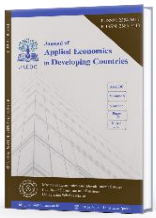

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THE IMPACT OF LAND, SEA, AND AIR TRANSPORTATION INFRASTRUCTURE ON ECONOMIC GROWTH IN G7 COUNTRIES

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ABSTRACT

This research analyzes the influence of road length, rail length, containers traffic, air freight, GFCF, and labor force on economic growth. This study uses quantitative methods with G7 countries as research objects during 2010-2021. Panel data consisting of 84 observations was analyzed with the help of Eviews12 software. The statistical analysis used in this research is the Ordinary Least Square (OLS) method, with the Fixed Effect Model chosen as the best model for interpreting the research results. The findings show that the road length, container traffic, air freight, GFCF, and the labor force have a positive and significant influence. Meanwhile, only the rail length does not have a significant effect on economic growth. Based on the results of this research, the theoretical implication of this research is the development of transportation infrastructure, especially road length, containers, air freight, GFCF, and labor force can increase economic growth in a country. So countries must consider spending on developing transportation infrastructure. Meanwhile, practically, this research can be used as study material in considering infrastructure development because the negative impact caused by errors in infrastructure development can be a waste of budget.

1. INTRODUCTION

Adequate infrastructure will support economic growth because it facilitates the flow of goods coming in and out (Fahmi, 2022). Arsyad (2016) this effort includes various economic strategies, including investment to increase capital in a country. No exception to Group of Seven (G7) because the composition of these countries consists of the largest economies in the world, changes in economic growth in G7 member countries have a direct impact on the global economy as a whole. The fluctuations in worldwide economic growth closely mirror the economic performance of G7 nations, as this group collectively accounts for approximately half of the global GDP.

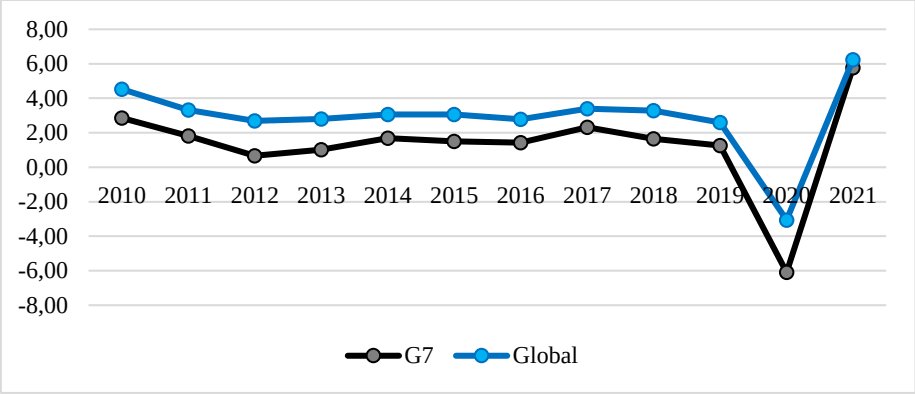

Figure 1. Comparison of Economic Growth Between G7 Countries and the World 2010-2021
Source: The World Bank (2024)

This phenomenon is demonstrated in the period 2010 to 2021, which reflects a significant phase of economic growth compared to previous years. This period was marked by the implementation of investment policies that focused on infrastructure development, which proved to be very beneficial in encouraging economic activity (Ardiansyah et al., 2020). Investments in transport infrastructure have created a strong multiplier effect on various economic sectors (Banelienė, 2021). Pradhan & Bagchi (2013) stated that transportation infrastructure cannot be separated from each other in supporting connectivity between regions.

Increasing the development of transportation infrastructure needs to be balanced with the provision of adequate capital and human resources as production factors. The existence of capital will encourage increased infrastructure development, while good quality human resources can increase productivity. This ultimately contributes to economic growth (Priyajati & Haryanto, 2020). Harbani (2022) emphasized that fluctuations in economic growth in one of the G7 countries have the potential to trigger multiplier effects which affect currency exchange rates, capital flows, and the dynamics of international trade. Furthermore, instability in infrastructure systems can have substantial economic consequences. The complex interconnectivity between transportation infrastructure, economic productivity, and global market stability, emphasizes the importance of continued investment in infrastructure development and maintenance to maintain economic resilience.

There have been many studies exploring the interconnection between transport infrastructure and economic development. However, most previous studies tend to focus on analyzing transport infrastructure as a whole, without separating the effects of different transport modes. For example, research by Hong et al. (2011), Banerjee et al. (2020), Maparu & Mazumder (2017), Tarigan et al. (2021), and Wang et al. (2020) only highlights land transportation modes, while Hakim & Merkert (2016) and Button & Yuan (2013) focus on airborne instruments without considering other transportation modes. Research by Özer et al. (2021) also shows a lack of complexity in the selection of variables analyzed. In addition, inconsistent results from research by Nugroho & Puspitasari (2023) and Yunar (2021) indicate that the relationship between infrastructure and economic growth is not two-way, but only one-way. These inconsistencies can be explained by differences in study areas, analysis periods, methodologies used, as well as various proxies applied to measure transport infrastructure and economic development.

This research aims to analyze and improve previous research on the influence of land, sea, and air transportation infrastructure on economic growth in G7 countries during the 2010-2021 period. This study aims to make meaningful contributions to both theoretical understanding and practical application. It addresses a gap in existing empirical research by offering a comprehensive examination of how various types of transport infrastructure individually impact economic development. Therefore, the title of this research is "The Impact of Land, Sea, and Air Transportation Infrastructure on Economic Growth in G7 Countries".

2. RESEARCH METHODS

This research model includes several variables such as road length, rail length, container traffic, gross fixed capital formation, air freight, and labor force using secondary data sourced from The World Bank, UNECE Transport Statistics, and the International Union of Railways from 2010–2021 received 84 observations. Using a panel data regression model assisted by Eviews 12 software. Using panel data because panel data provides data that is more informative, more varied, and more efficient (Baltagi, 2005). Concerning the model Augmented Solow Model by Canning (1999) the approach in this theory to estimate infrastructure productivity is to assess an aggregate production function that combines labor, physical capital, and infrastructure variables. Aggregate output depends on the input and productivity used in using that input which can be written in the following equation:

$$Y = A_{it}K_{it}^{\alpha}H_{it}^{\beta}X_{it}^{\gamma}L_{it}^{1-\alpha-\beta-\gamma}U_{it} \quad \text{.....(1)}$$

Y represents total output, A stands for total factor productivity, K denotes physical capital, H refers to human capital, X signifies infrastructure capital, L indicates labor, and U represents the error term. In linear form, equation 1 can be written as follows:

$$lnY_{it} = \alpha lnK_{it} + \beta lnH_{it} + \gamma lnX_{it} + (1-\alpha-\beta-\gamma)lnL_{it} + U_{it} \quad \text{.....(2)}$$

This theory assumes a constant return to scale, meaning that the exponents' sum equals one. Grigg (1988) infrastructure is defined as the physical network encompassing transportation, water supply, drainage systems, buildings, and various public facilities essential to fulfilling basic human needs, from both social and economic standpoints. Adequate transportation infrastructure will support economic growth because it facilitates the flow of incoming and outgoing goods (Fahmi, 2022). In this study, we decompose X (infrastructure) into road length (ROAD) are one of the basic infrastructures for transportation play a role in the production of goods and services (Pradhan & Bagchi, 2013). The development of road infrastructure brings spillover effects that arise due to the network effects it has. Rail length (RAIL) as a mode of land transportation is used in this research because trade distribution using trains is cheaper and can carry more loads than roads. Container traffic (SEA) an important component in international trade where the majority of export-import activities for high-volume cargo between countries use shipping by sea (Park et al., 2019). Air freight (AIR) is the fastest mode of transportation compared to others, but the costs are more expensive compared to others.

$$X = \theta_1 ROAD + \theta_2 RAIL + \theta_3 SEA + \theta_4 AIR \quad \text{.....(3)}$$

Pradhan & Bagchi (2013) state that transportation infrastructure cannot be separated from one another in supporting connectivity between regions. Roads as land infrastructure provide vital accessibility for the movement of people and goods between different locations within a specific area. However, roads cannot stand alone without support from other transportation infrastructure. The sea offers an important international trade route facilitating the movement of goods, but operating ships requires access to good ports and efficient logistics networks on land. Air transportation provides a fast solution for long-distance travel that must be connected to other transportation networks. Next, substituting equation 3 into equation 2, then equation 2 can be written as follows:

$$lnY_{it} = \alpha lnK_{it} + \theta_1 lnROAD_{it} + \theta_2 lnRAIL_{it} + \theta_3 lnSEA_{it} + \theta_4 lnAIR_{it} + (1-\alpha-\beta-\gamma)lnL_{it} + U_{it} \quad \text{.....(4)}$$

Where the parameterization of equation 4 is α is β_1, θ is denoted as β_2, and is β_6. This research uses panel data because it is better able to study the dynamics of adjustment. Ultimately, this study integrates cross-sectional data with time series data. The panel data regression model from this research is formulated as follows:

$$lnGDP_{it} = \beta_0 + \beta_1 lnROAD_{it} + \beta_2 lnRAIL_{it} + \beta_3 lnSEA_{it} + \beta_4 lnAIR_{it} + \beta_5 lnGFCF_{it} + \beta_6 lnLABOR_{it} + \varepsilon_{it} \quad \text{.....(5)}$$

In this equation, the constants β_0, β_1, β_2, β_3, β_4, β_5, and β_6 represent the coefficients for the independent variables: Gross Domestic Product (GDP), road length (ROAD), rail length (RAIL), container traffic (SEA), air freight (AIR), Gross Fixed Capital Formation (GFCF), labor force (LABOR). The symbol ln symbolizes a logarithm, i represents the cross-section for each G7 member nation, e indicates the error term, and t signifies the study's time period from 2010 to 2021.

3. RESULTS AND DISCUSSION

3.1. RESULTS

Descriptive statistics is intended to summarize the data samples utilized in the research and to present values such as the mean, minimum, maximum, and standard deviation so that the characteristics of the research data can be understood clearly (Ghozali, 2018). The following is a table that presents descriptive statistics from this study.

Table 1. Descriptive Analysis

Category	LGDP	LROAD	LRAIL	LSEA	LAIR	LGFCF	LLABOR
Mean	28.86	9.37	10.46	16.31	8.60	27.37	17.55
Median	28.70	9.12	10.26	16.17	8.69	27.14	17.33
Maximum	30.65	11.59	12.17	17.91	10.73	29.24	18.93
Minimum	27.97	8.20	9.67	15.16	6.63	26.46	16.75
Std. Dev.	0.76	0.97	0.76	0.75	1.08	0.77	0.65
Obs.	84	84	84	84	84	84	84

Source: Processed data (2024)

According to the findings from the descriptive statistics presented in Table 1, all variables were converted into logarithmic form, with each variable in this study containing 84 observations. The Gross Domestic Product (LGDP) variable, measured in USD and transformed into logarithmic form, shows a minimum value of 27.97, a maximum value of 30.65, an average of 28.86, a median of 28.70, and a standard deviation of 0.76. The road length variable (LROAD), measured in kilometers and also converted into logarithmic form, has an average of 9.37, a median of 9.12, a maximum of 11.59, a minimum of 8.20, and a standard deviation of 0.97. The rail length variable reports an average of 10.46, a median of 10.26, a maximum of 12.17, a minimum of 9.67, and a standard deviation of 0.76. The container traffic variable (LSEA) has an average of 16.31, a median of 16.17, a maximum of 17.91, a minimum of 15.16, and a standard deviation of 0.75. The air freight variable, expressed in tons/km in logarithmic form (LAIR), has an average of 8.60, a median of 8.69, a maximum of 10.73, a minimum of 6.63, and a standard deviation of 1.08.. The Gross Fixed Capital Formation (LGFCF) variable, which focuses on the capital needed for a country's infrastructure development, has an average of 27.37, a median of 27.14, a maximum of 29.24, a minimum of 26.46, and a standard deviation of 0.77. Lastly, the labor force variable (LLABOR) has an average of 17.55, a median of 17.33, a maximum of 18.93, a minimum of 16.75, and a standard deviation of 0.60.

The Chow test was conducted to determine the most suitable model between the Fixed Effect Model (FEM) and the Common Effect Model (CEM). The criterion states that if the resulting probability value exceeds the alpha significance level of 0.05, the selected model is CEM. Conversely, if the probability value is below this significance level ($\alpha < 0.05$), the chosen model is FEM. The results of the Chow test indicate a Chi-square probability value of 0.0000, which is below the alpha significance level ($0.0000 < 0.05$). Consequently, the Fixed Effect Model (FEM) is deemed the most suitable model, resulting in the rejection of the null hypothesis. Subsequently, a Hausman test was conducted to determine the most appropriate model between the Fixed Effect Model (FEM) and the Random Effect Model (REM). The criteria indicate that if the probability value obtained is greater than alpha ($\alpha > 0.05$), the selected model is REM; if it is less than 0.05, the chosen model is FEM. The Hausman Test results indicate a Random cross-section probability value of 0.0000, which is also less than the alpha significance level of 0.05 ($0.0000 < 0.05$). Thus, the null hypothesis is rejected, and the alternative hypothesis is accepted, confirming that the Fixed Effect Model (FEM) is the best model. In conclusion, based on the results of both tests, the most suitable estimation model is the Fixed Effect Model (FEM).

Table 2. Fixed Effect Model Regression Results

Variable	Coefficient	t-Statistics	Prob.	Description
C	6.983426	5.819164	0.0000***	Significant positive
LROAD	0.060695	2.088216	0.0404**	Significant positive
LRAIL	-0.043195	-1.475582	0.1445	No significant
LSEA	0.201494	10.58315	0.0000***	Significant positive
LAIR	0.021149	2.919303	0.0047***	Significant positive
LGFCF	0.120442	10.84152	0.0000***	Significant positive
LLABOR	0.854172	10.79079	0.0000***	Significant positive
R-squared	0.999864		F-statistic	43619.15
Adjusted R-squared	0.999841		Prob F-stat	0.0000

*Significant at α =10%, **Significant at α =5%, and ***Significant at α =1%
Source: Processed data (2024)

The purpose of this t-test is to assess whether each independent variable independently contributes to explaining variations in the observed dependent variable. It evaluates the significance of each independent variable's impact on the dependent variable, under the assumption that the other independent variables are ceteris paribus. The results of the t-test indicate that road length, container traffic, air freight, GFCF, and the labor force all have a positive and significant influence. In contrast, rail length does not significantly affect economic growth in G7 countries when considered on its own.

The statistical F test is conducted to evaluate the impact of all independent variables on the dependent variable. Collectively, the independent variables significantly influence the dependent variable in the model. As shown in Table 2, the F-statistic value for this study is greater than the F-table value ($43619.15 > 2.218817$). Additionally, the probability of the F statistic is 0.000000, which is less than the significance level of $\alpha = 0.05$ ($0.000000 < 0.05$). Therefore, it can be concluded that the independent variables road length, rail length, container traffic, air freight, GFCF, and the labor force significantly impact the economic growth variable.

The coefficient of determination presented in Table 2, with an Adjusted R squared value of 0.9998, indicates the extent to which the independent variables road length, rail length, container traffic, air freight, GFCF, and labor force account for variations in the dependent variable, demonstrating that these factors can elucidate 99.98% of economic growth. In contrast, approximately 0.02% of the variation in economic growth is attributed to factors that are not accounted for in the research model.

3.2. DISCUSSION

Based on road length (ROAD) the positive coefficient value is 0.060695. This coefficient figure shows that every 1 percent increase in highway construction will increase economic growth by 0.06 percent, assuming the values of other independent variables remain constant. These findings align with the research by Pradhan & Bagchi (2013) which revealed that road infrastructure serves as a fundamental component of transportation infrastructure in the production of goods and services. Enhancing road construction will positively affect economic growth by improving the efficiency of mobility factors. Production such as raw materials, human resources, and distribution of production results. Economic growth has contributed to the expansion of commercial sectors, with a particular emphasis on the manufacturing sector which requires road transportation as a basic input to support logistics supply chains on an increasingly large scale. The development of road infrastructure brings spillover effects that arise due to the network effects it has. Economic activities in various regions are spatially connected through these transportation networks, allowing economic effects to spread from one region to another (Sasana, 2017). Ease of access in an area is beneficial for economic growth in that area, and the spread of road construction encourages economic development in the surrounding area (Wang et al., 2020). Tarigan et al. (2021) stated that road transportation infrastructure provides economic benefits such as expanding market reach with an extensive transportation network so that the delivery of goods to various markets is carried out smoothly.

Rail length (RAIL) does not demonstrate a significant impact on economic development in G7 countries during the 2010-2021 period. This result is in contrast to research by Pradhan & Bagchi (2013) which states that to encourage economic growth in a country it is necessary to build a large rail infrastructure. Because the focus on train transportation is passengers, this results in economic potential that has not been utilized optimally. Considering that economic growth is much influenced by the flow of goods and services rather than train passengers because of its crucial role in distribution, reorienting rail transportation policies to accommodate logistics needs can have a significant impact. The difference in focus on accelerating railway technology adopted by G7 member countries on the Asian and European continents was realized in High-Speed Rail or fast train, the aim is to save time for its users. Li et al. (2020) the impact of high-speed train construction is not felt directly, but the longer it operates, the greater the impact. This positive effect can be seen in the economic efficiency of cities with relatively high population density. Over time, high-speed trains have made a significant contribution to increasing productivity in sectors that utilize efficient transportation services. In addition, large projects such as High-Speed Rail (HSR) require high costs and fail to have an impact on the economy in the short term. In the short term, large infrastructure projects are likely to face significant challenges due to high maintenance costs (Zhang & Cheng, 2023).

The increase in container traffic (SEA) reflects the volume of international trade which has an impact on economic growth. Good port management and capacity allow for faster movement of goods and lower costs which can increase competitiveness at the global level. The positive coefficient value is 0.201494, this figure indicates that a 1 percent rise in container traffic will result in a 0.20 percent increase in economic growth, assuming the values of the other independent variables remain unchanged. The findings of this study align with previously conducted research by Hong et al. (2011) who stated that sea transportation has developed rapidly from being just a main channel for international trade to becoming an important component in supporting the global economy because more than four-fifths of world trade is transported using containers via sea routes, making it an important part of the manufacturing supply chain. This growth is driven by increasing demand for various commodities so it requires an efficient transportation system with a global reach, a rapid industrialization process that creates demand for raw materials, and limited resources in a country increasing dependence on imports by sea (Özer et al., 2021).

The dominant sea transportation mode for inter-regional cargo in high volumes, since this mode of transportation is considered the most cost-effective for moving goods between continents, enhancing sea infrastructure is crucial for boosting economic growth. Both developed and developing nations can achieve economic growth by investing in marine infrastructure. Efficient and modern marine infrastructure not only increases economic growth but also strengthens the country's position in the global trade network (Park et al., 2019).

This finding (AIR) is supported by Hong et al. (2011) the productivity created by air transportation infrastructure is not as big as land and sea transportation. Although air transportation contributes to economic growth, its impact is still too small because its reach is more limited than other modes of transportation. This is evident from the positive coefficient value of 0.021149, indicating that a 1 percent increase in air freight will lead to a 0.02 percent increase in economic growth, assuming the values of the other independent variables remain unchanged. The small influence of air cargo on economic growth is because the development of air infrastructure often does not contribute enough to economic growth, improvements in infrastructure and services that are not balanced with good planning can hinder economic development. This is because air transportation infrastructure requires large investments, and is not always utilized effectively due to a lack of supporting services. As a result, the economic benefits of infrastructure investment are much smaller than expected (Park et al., 2019). This result is in line with research from Zhang & Cheng (2023), the nature of the aviation industry which requires large investment capital and infrastructure projects which generally take a long time are the main problems why positive impacts on the economy tend to be seen in the long term.

The coefficient value of LGFCF is 0.120442, this figure indicates that a 1 percent rise in gross fixed capital formation will result in an increase in economic growth by 0.12 percent assuming the conditions of the other independent variables remain constant. This finding is in accordance with Solow's theory which states that capital accumulation is an important factor in economic growth. In this context, the accumulation of capital used for infrastructure development can be seen through indicators of gross fixed capital formation. GFCF functions as one of the main inputs in the production function contributing to increasing output as measured by GDP. The findings of this research are consistent with other studies from Zhang & Cheng (2023) and Pradhan & Bagchi (2013) which suggests that increasing Gross Fixed Capital Formation allows greater investment in areas such as infrastructure development. Ultimately, when infrastructure improves the government can impose taxes which can increase government revenues which can partly contribute to increasing gross fixed capital formation. When there is an increase, it can be used to expand economic investment. Investment in infrastructure is crucial for stimulating economic growth by enhancing the demand for goods and services. In the early stages, infrastructure development in many areas was difficult to achieve due to low allocation. So, to overcome backwardness, it is necessary to increase government spending and the ability to plan infrastructure projects to support economic growth (Hong et al., 2011). Banelienė (2021) the existence of industry is beneficial for economic activity, where the increase in the industry's share of gross value added affects economic development. This shows that capital can provide a powerful boost to the industrial sector, which in turn increases overall economic output. Then, the multiplier effect of research and development financed by businesses has an important impact on economic growth.

The positive LLABOR coefficient value is 0.854172, this means that a 1 percent rise in the labor force will lead to an increase in economic growth by 0.85 percent assuming the conditions of the other independent variables remain constant. These results follow Solow's theory which emphasizes the importance of the labor force as a key element in the production process. Human resources are very crucial because no matter how sophisticated machines and technology are, they cannot function without human intervention. This theory emphasizes that apart from capital, labor plays a vital role in carrying out production functions, directly influencing the level of output.

From the production factors used, the productivity of capital, human resources, or raw materials can be increased. The efficiency most often used in economics is labor productivity which in turn is guaranteed by knowledge and skills (Korkmaz & Korkmaz, 2017). The productivity levels in developed countries exceed those in developing nations due to the presence of robust infrastructure. Additionally, there is a trend where the labor force in these countries consists of experience seekers, early movers, and late movers (Madgavkar et al., 2022). Wang et al. (2020) the labor force is a critical factor driving economic growth in both developed and developing nations. Despite significant technological advancements altering production methods, the labor force remains an essential component of production. In developed countries, advanced technology increasingly dominates specific sectors, necessitating a skilled workforce for operation. A skilled and productive labor force is also vital for maintaining economic competitiveness in a challenging global market.

4. CONCLUSION

This research was conducted to identify factors that influence economic growth in G7 member countries in the 2010-2021 period. Economic growth in the G7 fluctuates from year to year, but if you compare the direction of fluctuations from the G7 and globally it shows the same direction. Shows that the dominance of the G7 economy has an impact on the world economy. Based on the research results, the most appropriate model is the Fixed Effect Model (FEM). The analysis and discussion lead to the conclusion that road length, container traffic, GFCF, air freight, and the labor force all have a positive and significant impact. In contrast, rail length does not significantly affect economic growth.

The development of transportation infrastructure indicates that expanding road length, container traffic, air freight, gross fixed capital formation, and the labor force holds substantial potential for stimulating economic growth. Therefore, policymakers must make decisions based on comprehensive information regarding potential infrastructure to optimize increased economic activity. On the other hand, rail infrastructure must also be considered with a more strategic focus, where operational priorities are not only time efficiency for passengers, but also increasing the flow of goods and services, which directly contributes to economic growth.

Based on this research, there are still several limitations including the research period needing to be longer, even though there are still many vulnerable phenomena that can be discussed. Apart from that, more diverse research methods are used to get a more accurate picture. However, this research continues to run smoothly so that the required data can be processed according to what was previously expected.

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