{j-1}^{n} \beta_j y_{t-j} +\varepsilon_{1t}$ (i)

$x_i= \sum_{i-1}^{n} \varphi_i x_{t-i} +\sum_{j-1}^{n} \delta_j y_{t-j}+\varepsilon_{2t}$ (ii)

With the assumption that the disturbances ε_{1t} and ε_{2t} are uncorrelated. Four cases will be distinguished:

1. Unidirectional causality fromx_i to y_t is indicated if the estimated coefficients on the lagged x_i in (i) are statistically different from zero as a group $(\sum_{i=1}^{n} \alpha_i \neq 0)$and the set of estimated coefficients on the laggedy_t in (ii) is not statistically different from zero$\left(\sum_{j=1}^{n} \delta_j \neq 0\right)$

2. Unidirectional causality from y_t to x_i is indicated if the estimated coefficients on the lagged y_t in the (ii) are statistically different from zero as a group $\left(\sum_{j=1}^{n} \delta_j \neq 0\right)$and the set of estimated coefficients on the laggedx_i in (i) is not statistically different from zero $(\sum_{i=1}^{n} \alpha_i \neq 0)$

3. Bilateral causality is indicated when the set of x_i and y_t coefficients are statistically different from zero in both regression equations (i) and (ii).

4. Independence – occurs when the set of x_i and y_t coefficients are not statistically significant in both regression equations (i) and (ii).

It lies on the assumption that the two variables are stationary.

The Granger causality test was used in this study to examine whether there is a positive relationship between econometric models, paved roads and real gross domestic product.

Akaike (2) definition of causality used to determine the optimum lag for each variable. The Akaike Information Criterion (commonly referred to simply as AIC) is a criterion for selecting the nested statistical or the AIC is essentially an estimated measure of the quality of the available econometric models.

The AIC is a number associated with each model:

$$AIC=\ln (s_m^2) + 2m/T$$

Where m is the number of parameters in the model, and s_m^2 (in an AR (m) example) is the estimated residual variance: s_m^2 = (sum of squared residuals for model m)/T. This criterion may minimize choices of m to form a trade-off between the fit of the model and the model's complexity that is measured by m. Thus, an AR (m) model versus an AR (m+1) can be compared by this criterion for a given batch of data.

An equivalent formulation is AIC=T ln (RSS) + 2K where K is the number of regressions, T is the number of observations, and RSS is the residual sum of squares; minimize over K to pick K...

Results and discussion:

4.1. Results of the Study:

The result of the ADF unit root tests is presented in table (1). The table illustrates that RGDP is stationary indifference one with intercept and significance at 10%, and Road is stationary indifference one with intercept and significance at 5%.

Table 2: ADF unit root test for paved roads (Road) and Real Gross Domestic Product (RGDP)

Variable	Test for a unit root in	ADF Test Statistic	Critical Value
Real Gross Domestic Product (RGDP)	1st difference	-4.135695	1% → -3.689194 5%→ -2.971853 10%→ -2.625121
Paved roads (ROAD)	1st difference	-7.512889	1% → -3.689194 5%→ -2.971853 10%→ -2.625121

Source: Author calculations based on data from WB and. SAMA.

Table 2 shows the Akaike information criterion (AIC) by determining the optimum lag length by choosing the lower AIC value. Thus result lag 2 is the optimum lag for the period from1988 to 2017.

Table 3 Akaike information criterion (AIC) for the period of1988-2017

Lag	AIC
1	44.50*
2	45.46
3	45.48

Source: Author calculations based on data from World Bank and SAMA 2018

Table 3 below shows Granger causality tests results for the period of 1988 to 2017. The results recorded unidirectional causality from real GDP to road in lag (1) representing that the correlation was positive in the last years because the economic activity was consistently increasing from 1988 to 2017.

Table 4: Correlation test for the period of1988 to 2017

	GDP	ROAD
GDP	1.000000	0.778845
ROAD	0.778845	1.000000

There is a strong and positive correlation between the two variables. Real Gross Domestic Product (RGDP) is R^2=0.78. It reflects that infrastructure plays a tangible role in contributing to economic growth and vice versa. This indicates that the Granger causality analysis can be conducted.

Table 5: Granger Causality test results for the period of 1988-2017

Null hypothesis	Observations	F-statistic	Probability	Decision
Lags1:2				
ROAD does not Granger Cause RGDP	29	1.69121	0.2049	Don't reject
RGDP does not Granger Cause ROAD	29	8.25450	0.0080	Reject

Source: Author calculations based on data from WB and. SAMA 2018.

Vector autoregressive (VAR) models facilitate to find substantial effects and to determine the interrelationships among the variables. The result presented in Table 5 shows that the coefficients of lagged RGDP (-1) and ROAD (-1) are significant in the regression of the RGDP, and coefficients of lagged RGDP (-2), and ROAD (-2) are insignificant in the regression of the RGDP. While coefficients of RGDP (-1), ROAD (-1) RGDP (-2) and ROAD (-2) are insignificant in the regression of the ROAD.

Table 6: Vector Autoregression (VAR) results for the period of 1988 to 2017)

Dependent Variable	RGDP	ROAD
RGDP(-1)	1.057152 (0.22532) [4.69173]	0.017374 (0.01180) [1.47190]
RGDP(-2)	-0.099995 (0.22476) [-0.44490]	-0.012358 (0.01177) [-1.04961]
ROAD(-1)	6.142121 (4.60106) [1.33494]	0.140884 (0.24103) [0.58451]
ROAD(-2)	-1.631691 (4.61867) [-0.35328]	0.405803 (0.24195) [1.67722]

C	73074.85 (54891.1) [1.33127]	-3484.717 (2875.48) [-1.21187]

Source: Author calculations based on data from the World Bank and. SAMA 2018.

4.2 Discussion

The results presented in table 6, shows that there is a unidirectional causality between real GDP to the road in lag (1) showing positive correlation in the last years. This is due to consistent increase in economic activity during 1988 to2017. Thus, change in the rate of economic growth brings significant change in transportation infrastructure. The analysis provides enough evidence that there is a unidirectional causal relationship between economic growth and transportation infrastructure and that real GDP Granger causes transportation development. This indicates that GDP is a significant cause for the development of transportation infrastructure in Saudi Arabia.

Conclusion

The above analysis concludes that there is enough evidence to show that there exists a unidirectional causal relationship between economic growth and investment in innovative road transport in Saudi Arabia. Thus, it proves that GDP or economic growth is the cause of development of transport infrastructure in Saudi Arabia. However, transport infrastructure is necessary but not enough condition for economic growth as other factors or variables are also needed to meet further economic development.

With its vison 2030, there is a high demand for industrial goods and logistic facilities which will increase demand for better transport facilities thereby enhancing more transport project utilities and plans. This shows that economic growth provides necessary financial and technical support for investment in infrastructure and development. This enhances the mobility and efficiency of goods and services in the country thereby increasing regional productivity. Thus, efficient infrastructure facilitates country's economic growth.

Declaration

This Research work was carried and completed by Dr. Puja Sunil Pawar under the Department of Economics, College of Business Administration, Princess Nourah Bint Abdul Rahman University, Riyadh, Saudi Arabia.

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Appendix

Null Hypothesis: D(ROAD) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=7)

Prob.*	t-Statistic			
0.0000	-7.512889	Augmented Dickey-Fuller test statistic		
	-3.689194		1% level	Test critical values:
	-2.971853		5% level	
	-2.625121		10% level	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ROAD,2)
Method: Least Squares
Date: 11/21/18 Time: 20:54
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0000	-7.512889	0.210808	-1.583779	D(ROAD(-1))
0.4111	0.835337	708.8904	592.1621	C

513.1429	Mean dependent var	0.684632	R-squared
6554.002	S.D. dependent var	0.672503	Adjusted R-squared
19.36601	Akaike info criterion	3750.682	S.E. of regression
19.46117	Schwarz criterion	3.66E+08	Sum squared resid
19.39510	Hannan-Quinn criter.	-269.1242	Log-likelihood
2.025803	Durbin-Watson stat	56.44350	F-statistic
		0.000000	Prob(F-statistic)

First difference

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

Prob.*	t-Statistic			
0.0034	-4.135695	Augmented Dickey-Fuller test statistic		
	-3.689194		1% level	Test critical values:
	-2.971853		5% level	
	-2.625121		10% level	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(GDP,2)
Method: Least Squares
Date: 11/21/18 Time: 21:08
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0003	-4.135695	0.194351	-0.803777	D(GDP(-1))
0.0118	2.708199	17007.48	46059.64	C

-618.8929	Mean dependent var	0.396807	R-squared
85061.00	S.D. dependent var	0.373608	Adjusted R-squared
25.14110	Akaike info criterion	67321.49	S.E. of regression
25.23625	Schwarz criterion	1.18E+11	Sum squared resid
25.17019	Hannan-Quinn criter.	-349.9753	Log-likelihood
1.689660	Durbin-Watson stat	17.10397	F-statistic
		0.000328	Prob(F-statistic)

FIRST DIFFERENCE

Pairwise Granger Causality Tests
Date: 11/21/18 Time: 21:15
Sample: 1988 2017
Lags: 1

Prob.	F-Statistic	Obs	Null Hypothesis:
0.2049	1.69121	29	ROAD does not Granger Cause GDP
0.0080	8.25450		GDP does not Granger Cause ROAD

Vector Autoregression Estimates
Date: 11/21/18 Time: 21:21
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments
Standard errors in ( ) & t-statistics in [ ]

ROAD	GDP	
0.017374	1.057152	GDP(-1)
(0.01180)	(0.22532)	
[1.47190]	[4.69173]	
-0.012358	-0.099995	GDP(-2)
(0.01177)	(0.22476)	
[-1.04961]	[-0.44490]	

0.140884	6.142121	ROAD(-1)
(0.24103)	(4.60106)	
[0.58451]	[1.33494]	
0.405803	-1.631691	ROAD(-2)
(0.24195)	(4.61867)	
[1.67722]	[-0.35328]	
-3484.717	73074.85	C
(2875.48)	(54891.1)	
[-1.21187]	[1.33127]	
0.730589	0.981700	R-squared
0.683735	0.978517	Adj. R-squared
2.97E+08	1.08E+11	Sum sq. resids
3591.389	68557.20	S.E. equation
15.59283	308.4587	F-statistic
-266.1926	-348.7682	Log likelihood
19.37090	25.26916	Akaike AIC
19.60879	25.50705	Schwarz SC
11701.21	1732085.	Mean dependent
6386.112	467746.2	S.D. dependent
5.28E+16	Determinant resid covariance (dof adj.)	
3.56E+16	Determinant resid covariance	
-613.0194	Log-likelihood	
44.50138	Akaike information criterion	
44.97717	Schwarz criterion	