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Analysis the Relationship between Selected Rail Transport Indicators and the Growth of the Transportation Sector's Value Added Using Vector Autoregressive Model

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A B S T R A C T

Transportation, as a critical sub-sector of the communication infrastructure, constitutes a fundamental pillar of economic development and policy planning. Among the various modes of transportation, rail transport holds a crucial role. Access to smooth, safe, high-speed, efficient and effective rail systems can substantially influence trade development, price stabilization, optimal allocation of scarce resources, increased competition, efficient labor distribution and overall economic development. Accordingly, this study investigates the relationship between selected rail transport indicators and the growth of the transportation sector's value added in Iran over the period 1997–2023 by using the Vector Autoregressive (VAR) model. The Johansen-Juselius cointegration approach is utilized to estimate the long-run relationships among the variables. The Vector Error Correction Model (VECM) is employed to examine the convergence of the model's variables and analyzes the short and long-run relationships among them. The obtained results confirm the presence of a long-run relationship among the variables. The number of locomotives, total railway track length, volume of freight transported, and the exchange rate demonstrates a positive influence on the growth of the transportation sector's value added. Conversely, the inflation rate negatively affects this indicator. The estimated error correction coefficient is 0.12 and indicates that the model converges towards equilibrium, and approximately 8 periods are required to eliminate deviations and align the short-run equilibrium with the long-run steady state.

1. Introduction

Efficient and reliable transportation infrastructure is among the critical factors that substantially contribute to economic development [1]. The importance of this issue in the economy is such that Borrow (1990) considers efficient transportation as an accelerator and even the foundation of economic growth [2]. Therefore, efficient and well-developed transportation can be a significant factor in stabilizing prices, developing scarce resources, increasing competition, ensuring proper and optimal labor distribution, and ultimately promoting economic growth and development.

Given the importance of transportation, proper organization and policy planning in this sector must be implemented effectively and efficiently. Rail transport provides access to various geographical regions of the country and plays a fundamental role in the movement of goods, services, and people. In addition to facilitating the proper and rapid distribution of domestic products, it also creates conditions for

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increased production. Therefore, it is of high importance to determine the impact of rail indicators on the economic development of country.

The current study seeks to investigate this issue and examine the relationship between selected rail indicators and the growth of the transportations sector's value added in Iran.

The structure of this research is as follows: Section 2 provides an overview of the relevant literature; Section 3 outlines the research methodology and the model; Section 4 presents the research findings; and finally, Section 5 concludes the study.

2. Literature Review

If economic activities are considered to encompass production, distribution and consumption, members of society are inherently dependent on natural resources to fulfill their needs. Due to geographical disparities and different living standards across regions, there arises a critical necessity for the transportation of resources within a country. These resources may encompass everything from natural materials to knowledge and skills. Therefore, economists generally consider transportation as fundamental and foundational components of economic growth and essential prerequisites for the economic transformation. Transportation can not only facilitate the proper and rapid distribution of domestic production but also create conditions to increase production. In any country, regardless of its economic status, production and transportation are inherently interdependent

The significance of transportation infrastructure in promoting economic growth and their interrelationship have been widely examined in economic literature and empirical studies. Transportation infrastructure constitutes a fundamental component of economic development, facilitating the movement of people and contributing to the efficient and effective allocation of resources. On the other hand, increased value added and higher levels of economic development positively influence public revenues, thereby stimulating greater demand for high-quality infrastructure and contributing to further enhancements in transportation systems. Transportation infrastructure has often been used as a policy instrument to reflect government agendas, reducing inequalities, and promote economic growth.

Rail transport as a fundamental prerequisite and backbone of development, playing a crucial and efficient role in each countries. Through the movement of freight and passenger, it establishes an inseparable link between various factors of growth and manifests its significance as one of the most influential indicators of economy development. This study examines the impact of several selected railway infrastructures, alongside economic variables such as exchange rate and inflation rate, on the growth of the transportation sector's value added. In the following, the literature related to this topic are reviewed.

In 2007, Rezaie Arjeroudi and Bazdar Ardabili [3] examined the influence of the railway transport sector on the Iran's economy over the period 1971-2005. This study employed a Vector Autoregressive Model (VAR) for the analysis. The estimation results indicate that, in long-run, the expansion of the railway transportation sector contributes positively to the country's economic growth. Furthermore, the study utilized the Forecast Error Variance Decomposition (FEVD) method to investigate how variations in the growth of the transportation sector's value added influence the economic growth of the country.

In 2012, Bazdar Ardabili and Pezhmanzad [4] examined the production factors in Iran's railway transport sector using the Cobb-Douglas production function. This study analyzed how changes in investment in communications, labor force, and capital stock effect the economic growth of the railway transport sector by employing the Forecast Error Variance Decomposition (FEVD) method. The findings indicate that, in long-run, investments in the communications, labor, and capital stock have a positive impact on the economic growth of Iran's railway transport sector.

In 2014, Rezaie Arjeroudi et al [5] investigated the impact of the construction of railway lines on the growth of Iran's rail transportation sector's value added using Translog production function. For this purpose, data for period 1981-2012 were utilized. The study's results indicate a positive partial elasticity of labor input, implying that an increase in labor input in the rail transportation

sector leads to a corresponding increase in the value added. Additionally, the partial elasticity of capital input also contribute to the growth in the rail transportation sector's value added.

In 2016, Khaksari [6] investigated the development of rail transport and its influence on the economic growth of Iran during the period 1971-2014. For this purpose, a VAR model was used to estimate the relationship. Some rail transport indicators were considered including ton-kilometers of freight transported, distance traveled by trains, and number of passengers transported that have a significance positive effect on Iran's economic growth. However, diesel consumption in the rail transport sector does not have a considerable impact on the country's economic development.

In 2017, Mohammadzadeh et al. [7] examined the effectiveness of rail transport indicators on the economy of Iranian provinces using panel data analysis and the least square method. This study employed rail indicators such as rail track length and passenger-kilometers traveled in each provinces, along with the economic indicator of provincial GDP related to rail transport. The results indicate a direct and significant impact of the independent variables on the dependent variable, and establish a bidirectional relationship between rail transport and the economy of the provinces.

In 2018, Varahrani and Hosseinpour [8] investigated the effect of energy price volatility on the value added and inflation rate of transportation, including both rail and road sectors. For this purpose, the instance response function correction model was applied over the period 1991-2014. The results indicate that the relationship between energy prices volatility and value added is negative, whereas its relationship with the inflation rate in the land transport sector is positive. Moreover, energy price volatility has a greater impact on the inflation rate compare to its effect on the value added in this sector.

In 2019, Abolhasani et al [9] analyzed the relationship between transportation infrastructure investment and economic growth in Iran. By employing a VAR model, they analyzed this relationship over the period 1959-2016.In both short-run and long-run horizons, VAR and VECM approaches were employed along with cointegration and Wald test. The findings indicate that economic growth responds significantly to transport infrastructure investment in both the short and long-run. Furthermore, investment in transport infrastructure has a meaningful impact on economic growth fluctuations in both time horizons. Overall, the study confirms a bidirectional relationship between investment in transport infrastructure and economic growth, suggesting that growth in one leads to growth in the other.

In 2016, Chen et al. [10] analyzed the relationship between the development of the railway network and Gross Domestic Product (GDP) in China. The findings of this study indicate that the expansion of railway lines in China led to a 10.3% increase in GDP during the period 2002 -2013. The results emphasize that the development of the railway industry contributes to increased production, thereby playing a key role in driving positive economic growth.

In 2018, Cigu et al. [11] examined the relationship between transportation infrastructure development and economic performance in European Union countries during the period 2000-2014 by using panel data analysis. The results, based on coefficient estimation, reveal a significant impact of transportation infrastructure components on economic performance. Moreover, the analysis indicates a long-run unidirectional relationship among transportation infrastructure, economic growth and public sector performance.

In 2021, Wu et al. [12] analyzed the impact of rail transport infrastructure on sustainable economic growth in China. For this purpose, data from China provinces during the period 2008-2018 were utilized. The findings indicate that investment in railways and rail infrastructure directly enhance sustainable economic development and indirectly promotes economic growth through increased tourism.

In 2021, Raimbekov and Sezdikbayeva [13] investigated the role of transport logistics in economic growth within emerging economies. This research analyzed how logistics indicators correlate with economic growth in Kazakhstan over the period 1995-201 by using production, demand and error vector model. The results indicate a bidirectional and casual relationship between economic growth and rail transport infrastructure, as confirmed by Granger test. Additionally, the study suggests that in small economies, road and maritime transport have a

more important impact on long-run economic growth.

In 2022, Alotaibi and Kaddous [14] examined the impact of transport investment on the (GDP) of United Arab Emirates. For this purpose, data from 13 regions of this country over the period 1999-2018 were collected and examined by using both static and dynamic panel data models. The findings indicate that the elasticity of GDP with a one year lag is positive and statistically significant across all specifications, and show the existence of a dynamic trajectory toward economic growth. Furthermore, rail accessibility was found to have a positive and statistically impact on GDP with a two-year lag.

In 2022, Raimbekov et al. [15] analyzed the influence of developing international transport corridors on regional economic development in Kazakhstan. For this purpose, multidimensional regression analysis was employed to determine the impact of economic factors which influence the development of transport corridors, as well as corridor-related indicators affecting regional economic growth. In this study regional net output and labor force were considered as dependent variables, while investment, average monthly income of the population, corridor revenue, transit traffic volume, import traffic volume at the international terminal, export traffic volume at the transport terminal, and investment in transport and warehousing were used as independent variables. According to the results, factors representing the internal linkage between socio-economic development indicators of the region and international transport corridor infrastructure have a considerable impact on bilateral economic growth and development in the country.

In 2022, Boldizsár and Mészáros [16] investigated the influence of rail freight transport on the economics of European countries. The study considered economic regions in Europe such as Switzerland, Norway and some other countries, totaling 37 countries. Data on freight volumes transported in these countries were analyzed by using a spatial econometric model. The results show the spatial relationship between rail freight transport and GDP in Europe. Countries with higher GDP levels experience a positive effect, whereas countries with lower GDP levels are negatively affected.

In 2022, Meersman et al. [17] investigated the direct and indirect economic impacts of rail freight transport in Belgium by using an input-output table analysis. The study produced an input-output table with partial vectors of rail freight transport, which identify various economic linkages with the main vectors of the input-output table. Additionally, a Leontief multiplier was calculated to estimate the overall economic impact from a monetary viewpoint when the estimated output demand of rail freight vector increases. The results show that rail freight transport has a significant effect on the national economy.

In 2023, Maltseva and Suchalkina [18] examined the effect of the railway industry on socio-economic development in Russia. The study's findings indicate that, the development of rail transportation is a priority for large countries and has a considerable impact on the socio-economic growth of the nation. Therefore, this country should prioritize targeted development and performance enhancement in the railway industry.

A review of the existing literature reveals a lack of studies investigating the impact of rail infrastructure variables- such as ton-kilometers of freight transported, number of locomotives and rail line length- alongside key economic variables like inflation rate and exchange rate on the growth of Iran's transportation sector's value added. Therefore, this study aims to examine these relationships using the VAR model. The Johansen-Jealous cointegration approach will be employed to estimate the presence of long-run relationships among the variables, and subsequently, the VECM will be utilized to analyze convergences and to explore both short-run and long-run relationship within the model.

3. Methodology

The present study seeks to explore the relationship between selected rail transport indicators and the growth of the transportation sector's value added, using time series data from 1997 - ۲۰۲۳. In terms of its purpose, this study is classified as applied research. The data for this research are quantitative, and the required information and statistics were obtained from "the balance sheets of the Central Bank and the

statistical yearbooks published on the website of the Islamic Republic of Iran Railways."

This study uses the vector autoregressive model for analysis and model estimation.

The most important reasons why vector autoregressive models are used for research are as follows:

1. Causal relationships can be studied using the time series of this system in any particular economy.

This approach is beneficial for macroeconomics and some other measures in third-world countries that lack coherent economic theories, and through this, it is possible to identify key variables in that particular economy and develop the theory obtained about that economy.

2. Another practical application of vector autoregressive models is the study of the timing of economic shocks. If the system accurately represents the economy, it is possible to see how long shocks to the economy will last and during which periods their maximum effects occur. Studying these shocks and their timing is a way to identify the dynamics of economies, because the same shocks leave different effects in each economy, depending on its specific characteristics. Additionally, examining shocks and their corresponding periods can help policymakers understand their impact on the entire economic system.

3. Third use of this approach focuses on analyzing the variance of economic indicators over time, which is related to the second application. It means that these studies examine how each key economic variable contributes to changes in other variables.

4. The vector autoregressive model does not require consideration of whether the variables are endogenous or exogenous; all variables in vector autoregressive models are endogenous.

5. The predictions obtained from this method are often better than those from complex simultaneous equation models or OLS [19].

Based on the theoretical foundations presented in Section 2, the model under study is specified as follows:

$$VA_t = A + \alpha_1 INF_{t-1} + \alpha_2 RAI_{t-1} + \alpha_3 LEX_{t-1} + \alpha_4 DIES_{t-1} + \alpha_5 CA_{t-1} + \varepsilon_t \quad (1)$$

Where VA is the growth of the transportation sector's value added, RAI is the length of rail lines, INF is the inflation rate, DIES is the number of locomotives, CA is the amount of cargo moved, and EX is the exchange rate. To estimate the model, the vector autoregressive model is used. Then, the long-run relationship among the variables is estimated using the Johansen-Juselius cointegration method. Finally, the model adjustment coefficient is calculated using the vector error correction method.

4. Research Findings

In time series methods, the first step is to examine the stationarity of the variables, which is shown in Table 1, where the Dickey-Fuller test results are shown.

Table 1 .Dickey-Fuller stationarity test

Variable	Unit root test			
	levels		First difference	
	t-statistic	prob	t-statistic	prob
VA	-۲/۰۷	۰/۲۵۵	-٦/۲٤	۰/۰۰۰
EX	۱/٤۰	۰/۹۹۹	-٤/۹۱	۰/۰۰۳
INF	-۲/۷۳	۰/۲۳۱	-٥/٥۱	۰/۰۰۰
RAI	-۰/٥٦	۰/۹۷۲	-٥/٦٤	۰/۰۰۰
DIES	-۰/٦۷	۰/۸۳٥	-۳/۱۸	۰/۰۳۳
CA	-۲/٥۹	۰/۱۰۸	-٤/۱۳	۰/۰۰۰

Source: Research findings

According to the results obtained, all variables were found to be stationary after taking their first difference, and they are I (1). But since the residuals are at the stationary level, there is no concern about spurious regression .Also, the unit root of all variables makes it possible to estimate the Johansen -Juselius model.

The next step is to identify the optimal lag. The optimal lag is generally identified based on two statistics: Akaike and Schwarz-Bayesian. Since the Schwarz statistic is data-saving, this statistic is used in this study to select the best lag. According to table 2 and based on the Schwarz statistic, lag one has been determined as the optimal lag.

Table 2. Test to determine the optimal lag

Lag	Akaike	Schwarz	Hannan-Quinn
۱	-۲۰/۹۷۱۶۰	-۱۹/۲۲۹۶۲*	*-۲۰/٤٦۹۹۸
۲	-۲۱/۲۰۰۹۷*	-۱۷/۷۱۷۰۱	-۲۰/۱۹۷۷۲

Source: Research findings

In this study, the relationship between variables in the short-run is initially measured using the vector autoregressive model. The VAR models provide two essential tools: variance decomposition and impulse response functions analysis. Thus, the VAR model serves as a foundation for analyzing IRFs and VD, ultimately leading to the examination of the long-term association among variables. Table 3 presents the results of estimating vector autoregressive model.

Table 3. Estimation results of the vector autoregressive model

variable	Ex (-1)	RAI (-1)	CA (-1)	Inf (-1)	DIES (-1)
VA	۰/۱۱	0/65	۰/۰۲۱	-۰/۱۷	۰/۷۷

Source: Research findings

As observed, in the short run, except for the inflation rate, which had a negative effect, other variables in the model positively influenced the value added of the transport sector. The theoretical foundations of the association between inflation and economic growth have always been challenging. Economic theories also have different perspectives on the relationship between growth and inflation, with a number of theories underscore the positive relationship between inflation and economic growth, while others believe in a negative relationship between them. One of these theories is the famous Phillips curve, which significantly addresses the link between growth and inflation. According to the Phillips curve, there exists a negative association between inflation and unemployment**,** which consequently indicates a positive correlation between inflation and economic growth**.** However, Friedman and Phelps modified the theory by incorporating inflation expectations into the Phillips curve, arguing that the relationship holds just in the short-term. They emphasized that, in the long run, and by adjusting inflation expectations, the Phillips curve becomes vertical; therefore, the slope of the curve is no longer negative, and unemployment and inflation can increase or decrease together. As a result, the presence of a positive relationship between production and inflation will be ruled out. Robert Lucas, another rational expectations theorist, goes even further and states that if monetary policies are implemented as predicted, the Phillips curve will be vertical even in the short-run, therefore, the positive link between growth and inflation will not be acceptable in either the short or long-run.

Given that the value added growth is an estimator of economic growth, this study identifies a negative association between the inflation rate and the growth of the transportation sector's value added. In other words, as the general price level has increased, the growth of the transportation sector's value added has decreased.

Alternatively, an increase in the number of locomotives and the length of rail lines as the main infrastructure of rail transportation, provided they are used optimally, will pave the way for increasing the capacity for carrying cargo by this mode of transportation. Therefore, considering the advantages stated regarding rail transportation, such as the possibility of holing large volumes of cargo, high safety, more affordable costs, lower fuel consumption, and environmental friendliness, cargo owners are inclined to move their cargo via the rail network, so the amount of cargo transported will increase.

Increasing freight leads to increased income in this field of activity and ultimately to increase the growth of the transportation sector's value added. In the model described, a positive relationship is observed between the indicators of the number of locomotives, the amount of

freight transported, and the length of railway lines with the index of the transportation sector's value added. Regarding the relationship between exchange rate and value added, given that part of the cargo transported by the rail network is international transit cargo, with an increase in the exchange rate, because income in this sector is in foreign currency, we observe an increase in income, leading to a subsequent rise in the growth of the transport sector's value added, which is also evidenced by the results obtained in Table (3).

One of the tools provided by the vector autoregressive model is variance decomposition. It may be said that variance decomposition, as a measure of dynamic performance, is capable of determining the instability of each variable against a shock to any of the other variables. In other words, variance decomposition shows the contribution of other variables to the fluctuations of a variable and the extent of their influence on that variable. Table 4 shows the variance decomposition of the growth of the transportation sector's value added variable over ten years and during the short, medium, and long run.

Table 4. variance decomposition of the growth of transport sector's value added

PERIOD	S.E	VA	DIES	EX	INF	RAI	CA
١	٠/٠٢٩٨٤٥	١٠٠/٠٠٠٠	٠/٠٠٠٠٠٠	٠/٠٠٠٠٠٠	٠/٠٠٠٠٠٠	٠/٠٠٠٠٠٠	٠/٠٠٠٠٠٠
٢	٠/٠٣٧٩٢٧	٧٦/٦٥٧٣٨	٩/٧٣٧٩١٧	٤/٧٦١٢٣٧	٥/٦٨٠٨٣٦	٢/٢٦٢٩٦١	٠/٨٩٩٦٦٧
٣	٠/٠٤٥٠٢٥	٦٢/٣٣٤١٢	١٤/٧٦٠٣٨	٧/٢٨٦٣٦٨	٩/٧٨٢٤١٥	٤/٥٧٦٨١٣	١/٢٥٩٨٩٨
٤	٠/٠٥١٧٧٤	٥١/٢٥٣٠٧	١٥/٠٤١٧٩	٩/٢٦٧٨٠٢	١٢/٤٨١٥٢	٧/١٣٦٧٧٧	٤/٨١٩٠٣٥
٥	٠/٠٥٨٦٢٣	٤١/٨١١٧٣	١٢/٨٧٤٦٩	١١/٥٢٧٦٨	١٤/٠٢٥١٤	٩/٦٦٤٠٨٩	١٠/٠٩٦٦٦
٦	٠/٠٦٥٧١٦	٣٤/٠٢٧٣٤	١٠/٣٣٦٠٥	١٤/٤١٣٠٧	١٤/٦٧٨٢٢	١١/٧٢٤٨٩	١٤/٨٢٠٤٣
٧	٠/٠٧٣٠٢٦	٢٧/٨٩٥٠٣	٨/٤٣٣٣٢٤	١٨/٠١٢٧٤	١٤/٧٤٢٥٨	١٣/٠٥٦٠٣	١٧/٨٦٠٢٩
٨	٠/٠٨٠٤٩٦	٢٣/١٦٨٧٤	٧/٢٨٥١٠٠	٢٢/٢٢٩٥٧	١٤/٤٦٦٣٦	١٣/٦٢٨٩٣	١٩/٢٢١٣٠
٩	٠/٠٨٨١٢٥	١٩/٥٣١٢٥	٦/٦٤٢١٣٣	٢٦/٨٤٥٤٥	١٤/٠٠٧٧٩	١٣/٥٦٧٣٩	١٩/٤٠٥٩٨
١0	٠/٠٩٥٩٧٣	١٦/٧١١٤٨	٦/٢٤٢٤٢٥	٣١/٥٩٢٩٠	١٣/٤٥١٨٩	١٣/٠٥١٩٩	١٨/٩٤٩٣١

Source: Research findings

As can be seen, in the short run, the growth of the transportation sector's value added, inflation rate, and exchange rate have the greatest impact on its growth. In the medium run, despite the increase in the share of other variables, the growth of the transportation sector's value added still has the greatest impact on itself, followed by the exchange rate. In the long run, the growth of the transportation sector's value added is most affected by the exchange rate. After examining the variance decomposition, the next phase involves estimating the long-term association among the research variables with the Johansen-Juselius cointegration method. Given that the Engel-Granger cointegration test assumes the existence of a single cointegration vector, it has a fundamental weakness: there may be more than one cointegration vector in a model. Therefore, the Johansen method is used to overcome the limitations of the Engel-Granger method. To perform the Johansen cointegration test, two tests—the maximum eigenvalue test and the trace test are employed. The trace test statistics and the maximum eigenvalue test statistics.

In this study, to obtain the relationship between selected rail transport indicators and the growth of the transportation sector's value added, the fourth model is used. In this model, the trace test confirms the existence of four cointegration vectors, while the maximum eigenvalue test confirms the existence of one vector. Since the maximum likelihood method is used in the maximum eigenvalue test to determine the cointegrated vectors, it has less variance than the trace test; therefore, in this study, the results of the maximum eigenvalue test are used to identify the number of cointegrated vectors, and the number of one cointegrated vector is used in estimating the function.

After determining the type of pattern and the number of cointegration vectors, the next step is to report a cointegrated vector that can express the long-run elasticity of the variables according to economic theories and the expected signs of the variables. To interpret the estimation findings, the estimated coefficient for the dependent variable must equal one; however, the regression coefficient for the dependent variable of the equations estimated by the Johansen method is not equal to one. Therefore, the estimated coefficients can be normalized by dividing every coefficient associated with the dependent variable and independent variables by the estimated coefficient of the dependent variable.

Table 5. Trace test result

Hypothesized No of CE. H0	Trace Statistic	Critical value	prob
r=0	۱۵۳/۰۶۳۹	۱۱۷/۷۰۸۲	۰/۰۰۰۰
r≤1	۱۰۶/۱۳۴۳	۸۸/۸۰۳۸۰	۰/۰۰۱۶
r≤2	۷۲/۱۵۸۲۰	۶۳/۸۷۶۱۰	۰/۰۰۸۵
r≤3	۴۲/۲۴۹۸۰	۴۲/۹۱۵۲۵	۰/۰۲۸۷

Source: Research findings

Table 6. Maximum eigenvalue test result

Hypothesized No of CE. H0	Max-Eigen Statistic	Critical value	prob
r=0	۴۶/۹۲۹۶۳	۴۴/۴۹۷۲۰	۰/۰۲۶۶
r≤1	۳۳/۹۷۶۱۱	۳۸/۳۳۱۰۱	۰/۱۴۵۵
r≤2	۲۶/۹۰۸۳۹	۳۲/۱۱۸۳۲	۰/۱۸۹۶
r≤3	۲۳/۵۹۵۱۶	۲۵/۸۲۳۲۱	۰/۰۹۵۸

Source: Research findings

In this study, because the aim is to investigate the relationship between selected rail transport indicators and the transportation sector's value added, the cointegration vector is normalized based on the growth of the transportation sector's value added. The estimation results indicate that the model variables are convergent and have a long-run equilibrium relationship with each other, which is consistent with the theory. Finally, the long-run relationship between variables can be written as follows using the Johansen method:

$$VA = 0/40\,EX - 0/49\,INF + 3/17\,RAI + 0/41\,CA + 0/90\,DIES \quad (2)$$

Table 7. Estimating the long-run coefficients

variable	EX	INF	RAI	CA	DIES
Long-run coefficient	۰/٤۰	-۰/٤۹	۳/۱۷	۰/٤۱	۰/۹۰
t-statistic	٦/٤٥	-٥/٥۱	٤/۷٤	٥/٥٥	۲/۷۸

Source: Research findings

Finally, the effect of imbalances in the model is examined by using the vector error correction method. The error correction model is considered a feedback mechanism; accordingly, the dependent variable is adjusted for the system imbalance, which ensures the achievement of a long-run relationship.

The VECM model estimates their short-run relationship using a selected convergence vector, which truly reflects the long-run relationship between the variables and the ECT coefficient demonstrates the convergence of the model and the associated variables. In VECM, the conditions for convergence are that the error correction coefficient is statistically significant, its absolute value falls between zero and one, and it is negative in sign. In this study, based on the estimation of the VECM model, regarding the relationship between selected rail transport indicators and the growth of the transportation sector's value added, the ECT coefficient is -0.12, and the estimated t-statistic size for it is -2.008, which indicates its significance at the 0.99 level. As can be seen, this coefficient has the desired sign and is between zero and one. The obtained coefficient value shows that, in each period, 12% of the deviation caused by the shock disappears, and the variables return to their long-run trend. Therefore, it takes about 8 periods for the short-run equilibrium to adjust and converge to the long-run equilibrium.

5. Conclusion

The rail transport sector, with its unique features—such as transporting goods with greater volume and safety, as well as more reasonable tariffs—has gained a special position compared to other modes of transportation. As a result, the condition and status of the railways are considered key indicators of growth and development. Therefore, the infrastructure of this industry and its indicators can affect economic growth and, in particular, the growth of the transportation sector's value added. For this purpose, in this research, we sought to examine and analyze the relationship between selected indicators of rail transportation and the growth of the transportation sector's value added.

For this purpose, using the vector autoregressive model, the relationship between the variables of line length, transported load, number of locomotives, exchange rate, and inflation rate, and the growth of the transportation sector's value added during the period 1976-2023 was evaluated. For estimation first, the Dickey-Fuller stationary test is performed, and based on the results obtained, all variables have a unit root. In the next step, the best lag length for estimating vector autoregressive was determined, which was determined to be one based on the Schwartz criterion. Since vector autoregressive models are an introduction to the study of shocks and variance decomposition, variance decomposition was examined in the next step. The results of variance decomposition also show that, in the short run, the growth of the transportation sector's value added, the inflation rate, and the exchange rate have the greatest impact on the growth of the transportation sector's value added. In the medium run, despite the increased contribution of other variables, the growth of the transportation sector's value added remains the most influential variable, followed by the exchange rate. In the long-run, the growth of the transportation sector's value added variable is most affected by the exchange rate.

Then, to estimate the cointegration vector, cointegration vectors are determined using the maximum eigenvalue and trace tests. Based on the maximum eigenvalue test and using the fourth pattern, the existence of a cointegration vector was confirmed. The results show that, in the long run, the growth of the transportation sector's value added has a negative association with the inflation rate and a positive relationship with the exchange rate, the number of locomotives, cargo transported, and the length of

lines. Finally, using the VECM method, the model convergence and its adjustment speed were determined. Based on the estimation of the VECM model, the ECT coefficient is -0.12, and its estimated t-statistic is -2.008, indicating significance at the 99% level. As can be seen, this coefficient has the desired sign and is between zero and one. The value of the coefficient obtained shows that, in each period, 12% of the deviation caused by the shock disappears, and it takes about 8 periods for the short-run equilibrium to adjust to the long-run equilibrium.

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