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Article

Determining non-linear causality between urban and non-urban ground transport and economic growth using wavelet neural network (case study: Iran)

Determining Non-Linear Causality between Urban and Non-Urban Ground Transport and Economic Growth Using Wavelet Neural Network (Case Study: Iran)

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Abstract: In the last few decades, the relationship between economic infrastructures, particularly transport sector, and economic growth has been the subject of many reseracher in different economies. Iran has many advantages considering particular geographic situation in terms of transport facilities as it connects many countries. In this study, the relationship among ground transport, economic growth, capital formation , and work force was examined by using quarterly data during 1992 to 2012. Required data were extracted from the statistics of Centeral Bank of Islamic Republic of Iran and yearbooks of Statistical Center of Iran. The most important difference of this study compared to other previous studies is using wavelet neural network method and non-linear approach in explaining the relationship among discussed variables. The results of causal relationship test between variables imply the existence of causality from ground transport to economic growth.

Keywords: economic growth, transport, neural network, causality, Iran
JEL Classification: R41, C2, R11, N95

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1- Introduction

Today, transport sector is one of the infrastructures of each society that not only it affects economic development process, but it also changes in development flow. Iran is a bridge connecting the Asia to the Europe and north to south. Geographically, it can play key role in the transfer of goods through road (land and rail), air, and sea. For this purpose, after the impose war, it was tried to develop communication and transport systems comprehensively in the country with huge investment in order to have appropriate position at international arena for transit services. From long ago, trading has been in the center of all economies as a heart. People exchange their time and ideas in order to obtain money in order to provide goods and services. Technological agencies exchange expertise, financial power, intermediate goods, executive factors and so many other issues individually with other agencies and government. All these transactions require communication and most of them need transfer of goods and people for job, purchase, establishment of tourists, and locating. Therefore, it can be certainly said that, transport is in the center of all economic activities (Smell & Verhoef, 2007). In fact, transport sector has key role in sustainable development of an economy. Advantage and importance of transport infrastructure in economic growth have been considered significantly since long ago (Phang, 2003).

Transport can be applied as an effective and useful factor in predicting the future of countries' economy in short-term and long-term. Transport is vital and undeniable capital. This has a significant influence on the flows of trade and exchange of a country. On the other hand, its operations and maintenance are of great importance in absorbing human resources (Short & Kopp, 2005). Therefore, considering important advantages of this sector, studying the relationship of this sector, economic growth, and the way of their effectiveness on each other are of great importance. Thus, this research has been written aiming to analyze causality relation between these two key variables. The difference is that a new method has been used for this purpose. Unlike common econometric methods, it has been tried to study neural networks based on the concept of causality proposed by Grange 1969.

2- Literature Review

Regarding transport and its position in economy, several studies have been done to investigate the impact of this sector on different economic aspects including revenue distribution, economic growth, business, and so on. Studies at macro-economy level of some countries indicate that investment in transport leads to economic growth in them. Grounds for investment in transport infrastructures have been prepared by adding social efficiency on private investment. Thus, there is a one-way path between these two variables. The growth of one of them will be resulted in the other's growth and vice versa. In the following, some of Iranian and foreign researches in transport sector and economic growth will be addressed.

a. Foreign Researches

Much attention has been paid to the issue of infrastructure, the impact of public investment and its relation with economic growth among foreign studies in the recent decades.

The studies of Aschauer (1989) and Munnell (1990) are some of the most important ones. In these two studies, they concluded a strong relationship among the variables of public investment in infrastructure and private sector production by putting public capital in the production function and using time series data. Munnell argued positive traction for investment.

Aschauer (1989) indicated that infrastructure investment such as building highway, road, airport, transit corridor, and other governmental costs are the most influential factors to improve the efficiency of private sector in the U.S. during 1945 to 1985.

Easterly and Rebelo (1993), Miller and Russek (1977), and Devarajan et.al. (1996) are other important studies in this field. They concluded that investment in transport and communication works as an engine for economic growth. Transport and communication sectors play an important role in reducing regional differences and improving regions' competition through business and movement of production factors.

Haque and Kim (2003) used two traditional estimation (instrumental variables) and combined estimation methods (fixed and random coefficients) and studied causative relationship among governmental investment in transport and communication sectors and economic growth of developing countries during 1970 to 1987. According to the results, the first interruption coefficient of difference between public investment in transport and communication is negative and significant, and the second one is positive and statistically insignificant. Governmental investment in transport and communication is the result of economic growth.

Fedderke et.al. (2006) studied long-term relationship between investment in economic infrastructures and economic growth during 1975 to 2001 in South Africa by co-integration and vector error correction methods (VECM). In this study, the growth of moved goods and presented services by different infrastructures, including railway, road, air transport, telecommunications, and electricity, were used against GDP growth. One of the most important results was direct and indirect strong relationship of infrastructure sector to economic sector and weak relationship between economic growth and infrastructures.

Pradhan and Bagchi (2013) studied the relationship among capital formation, economic growth, and transport sector by using VECM for India during 1970 to 2010. The results indicate a mutual causative between land transport and economic growth, land transport and capital formation, and economic growth and capital formation. Many economists consider the reason of conflicting results around experimental evidences from period of studied countries and using different approaches of econometrics.

b. Iranian Researches

Rezayi Arjroodi and Tasbihi (2008) studied to determine the VAT of explanatory variables of transport sector on economic growth by using forecast error analysis and examined the impacts of different shocks of transport sector on economic growth during 1971 to 2014. The results of this study indicate that transport sector has positive impact on economic growth, but it is weak. This indicates underdevelopment of transport sector. From researchers' perspective, investment in transport sector not only leads to improve market in different aspects, but it also creates various employment fields, expands the use of any individual of produced goods, and increases production power of society.

Babazadeh et.al. (2008) in a research entitled, "the impact of investment in transport sector on economic growth in Iran" studied the relationship between governmental investment transport sector and economic growth in Iran by using co-integration method during 1959 to 2005. The results indicate that investment in transport sector will have significant impact on economic growth in long and short term.

Mehregan and Dehghani Ahmadabadi (2010) studied the impact of economic growth of transport sector on revenue distribution in Iran during 1969 to 2005. The results indicated that transport sector was accompanied by reducing inequality. In this study, the strategic position of Iran has been proposed as a potential in improvement of revenue distribution that is able to reduce urban and rural revenue gap.

3- Theoretical Principles

The interests and importance of transport sector have been always considered in the literature of economic growth. Investment expenses in transport sector are proposed as an incentive of demand side to economic growth and establishing economically particular regions. In the following, mutual impact of transport sector and economic growth will be explained.

The Impact of Transport Sector on Economic Growth

Land transport, like other transport infrastructures, can influence economic growth through changing total demand. For instance, it can create and increase the demand of intermediate inputs from other sectors, and create multiple impacts on economy (Pradhan & Bagchi, 2013). Development of land transport infrastructure can increase economic growth by increasing investment, improving the quality of capital stock through constructing new highways and airports, improving in effective consumption or efficiency in consumption such as creating additional capacity in infrastructure investment, optimizing transport organizations, and changing fuel expenses.

Barchaman (2001) considered more interest than direct and initial interests of transport did; improvement of access to production factors and increase in operational power can be noted. Figure1 shows initial advantages of growth dependent on external impacts in different markets. The main reason of this growth is caused by allocating resources in economy that is typically formed by economic advantages, volume, area, integration and density of transport networks. Combined results of such impacts in higher economic growth that are measured as changes in employment, production, and efficiency will be displayed. In contrast, if there are no such external impacts, transport interests will be formed only in a type of investment.

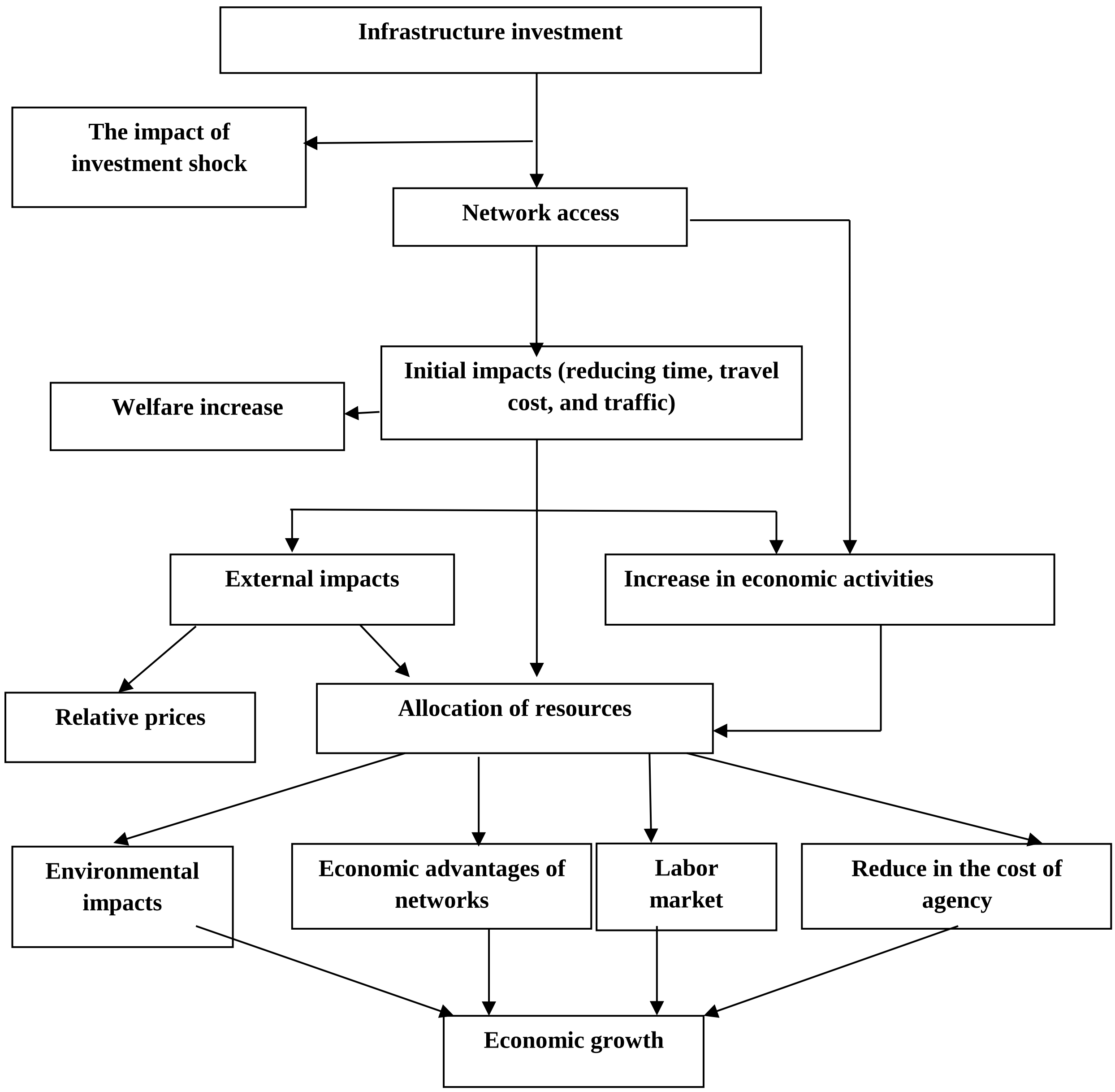

Figure1. The relationship between infrastructure investment in transport sector and economic growth

Reference: (Banister & Berechman, 2001)

Effectiveness of Economic Growth on Transport Sector

Economic infrastructures affect efficiency, production, and economic growth. On the other hand, as efficiency and economic growth increases, demand and supply of infrastructures increases as well (Esfahani & Ramirez, 2003). Transport demand and creating infrastructure increases with economic growth, population growth, and urbanization increase. Furthermore, private sector investment increases in the regions that have appropriate infrastructure of transport. This infrastructure increases investment; therefore, it will be followed by economic growth (Pradhan & Bagchi, 2013). Ramanathan (2001) proposed urban transport as an important factor in road transport sector and considered transport expansion because of increase in development and urbanization. According to the researcher, urbanization development, population increase, and density of cities lead to increase transport development; therefore, transport sector affect economic variables such as production in different sectors, total employment, price, and cost index in short, medium, and long term, and it is influenced by economic growth mutually. Certainly, it is complicated to analyze this relation and multi-aspect entity of relationship between transport and economic growth should be considered.

4- Research Method

Model Structure

Desired model in this study follows Paradhan and Bragchi (2013) with slight changes to study the causality of economic growth, land transport, and capital formation as equation1:

$$EG=f\,(TINF, CF, TLF) \qquad (1)$$

EG: economic growth

TINF: total Transport Infrastructure

CF: capital formation

TLF: total labor force

As it can be seen in equation1, according to this model, economic growth is a function of capital formation, transport, and labor force. It has been tried in this article to test causal relationship between economic growth and land transport infrastructure by using non-linear methods (with high accuracy) and neural networks.

Non-linear Causative Test by Using Group Method of Data Handling (GMDH)

Using neural networks in implementing the algorithm method of grouping data has resulted in its flexibility and optimization because of creating different network structures. Generally, using the neural network in this algorithm made models' analysis or trivial functions in different ways simpler and more reasonable (Soleymanikiya, 2007).

Briefly, the advantages of non-linear causality of Group Method of Data Handling against Granger causality are as follows:

- Insensitivity to the number of variables' interruptions
- Lack of need to check stability of variables
- Insensitivity to the number of variables' breaks
- Exploring complex non-linear relationships

Generally, causality of classified data group is a very appropriate method to investigate causality relationship (in the concept of econometrics) among variables that is more efficient than conventional method in econometrics and it can be used in experimental works (Noori, 2010).

The Structure of Neural System; Method of Grouping Data

Neural network is self-organizing; unidirectional regarding method of grouping data composed from several layers, and each of them is made of several neurons. All neurons enjoy similar structure. All of them have two inputs and one output. Each neuron processes among input data and output ones with five weights and a skewed sentence. Figure2 shows a neuron and equation 2 represents neuron structure with five weights and a skewed sentence.

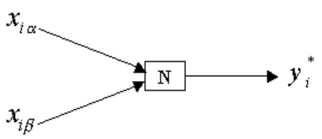

Figure2. Neuron structure
Reference: (Soleymanikiya, 2007)

$$y_{ik}^{*} = N(x_{i\alpha}, x_{i\beta}) = b^k + w_1^k x_{i\alpha} + w_2^k x_{i\beta} + w_3^k x_{i\alpha}^2 + w_4^k x_{i\beta}^2 + w_5^k x_{i\alpha} x_{i\beta} \quad (2)$$

In equation2, i=1,2,3,…,N. N is the number of input and output data and (k=1,2,3,…, C_m^2),{1,2,3,…M} ∈α,β that m is number of neurons in previous layer.

The weights were calculated based on minimum square error methods and they were placed as fixed amounts inside of each neuron. An obvious feature in these networks indicates previous neurons or previous layers (m) are generators of new neurons$C_m^2 = \frac{m(m-1)}{2}$. Some of them are necessarily must be removed among the produced neurons in order to avoid divergence of the network.

Selection criterion and removing a set of neurons in a layer are percent of the total square error(r_j^2) among real output amounts(y_i) and neuron output of j-th (y_{ij}^*).

$$r_j^2 = \frac{\sum_{i=1}^{N}\left(y_i - y_{ij}^*\right)^2}{\sum_{i=1}^{N} y_i^2} \quad (۳)$$

In the above equation, we have $j \in \{1,2,3,\dots,C_m^2\}$ that m is the number of selected neurons in previous layer.

The final equation between input and output variables is established by this type of neural network will be Volterra non-linear function as follows:

$$\hat{y} = \alpha_\circ + \sum_{i=1}^{m} \alpha_i x_i + \sum_{i=1}^{m}\sum_{j=1}^{m} \alpha_{ij} x_i x_j + \sum_{i=1}^{m}\sum_{j=1}^{m}\sum_{k=1}^{m} \alpha_{ijk} x_i x_j x_k + \cdots \quad (۴)$$

Application of Artificial Neural Network in Causality Test

In order to clarify causal relationship between X and Y, the breaks of these two variables are formed first as input variables to group data network, and then the current level of X and Y will be predicted by using this network.

As current values of two time series are considered as exogenous variable in standard Granger causality, previous values of two time series are used as network inputs in this method. In order to determine causality direction from X to Y, two input categories are considered for the network; one category includes previous values of X and Y, and another one consists of only previous values of Y. Therefore, two predictions of the variable output may be achieved. The first prediction is based on previous values of two series, and the second one is only based on previous values of Y. The derivation of these two predictions in determining causality path is so that if the error obtained from the first pattern is less than error rate in the second pattern, X may improve the prediction of Y and X may be considered as the reason of Y. Such conditions are considered for X and the causality of Y to X may be investigated.

5- Research Findings

Used Data

In this study, according to the available data, annual data of value added in land and rail transport, value of capital formation, labor force, and GDP during 1992 to 2012 were used. As mentioned before, one of the advantages of neural network is its less sensitivity to the number of observations than Granger causality. However, in order to strengthen the results, annual data were changed into seasonal ones.

The Results of Non-Linear Causality Test

The results of non-linear causality test were obtained by a written program in MATLAB software. According to the presented results in table1, the direction of causality between land transport and economic growth can be analyzed. The value of less error based on criteria of common error 1 has been specified by *. For example, interpretation of results is so that regarding the causality between economic growth and land transport, the model of predicting economic growth has been improved when land transport breaks were used and the non-break model of land transport has been used less. Therefore, it can be said that previous values of land transport forecasted economic growth well and land transport is the reason of economic growth.

Table1. The criteria of error functions for causality of land transport and economic growth

The values of obtained error function			
Predicting model of economic growth	RMSE	MAE	MAPE
With land transport break	6.2883	2.1449	406.579
Without land transport break	1.4647*	1.341*	118.719*
The values of obtained error function			
Predicting model of economic growth	RMSE	MAE	MAPE
With land transport break	8637.443*	8530.685	8530.658*
Without land transport break	8637.495	8530.703	99.999

Reference: (Researchers' calculations by using written program in MATLAB software)

In the next step, the significance of difference between error functions was examined by using a written program in E-views-72 software (table2).

Table2. The statistics of predicting criteria for causality of land transport and economic growth

Final Result	Alternative hypothesis	Granger-Newbold Statistic	P-value	Result
Causality verification	Land transport to growth	22.26	5.13E14	$RMS_2<RMS_1$
Causality rejection	Growth to land transport	-3.8	0.001426	$RMS_2>RMS_1$

Reference: (researchers' findings by a written program in Eviews)

Whenever the error function of the second model (RMSE2) is less than the error function of the first model (RMSE1), it means causality relationship is confirmed and there is causality significantly. If RMSE1 is less than RMSE2, there will be no causality. In other words, in the second case, the breaks of the second category did not improve the prediction of the first category.

In the following, causality test of land transport sector with other variables, capital formation, and labor force will be discussed as discussed earlier. The results of these tests have been represented in tables3 and 4. Obtained values of these tests have been shown in tables 5 and 6.

Table3. The statistics of error functions for the causality of capital formation and land transport

The amounts of obtained error functions			
Predicting model of capital formation	RMSE	MAE	MAPE
Without break of land transport	٢٠٠٦٦٦٠٧*	١٨٨٦٥٨١٩	١٨٨٦٥٨٨١٩*
With break of land transport	٢٠٠٦٦٦٠٨	١٨٨٦٥٨٢٠	١٠٠
The amounts of obtained error functions			
Predicting model of capital formation	RMSE	MAE	MAPE
Without break of land transport	8636.914*	8530.129*	8530.129*
With break of land transport	8636.769	8530.751	100.01

Reference: (Researchers' calculations by using written program in MATLAB software)

Table4. The statistics of error functions for causality of labor force and land transport

The amounts of obtained error functions			
Predicting model of labor force	RMSE	MAE	MAPE
Without break of land transport	٦٦٦٠٨١٠	٦٦٠٧٥٧٢	١٠٠
With break of land transport	6660808*	٦٦٠٧٥٧٠*	99.9999*
The amounts of obtained error functions			
Predicting model of labor force	RMSE	MAE	MAPE
Without break of land transport	8735.619	8530.129	99.93
With break of land transport	8636.914*	8528.957*	99.80*

Reference: (Researchers' calculations by using written program in MATLAB software)

Table5. The statistics of predicting criteria for capital formation and land transport

Final result	Alternative hypothesis	Granjer-Newbold statistic	P-value	result
Causality confirmation	Capital formation to land transport	-3.08	0.0067	$RMS_2 > RMS_1$
Causality rejection	Land transport to capital formation	-2.19	0.0042	$RMS_2 < RMS_1$

Reference: (researchers' findings by a written program in Eviews)

Table6. The statistics of predicting criteria for labor force and land transport

Final result	Alternative hypothesis	Granjer-Newbold statistic	P-value	Result
Causality confirmation	Labor force to land transport	10.26	0.0182	$RMS_2 < RMS_1$
Causality rejection	Land transport to labor force	1.39	1.5-E8	$RMS_2 < RMS_1$

Reference: (researchers' findings by a written program in Eviews)

Table7. The statistics of error functions for causality of labor force and capital formation

The amounts of obtained error functions			
Predicting model of labor force	RMSE	MAE	MAPE
Without break of capital formation	٦٦٦٠٨١٠	٦٦٠٧٥٧٢	١٠٠
With break of capital formation	٦٥٢٠٨١٩*	٦٦٠٧٥٧١*	١٠٠*
The amounts of obtained error functions			
Predicting model of capital formation	RMSE	MAE	MAPE
Without break of labor force	٢٠٠٦٦٦٠٧	١٨٨٦٥٨٢٠	١٠٠
With break of labor force	٢٠٠٦٦٦٠٥*	١٨٨٦٥٨١٩*	١٠٠*

Reference: (Researchers' calculations by using written program in MATLAB software)

Table8. The statistics of error functions for causality of labor force and capital formation

Final result	Alternative hypothesis	Granjer-Newbold statistic	P-value	Result
Causality confirmation	Labor force to capital formation	5.025	0.0001	$RMS_2 < RMS_1$
Causality rejection	Capital formation to labor force	2.842	0.0112	$RMS_2 < RMS_1$

Reference: (researchers' findings by a written program in Eviews)

Table9. The statistics of error functions for causality of labor force and economic growth

The amounts of obtained error functions			
Predicting model of labor force	RMSE	MAE	MAPE
Without break of economic growth	٦٦٠٠٨١٠	٦٦٠٧٥٧٢	١٠٠
With break of economic growth	٦٦٠٨٠٨*	٦٦٠٢٥٧١*	١٠٠*
The amounts of obtained error functions			
Predicting model of economic growth	RMSE	MAE	MAPE
Without break of labor force	1.7756*	1.1315*	1.1315*
With break of labor force	19.9233	14.425	1238.245

Reference: (Researchers' calculations by using written program in MATLAB software)

Table10. The statistics of error functions for causality of labor force and economic growth

Final result	Alternative Hypothesis	Granjer-Newbold Statistic	P-value	Result
Causality confirmation	Economic growth to labor force	8.71	1.11E-7	$RMS_2<RMS_1$
Causality rejection	Labor force to economic growth	-16.54	6.46E12	$RMS_2>RMS_1$

Reference: (researchers' findings by a written program in Eviews)

Table11. The statistics of error functions for causality of capital formation and economic growth

The amounts of obtained error functions			
Predicting model of economic growth	RMSE	MAE	MAPE
Without break of capital formation	6.288	2.144	406.57
With break of capital formation	2.023*	1.53*	186.43*
The amounts of obtained error functions			
Predicting model of economic growth	RMSE	MAE	MAPE
Without break of labor force	٢٠٠٦٦٦٠٧	١٨٨٦٥٨٢٠	١٠٠
With break of labor force	٢٠٠٦٦٦٠٦*	١٨٨٦٥٨١٩*	100*

Reference: (Researchers' calculations by using written program in MATLAB software)

Table12. The statistics of error functions for causality of economic growth and capital formation

Final Result	Alternative Hypothesis	Granjer-Newbold statistic	P-value	Result
Causality confirmation	Economic growth to capital formation	2.86	0.0115	$RMS_2<RMS_1$
Causality rejection	Capital formation to economic growth	5.66	-52.8E-	$RMS_2<RMS_1$

Reference: (researchers' findings by a written program in Eviews)

Obtained results of relationship among land transport sector, elements of economic growth, labor force, and capital formation have been shown in the above tables. In order to strengthen results and complete the relationship among these elements, the relationship among capital formation, economic growth, and labor force were examined pairwise. The obtained overall results are as follows:

1. One-way causality from land transport to economic growth
2. Two-way causality between capital formation and economic growth
3. Two-way causality between labor force and land transport
4. Two-way causality between capital formation and labor force
5. One-way causality from economic growth to labor force
6. No causality between land transport and capital formation

However, table13 shows the summary of obtained results from causality test among variables.

Table13. The summary of obtained results from causality test among variables

From \ To	Economic growth	Land transport	Capital formation	Labor force
Economic growth		No	Yes	Yes
Land transport	Yes		No	Yes
Capital formation	Yes	No		Yes
Labor force	No	Yes	No	

Reference: (Researchers' calculations)

6- Conclusion and Suggestion

Given the role of transport as one of the effective factors on economic boom, the areas of access to welfare and national facilities increase through moving cargo and passengers; therefore, it is of great importance in the process of economic growth. It is also affected by the process of economic growth and development. Most researchers confirmed positive impact of investment in transport sector on economic growth in their studies about transport and economic growth and by using different models. It can be concluded in this study by investigating experimental results of non-linear equation that a two-way causality between economic growth and capital formation indicates that higher economic growth can be achieved by increasing capital formation in different economic sectors and vice versa. The observed causality path between land transport and economic growth has confirmed a one-way path from transport to economic growth. This represents improvement of economic growth followed by increase of value added of transport sector. In fact, according to this research, improvement of land transport can be considered as one of the helpful policies in the country. Economic growth increases by development of this sector more than before although each of these two canals affects each other according to the proposed theoretical principles in this study. However, in the studied period and in the economy of Iran, increase in value added in land transport is both starter of change and its reason as well. According to the results, it can be said that in the past twenty years, economic growth has increased growth in capital formation and labor force while it cannot affect so much land transport sector. By improving transport sector, regarding its impact on economic growth, the ground for employment can be provided more than before. By improving transport infrastructure of the country, more economic growth will be achieved; therefore, it is necessary to consider transport sector (air, land, and sea) quantitatively and qualitatively along with economic growth in order that ground for more economic growth to be prepared by providing one of the necessary economic infrastructures.

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