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Impact of Indonesia's Non-Toll Road Policy on Travel Cost-Time

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Abstract

This study aims to provide empirical evidence on whether non-toll road construction, as a government investment (National Strategic Project) in the transport infrastructure sector, impacts local economic activity at the village level. It fills a gap in the literature by adopting a Difference-in-Differences (DiD) approach and analyzing at the village level using PODES data, comparing villages affected by the policy (treatment group) with those that were not (control group). Key outcome variables derived from PODES data include travel time and cost to sub-district and district centers. To ensure robustness, the analysis includes fixed effects for time and location, and placebo tests are conducted to validate the assumption of parallel trends. The results show that non-toll road construction leads to a statistically significant reduction in travel time by 21% and travel costs by 30.9%, associated with improved access to government services and modest growth in local economic indicators such as market activity, employment, or business formation.

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INTRODUCTION

Public infrastructure investment ensures sustainable economic growth (Aschauer, 1993). Various economic theories also suggest that infrastructure investment influences economic growth. Government investment in public capital, called infrastructure, includes roads, bridges, and drainage systems (Mankiw, 2016). Adolf Wagner (1883) proposed a theory of the relationship between public expenditure and economic growth, suggesting that government spending (e.g., road infrastructure development) is an endogenous variable correlated with a country's long-term economic growth (Udo & Effiong, 2014).

This study examines whether investment in transportation infrastructure, specifically non-toll national roads, influences local economic activity, measured using travel costs and travel time from village offices to sub-district or district/city offices. This study posits that in an archipelagic country like Indonesia, national roads can foster local economic development while serving as part of a broader national transportation system, particularly inter-provincial transportation. The study expects to find a positive relationship, as infrastructure investment projects have impacts not only on a national scale but also a more minor positive impact on regional economic growth through reduced travel costs (Cetin, 2024; Elburz et al., 2017; Lall, 2007), particularly in developing countries (Elburz & Cubukcu, 2021).

Roads serve as connectors for communities, facilitating economic exchanges and bridging distant locations (economically) (Audretsch et al., 2020). National roads (transportation infrastructure) can shape a country's economic geography by connecting remote areas with economic hubs and decentralizing regional populations (Baum-Snow, 2007; Huang & Bocchi, 2009). Road infrastructure can also influence firms' location decisions and households' residential choices by reducing travel costs (Rephann & Isserman, 1994).

However, infrastructure development does not always have a positive relationship with a region's economic growth. Inefficient and poorly planned infrastructure projects can burden the economy instead (Pritchett, 2000; Romp & de Haan, 2007). Government infrastructure projects that lack accountability, are poorly targeted, and are rife with corruption can result in infrastructure that hinders rather than supports economic development (Keefer & Knack, 2007; Tanzi & Davoodi, 1998).

Regarding highway infrastructure, studies generally find a positive relationship with regional economic growth, primarily through reduced travel costs (Aschauer, 1989; Buys et al., 2010; Calderón & Servén, 2004; Faber, 2014; Jacoby, 2000). Ghani et al. (2016) used a Difference-in-Differences analysis to examine the development of India's Golden Quadrilateral (GQ) highway network. They found that the project positively impacted the economy by improving market accessibility, reducing transportation costs, and boosting manufacturing productivity, especially in areas near the GQ, driven by adjustments in transportation costs. Chandra & Thompson (2000) noted that highway infrastructure not only directly boosts the economy in areas where the infrastructure is located but can also negatively impact neighboring areas. This occurs as economic activities are drawn closer to the new highways due to the lower transportation costs in regions served by the new roads.

Infrastructure investment during the New Order era was more concentrated on the island of Java (Rosmeli & Nurhayani, 2014), resulting in significant disparities in road infrastructure availability across Indonesia. The Indonesian government has yet to distribute road infrastructure investments evenly. In his research, Sukwika (2018) found that the Williamson index, indicating inter-provincial development disparities in Indonesia during 2013-2015, was relatively high.

Transportation infrastructure development has been a primary program of President Joko Widodo's administration to reduce regional disparities (Bappenas, 2019). The development of non-toll national/strategic roads was a key part of the National Strategic Projects (PSN) from 2015 to 2019. Five major non-toll national road projects occurred during this period: (1) Trans Morotai Ring Road, located in North Maluku Province. This 201.89 km road was constructed to support the National Tourism Strategic Area (KSPN) of Morotai Island. The Palu–Parigi Road, located in Central Sulawesi Province, is an 83.6 km road that was built to connect the Makassar Strait (part of Indonesian Archipelagic Sea Lanes [ALKI] II) with Tomini Bay (part of ALKI III). The Flyover to and from Teluk Lamong Terminal, located in East Java Province, is a project that aims to ease traffic on Tambak Oso Wilangun Road in Surabaya, thereby reducing congestion and road user density. (4) Gorontalo–Manado Connecting Road, stretching 301.73 km, this project links Gorontalo Province and North Sulawesi Province. (5) Trans Maluku Road (7 Segments), located in Maluku Province, this project focused on equitable development and social justice for frontier, outermost, and underdeveloped regions (3T) in the Maluku Archipelago (KSP, 2021).

Literature on the impact of road infrastructure development on the economy has predominantly focused on toll roads or expressways. However, it is important to note that non-toll national roads are public goods with non-rivalry characteristics, meaning they can be utilized without user payment (Pindyck & Rubinfeld, 2013). This contrasts with toll roads, where users must pay to access the roads. Non-toll national roads are accessible to everyone and all types of vehicles, potentially impacting regional economies more than toll roads. There is limited literature discussing the impact of non-toll road development on the economy in Indonesia, particularly at the regional level, using travel cost and travel time as indicators.

The Difference-in-Differences (DiD) method and carefully selected variables are expected to offer a robust analytical framework that can be applied to future studies in various regions. The use of the DiD method in this study to estimate the impact of non-toll national road construction on travel costs and travel time is justified by its ability to: (1) Address selection bias, reverse causality, and endogeneity, while controlling for time-invariant heterogeneity; (2) Control for common trends, ensuring that differences between treated and control groups are attributable to the intervention; (3) Cluster standard errors, addressing the issue of correlation in error terms, (Chandra & Thompson, 2000; Donald & Lang, 2007; Duflo, 2004; Duranton et al., 2014). Using village-level data—while most other studies utilize district/city or provincial-level data—this study allows for a more detailed and precise measurement of changes in travel costs and times. It seeks to observe and identify patterns of changes in travel costs and travel times resulting from improved transportation infrastructure.

Transportation costs are the money providers must incur to deliver a service (Rodrigue, 2024). Meanwhile, according to Small & Verhoef (2007), transportation costs refer to various expenses associated with the operation of transportation services, including direct and indirect costs (externalities) such as congestion and environmental impacts. Travel time is generally defined as the duration required to move from one location to another, including transit time, waiting time, traffic congestion, and delays. According to Rodrigue (2024), travel time encompasses all aspects related to the actual duration of transportation or travel, which can also be interpreted as the fact that travel time is a proportional function of distance. At the micro level, the reduction in transportation and production costs for parties with better access to such infrastructure represents the contribution of infrastructure development to economic growth (Khoirunurrofik & Anas, 2023).

In their research, Chandra & Thompson (2000) modeled adding new highways, showing that it reduces transportation costs as the total road length increases due to the construction of new roads, travel costs, and time decrease. According to Rodrigue (2024), the farther a journey, the greater the likelihood of travel disruptions affecting travel time. The addition of available road length impacts the choice of travel routes, increasing route options and ultimately reducing travel distances, decreasing travel time.

Combes & Lafourcade (2005) state that transportation costs are the sum of several cost components, the magnitude of which is influenced by the distance traveled by the mode of transportation, such as buses. These components include: (1) Fuel is the cost of vehicle fuel, toll is fees for using highways, maintenance is expenses for vehicle maintenance, particularly for the engine and tires, costs for tire usage and replacement, which wear out with increased distance traveled. Distance is the most fundamental component affecting transportation costs (Rodrigue, 2020). Infrastructure plays a significant role in determining the distance of a journey. Small & Verhoef (2007) noted that improvements in transportation infrastructure can reduce travel (freight) costs between locations.

Infrastructure development, particularly road construction, negatively affects travel time. For the same destination, the construction of new roads reduces travel time. New road infrastructure offers alternative routes for road users, thereby expanding the coverage of road systems (Ossokina et al., 2023). Improved surface quality and alternative routes save travel time and induce long-term spatial changes, such as population shifts and job creation.

The novelty of this study is its assessment of the impact of national infrastructure policies down to the village level using the DID method. Furthermore, this study also uses village-level (PODES) data from 2006, 2008, 2014, 2018, 2019, 2020, and 2021.

At the time of this study, data on travel costs and travel time from the PODES dataset were only available until 2021. Nevertheless, the study remains relevant today as it provides a strong historical foundation for evaluating the long-term effectiveness of road infrastructure development.

Using the Difference-in-Differences (DiD) method also adds significant novelty to the research. This approach enables causal estimation of the impact of road construction on travel efficiency by comparing villages that experienced road development with those that did not, before and after the intervention. Through this method, the study produces more valid and reliable findings supporting evidence-based decision-making in infrastructure planning and policy evaluation.

RESEARCH METHODS

This research utilizes various data sources to create a geo-referenced panel data set for villages in Indonesia for the years 2006, 2008, 2014, 2018, 2019, 2020, and 2021. The data is integrated from information obtained from the Directorate General of Highways of the Ministry of Public Works and Housing/ Direktorat Bina Marga Kementerian Pekerjaan Umum dan Perumahan Rakyat (PUPR), the Survei Potensi Desa (PODES) from the Central Statistics Agency/Badan Pusat Statistik (BPS), and Komite Percepatan Penyediaan Infrastruktur Prioritas (KPPIP).

The proxy for the impact of infrastructure development on the economy is derived from the Survei Potensi Desa (PODES) data set. PODES provides comprehensive village-level data, and this study uses travel costs and travel time from the village office to the sub-district office and the district/city government office as dependent variables. This data set is essential for assessing changes in economic activity over time to understand changes due to infrastructure development at a more detailed level.

The construction of non-toll national roads under the 2015–2019 National Strategic Projects (PSN) was initiated almost simultaneously in 2016. Using the Difference-in-Differences (DiD) model, this study seeks to identify the impact of non-toll national road construction on travel costs and travel time.

To estimate the causal effects of the 2015–2019 National Strategic Projects (PSN) non-toll national road construction on travel costs and travel time, this study adapts the methodologies of Ghani et al. (2016) and Combes & Lafourcade (2005) with the following modifications:

$$y_{it} = \beta_0 + \beta_1 D_{it} + X'_{it}\theta + \gamma_i + \delta_t + \mu_{it} \text{ ...... (1)}$$

Where, y_{it} represents the outcome variable sourced from the Village Potential Statistics (PODES). The outcome variables in this research are travel costs and travel time from the village office to the sub-district and district/city offices. D_{it} is the variable of interest in the study, representing the observed policy. D_{it} is a dummy variable that interacts with the treatment group and the post-policy period. In this study, the unit of travel costs is rupiah, while travel time is hours. X'_{it} represents the vector of time-variant control variables that may affect the estimation results. Control variables include fuel prices, topography, and public transportation. γ_i represents village fixed effects. δ_t represents a time trend and μ_{it} is the error term.

The study tests the primary assumption of the DiD method, which is that the treatment and control groups would have had the same trend without government intervention or policy. The parallel trend test and dynamic treatment effect/anticipatory effect tests were also conducted. Additionally, this study conducted a placebo test by modifying the dependent variable and observation period in model 1 and randomizing the time of implementation of non-toll road construction. The expected result for the placebo and anticipatory effects is zero.

The clustering of standard errors in this study is conducted at the district (kecamatan) level. The clustering approach produces more robust and accurate standard errors by accounting for relationships among observations within clusters, especially in regression analyses of panel or cross-sectional data with a clustered structure (Liang & Zeger, 1986). Using the DiD method with spatial data often involves clustering at a relevant geographic level to obtain correct standard errors (Donald & Lang, 2007).

The dependent variables in this study are travel costs and travel time obtained from Podes as explained above. Interviews with village heads/sub-district heads or other village officials collect podes data. In this case, BPS officers ask how much the travel costs and travel time are required from the village office to the sub-district or district/city office. These variables represent the first-degree effects of highway construction, inspired by the approach used by Ghani et al. (2016), which measures the spatial impact of highway development on regional economies.

The variable of interest in this study is the dummy variable for non-toll national road construction, which is interacted with the level of village exposure to the non-toll national road. The initial hypothesis for this dummy variable is that villages exposed to the construction of non-toll national roads have lower travel costs and travel time than villages not exposed to such development. Exposure levels are represented by the distance from the village center to the non-toll national road. This includes villages directly traversed by the road and those within a certain distance. The treatment group consists of villages within 0–10 km from the village center to the nearest non-toll national road. This distance is based on the assumption that the impact of non-toll national roads occurs within this range and aligns with the parallel trend assumption.

Control variables are incorporated into the model to account for other factors influencing the estimation results. Specifically, fuel prices are included to control travel costs, as fuel is a primary component of these expenses. Additionally, a Public Transportation dummy variable indicates the availability of public transportation or routes passing through a village, which can significantly affect travel costs and time. To further enhance the robustness of the framework, year-specific time trend variables or fixed effects are included to control for time variance. Furthermore, village-level fixed effects capture village characteristics that do not change over time. This set of control variables, adapted from the model used by Ghani et al. (2016), provides a robust framework for evaluating the impact of non-toll road exposure on regional economies.

The counterfactual group in this study, or the control group, consists of villages located beyond the treatment group up to 50 km from the non-toll national road. The counterfactual concept is adapted from the approach of Ghani et al. (2016). In their study evaluating the impact of the Golden Quadrilateral (GQ) Highway development in India, Ghani et al. (2016) used the Difference-in-Differences (DiD) method, designating areas within 0–10 km of the GQ Highway as the treatment group and areas within 10–50 km as the control group. The control group was chosen as a counterfactual because the impact of the GQ Highway was assumed to be negligible at distances between 10 and 50 km.

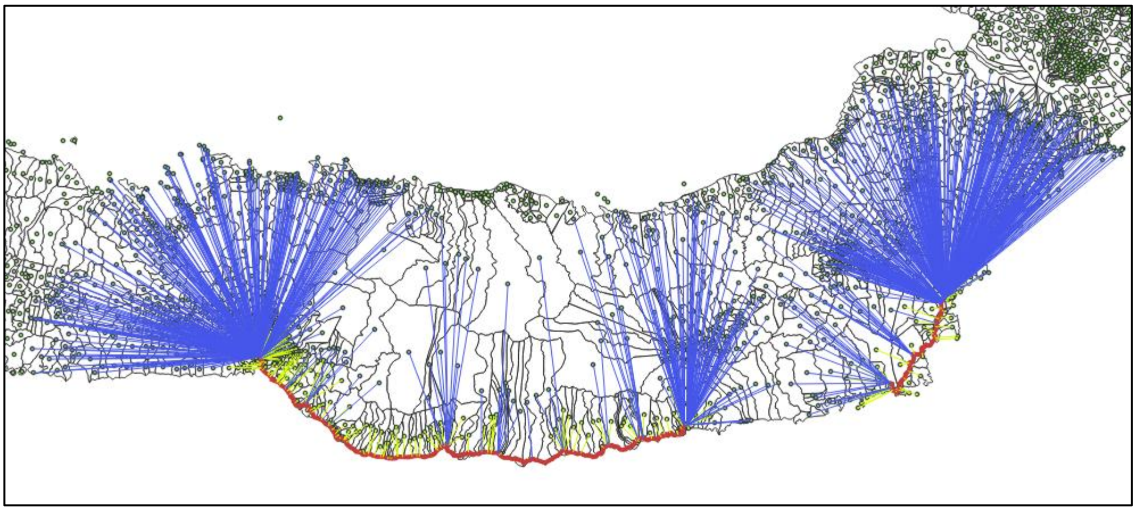


Figure 1. Treatment and Control Group Villages
Source: Kementerian PUPR, 2015 (processed)

RESULTS AND DISCUSSION

This study's treatment group includes villages selected based on the distance from the village center to the non-toll national road. The chosen distance reflects the significant and substantial impact of roads on the dependent variables, which diminishes beyond a certain distance. The control group is adapted from Ghani et al. (2016). It is estimated to experience the smallest and statistically insignificant effects of non-toll national road construction, making it an appropriate counterfactual.

The villages observed are those located within a 50 km radius of the non-toll national road nodes to the village centers, with this distance measured using the QGIS application over the periods 2006, 2008, 2014, 2018, 2019, 2020, and 2021. These specific periods were selected due to the availability of Village Potential Survey (PODES) data and their direct alignment with the pre- and post-implementation phases of the project in 2016.

Figure 1 illustrates the treatment and control villages for the Gorontalo–Manado Connecting Road Project. The red line represents the non-toll national road connecting Gorontalo and Manado. Circular dots indicate village centroids, the central points of the villages used to measure the distance between the villages and the non-toll national road. Villages connected by yellow lines are part of the treatment group, while those connected by blue lines belong to the control group.

Table 1 shows the estimation results (regression) regarding the impact of roads based on distances ranging from 0 to 50 km from the new non-toll road segments, measured in 5 km intervals. The impact of the new road construction on travel costs and travel time begins to diminish, with some effects disappearing entirely within the 45–50 km range from the new road segments. Therefore, I decided to use villages up to 50 km from the new road segments as the observations for this study.

Subsequently, Table 2 presents the results of the parallel trend test (Pre-trend Test) and the coefficient values for the impact of non-toll national road construction based on the distances of treatment and control villages. Row (1) shows the p-values from the parallel trend test, while row (2) shows the estimated coefficients of the impact of non-toll national road construction on travel costs to subdistrict offices. Columns (1)-(4) illustrate the differences in distance spectra between treatment and control groups. Columns (1) and (2) have a 5 km difference in the treatment group spectrum, while the control group includes distances ranging from the treatment group's spectrum up to 50 km from the non-toll national road.

Table 1. Estimation of the Impact of Road Construction Projects Based on Village Distance

Impact of Road Construction	Travel Cost per km		Travel Time per km	
	Sub-District Office	District/ City Office	Sub-District Office	District/ City Office
0-5 km	-17.47***	-36.39***	-0.104*	-0.673**
	(6.693)	(12.01)	(0.0576)	(0.266)
5-10 km	-14.37**	-27.81**	-0.0366	-0.456*
	(6.655)	(11.95)	(0.0547)	(0.267)
10-15 km	-14.08**	-17.49	-0.0128	-0.427
	(6.733)	(12.33)	(0.0581)	(0.275)
15-20 km	-11.38	-12.04	-0.0267	-0.319
	(7.052)	(13.66)	(0.0565)	(0.288)
20-25 km	-12.43*	-25.68**	0.0171	-0.428
	(7.066)	(11.99)	(0.0645)	(0.272)
25-30 km	-11.22*	-21.50*	-0.00869	-0.350
	(6.776)	(12.20)	(0.0619)	(0.279)
30-35 km	-12.57**	-14.44	0.182*	-0.235
	(6.374)	(11.87)	(0.0943)	(0.273)
35-40 km	-6.847	-5.943	0.264**	-0.1000
	(6.585)	(11.86)	(0.129)	(0.309)
40-45 km	-8.218	-6.032	0.0992	-0.182
	(6.005)	(11.63)	(0.101)	(0.295)
45-50 km	-0.351	3.676	0.0759	-0.0945
	(5.305)	(11.07)	(0.0765)	(0.263)
Constant	-14.51***	-41.75***	0.584***	1.043***
	(2.856)	(5.521)	(0.0570)	(0.0705)
Observations	19683	19752	22601	22601
R^2	0.037	0.075	0.013	0.019

*Notes: The dependent variables are travel costs, travel time to the sub-district center, and district/city as a proxy for economic activity. Standard errors grouped at the sub-district level are reported in parentheses. Control variables include fuel prices, village topography, and availability of public transportation; dependent variables are travel costs. Control variables for the travel time variable include village topography and the availability of public transportation. Data for control and dependent variables are PODES data. Data on the construction of non-toll roads comes from the Ministry of PUPR. ***, **, *, indicate statistical significance at 1%, 5%, and 10%, respectively.*

Based on the results presented in Table 1 and Table 2, this study decided to use the treatment group of villages located 0–10 km from the non-toll national road and the control group of villages located 10–50 km from the non-toll national road. This decision was made because the groups met the parallel trend assumption and showed a statistically significant impact at the 5% level.

Furthermore, the treatment group villages located within a distance of 0-10 km are assumed to receive direct benefits from the highway construction. Meanwhile, the control group villages within 10-50 km are close enough to experience indirect impacts but do not receive the same direct benefits as the treatment group. The use of village-level data in this study represents a significant novelty in policy evaluation in Indonesia, providing a more granular and accurate understanding of the real impacts.

This study uses distance as a parameter to determine treatment and control villages based on several considerations: 1. Identifying causal impact, by comparing villages in the treatment and control groups, the study aims to isolate the specific effects of highway construction. 2. Addressing selection bias (endogeneity), without using a specific distance threshold, it would be difficult to determine whether improvements in economic indicators are due to the highway or because those villages were already more prosperous or strategically located. 3. Strengthening the assumption of parallel trends, as previously explained.

Table 2. Parallel Trend Test and Impact of Road Construction on Different Spectra of Treatment and Control Groups

	Distance from Treatment Village			
	(1) 0-5 km	(2) 0-10 km	(3) 0-15 km	(4) 0-20 km
(1) P-value Parallel Trend Test	0.4251	0.2022	0.0806	0.0640
(2) coefficient	-2.907*	-2.777**	-3.428**	-2.394**
SE	(1.540)	(1.282)	(1.372)	(0.976)
Observations	17556	17556	17556	17556
R^2	0.721	0.721	0.721	0.721

*Notes: The dependent variables are transport costs at the sub-district center as a proxy for economic activity. Standard errors grouped at the sub-district level are reported in parentheses. Control variables include fuel prices, village topography, and availability of public transportation; dependent variables are travel costs. Data for control and dependent variables are PODES data. Data on the construction of non-toll roads comes from the Ministry of PUPR. ***, **, *, indicate statistical significance at 1%, 5%, and 10%, respectively. Parallel trend test using the Event Study Framework, using 2006 and 2014 data due to availability.*

For the travel cost dependent variable, this study uses PODES data from 2006, 2014, 2018, 2019, 2020, and 2021, as travel cost data was not disseminated by BPS in 2008. In estimating the impact of national non-toll road construction, this study excludes villages in the Maluku Province from its observations. The road sections constructed in Maluku Province are separated by islands, raising concerns about potential data collection bias. Furthermore, this exclusion is carried out to fulfill Parallel Trend Assumption.

PODES data from 2006, 2008, 2014, 2018, 2019, 2020, and 2021 are used for the travel time dependent variable. Unlike the travel cost estimation, all villages located within 0–50 km of the road segments will be included in the travel time analysis, with the exclusion of villages in Maluku Province.

Table 3 shows the steps taken to estimate the impact of non-toll road construction. The model uses observations from villages within 0 to 50 km of the non-toll road segments. The table includes four dependent variables used as proxies for the impact of non-toll road construction: Travel Costs to the Sub-district Office, Travel Costs to the District/City Office, Travel Time to the Sub-district Office, and Travel Time to the District/City Office.

The estimation equation (1) uses only the interaction dummy variable for non-toll national road construction with the treatment and control groups. Equation (2) adds control variables such as the availability of public transportation and fuel prices. Only the public transportation availability covariate is included for the dependent variable travel time. Equation (3) incorporates village-level fixed effects, and Equation (4) adds time-fixed effects. In all equations, cluster standard errors at the district level are applied, as previously explained.

The first row of Table 3 presents the estimated impact of non-toll national road construction using travel costs to the subdistrict office as the dependent variable. The coefficient in Equation (1) is -3.786, statistically significant at the 1% level. This indicates that after the construction of non-toll national roads, travel costs decreased by IDR 3,786 in areas within 0–10 km of the road compared to areas 10–50 km away. However, Equation (1) does not include control variables, so that the coefficient may be overestimated.

Equation (2) introduces control variables such as public transportation availability and fuel prices, which are positively related to travel costs. The estimated coefficient decreases significantly to -3.051, a reduction of about one-fifth from the initial estimate, still statistically significant at the 1% level. Adding village-level fixed effects in Equation (3) results in a slight increase in the coefficient to -2.835, while adding time-fixed effects in Equation (4) yields a coefficient of -2.834, statistically significant at the 5% level. The increasing R^2 values in each subsequent model suggest that the additional controls improve the model's explanatory power. The final specification in column (4) indicates that after non-toll national road construction, villages within 0–10 km of the road had travel costs to the subdistrict office IDR 2,834 lower than villages located 10–50 km away.

Table 3. Impact of Non-Toll Highway Development, Baseline Estimate

	Impact of Non-Toll Highway Development (1 after project start year (2016), 0 otherwise)			
	(1)	**(2)**	**(3)**	**(4)**
Travel costs to the sub-district office	-3.786***	-3.051***	-2.835**	-2.834**
	(1.294)	(1.171)	(1.320)	(1.319)
Observations	17635	17635	17601	17601
R^2	0.004	0.009	0.723	0.723
Travel costs to the district/city office	-6.766***	-5.449***	-5.567**	-5.534**
	(1.853)	(1.685)	(2.235)	(2.235)
Observations	17680	17680	17646	17646
R^2	0.026	0.037	0.695	0.697
Travel time to the sub-district office	-0.146***	-0.144**	-0.170***	-0.106*
	(0.0562)	(0.0570)	(0.0624)	(0.0627)
Observations	22601	22601	22567	22567
R^2	0.004	0.004	0.428	0.447
Travel time to the district/city office	-0.111	-0.114	-0.0534	-0.0130
	(0.0905)	(0.0902)	(0.0964)	(0.0939)
Observations	22601	22601	22567	22567
R^2	0.001	0.001	0.499	0.503
Control:				
Covariates	NO	YES	YES	YES
Fixed Effect	NO	NO	YES	YES
Time Trend	NO	NO	NO	YES

*Notes: The dependent variables are travel costs, travel time to the sub-district center, and district/city as a proxy for economic activity. Standard errors grouped at the sub-district level are reported in parentheses. Control variables include fuel prices and the availability of public transportation for the dependent variable of travel costs. The control variable for the travel time variable is the availability of public transportation. Data for control and dependent variables are PODES data. Data on the construction of non-toll roads comes from the Ministry of PUPR. ***, **, *, indicate statistical significance at 1%, 5%, and 10%, respectively.*

The second row of Table 3 presents travel costs to the district/city office as the dependent variable. The estimated coefficient follows a similar pattern, with a value of -5.534, statistically significant at the 5% level. This suggests that non-toll national road construction reduced travel costs by IDR 5,534 for villages within 0–10 km of the road compared to those within 10–50 km. The R^2 values also increase with the addition of controls. In absolute terms, the impact on travel costs to the district/city office is more than double the impact on costs to the subdistrict office. However, in percentage terms relative to average travel costs, non-toll national road construction reduced travel costs to the subdistrict office by 30.9% and to the district/city office by 27.8%. The minor percentage reduction for district/city office travel is likely due to longer distances, resulting in higher initial costs.

This study uses Travel Costs to the District/City Office as the dependent variable in the second row. The estimation results follow a similar pattern to those in the first row; the estimation coefficient is -5.568 at a 5% level of statistical significance. This result suggests that the construction of the Non-Toll Highway reduces travel costs from village offices to District/City Offices by Rp5,568.00 for villages located 0-10 km from the new road, compared to villages 10-50 km away from the road, with a statistical significance level of 5%. The R² value also increases, approaching 1 with each added control.

These findings align with prior research by Ghani et al. (2016) and Chandra & Thompson (2000), which show that areas closer to road construction benefit more economically due to lower transportation costs than areas farther away. The study also evaluates the benefits of non-toll national road construction regarding travel time. Data from the 2008 PODES survey was added because it recorded travel time but not travel costs. Notably, villages in Maluku Province were also included in this analysis, as the travel time variable satisfies the parallel trend assumption.

The third and fourth rows of Table 3 present the estimated impact on travel time to the subdistrict and district/city offices. Using Equation (4), the reduction in travel time to the subdistrict office is -0.106 hours, representing a 21% reduction compared to all observations, with statistical significance at the 10% level. The reduction in travel time to the district/city office is -0.01 hours, but it is not statistically significant. This result may be due to the waiting time associated with public transportation, such as switching modes or waiting for the next available transport (headway time).

Table 4. Impact Estimation Based on Distance

Distance of the treatment group village	Travel Cost to		Travel Time to	
	(1) Sub-District Office	(2) District/City Office	(3) Sub-District Office	(4) District/City Office
0-2 Km	-1.859*	-12.780***	-0.344	-0.204**
	(1.106)	(4.155)	(0.283)	(0.0860)
2-4 Km	-5.953**	-12.09**	-0.225	-0.441
	(2.630)	(5.711)	(0.139)	(0.279)
4-6 Km	-3.890	-5.323*	-0.133	0.225
	(2.866)	(3.155)	(0.169)	(0.253)
6-8 Km	-3.450	-3.190	-0.0422	-0.0287
	(2.146)	(3.326)	(0.0488)	(0.0716)
8-10 Km	-0.149	-5.270**	-0.0821*	0.00836
	(1.013)	(2.537)	(0.0469)	(0.135)
Baseline	-2.834**	-5.534**	-0.106*	-0.0130
	(1.319)	(2.235)	(0.0627)	(0.0950)
Observations	17601	17646	22567	22567
R^2	0.723	0.697	0.447	0.503

*Notes: All specifications include control variables and control groups as in the last column of Table 3. Standard errors grouped at the sub-district level are reported in parentheses. Village distance is a group of villages measured from the village center to the nearest highway using QGIS software. ***, **, *, indicate statistical significance at 1%, 5%, and 10%, respectively.*

The reduction in travel time due to road construction found in this study is in accordance with the theory presented by Rodrigue (2024). Overall, villages located within 0–10 km of the road experienced greater reductions in both costs and time compared to those located 10–50 km away. The most significant impact of non-toll national road construction is observed in travel to subdistrict offices, as the percentage reductions in costs and time are larger and statistically significant. The study concludes that non-toll national road construction policies effectively promote economic activity and reduce regional development disparities.

This study further investigates whether there are differences in the magnitude and direction of the impact of non-toll national road construction at specific distances. Differences may arise due to unobserved characteristics of villages that cannot be controlled for because of data limitations. The study tests this by incorporating an interaction variable between distance and non-toll national road construction into the baseline equation to measure the impact of road construction based on the distance of villages from the road.

The regression results, as shown in Table 4, broadly indicate that the impact of road construction on travel costs decreases with increasing distance between villages and the road. For travel costs to subdistrict offices, the initial impact of road construction is IDR 1,859, increasing for villages located 2–4 km away, and then decreasing for villages 8–10 km away from the road. Distance is more pronounced regarding travel costs to district/city offices. Villages located 0–2 km from the road experienced a reduction in travel costs of IDR 12,780, diminishing the effect for villages located 8–10 km from the road. The impact of road construction on travel time also exhibits a declining trend as village distance from the road increases.

The findings based on Table 3 and Table 4 show that the construction of non-toll national roads significantly reduced travel costs and travel time, particularly for villages located within 0–10 km of the road, indicating that the benefits are concentrated in villages closer to the roads, with diminishing effects as the distance increases. This pattern aligns with the economic geography theory, which posits that proximity to infrastructure enhances accessibility, reduces transaction costs, and stimulates local economic activity (Rodrigue, 2024; Chandra & Thompson, 2000). Villages closer to the road benefit from more direct and frequent transportation access, which lowers fuel consumption, reduces waiting time, and minimizes the need for multiple transport modes.

In contrast, villages located farther away (10–50 km) experience diminishing benefits. This may be due to factors such as limited feeder road connectivity, lower frequency of transport services, or topographical challenges that increase travel time despite major roads. The results also reflect findings from Ghani et al. (2016), who observed that infrastructure investments yield the highest returns in areas with immediate access, while remote areas require complementary investments to realize the benefits fully.

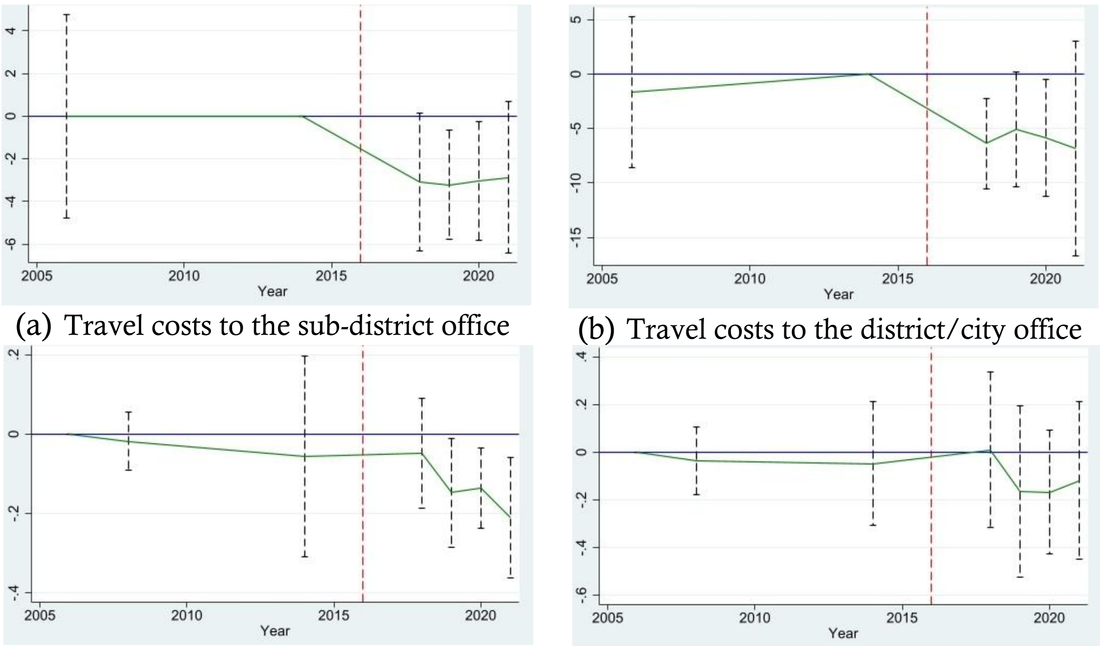
Moreover, the insignificant impact on travel time to district/city offices suggests that longer travel distances and reliance on intermodal transport reduce the effectiveness of road construction alone. This highlights the need for integrated transport planning, including secondary roads and public transport systems, to ensure equitable access across regions.

This study's findings on reduced travel costs and time align with existing research (Aschauer, 1989; Buys et al., 2010; Calderón & Servén, 2004; Faber, 2014; Jacoby, 2000), which shows that highway infrastructure positively influences regional economies. Reducing travel costs and time is expected to increase market activity, employment, and business formation.

The impact of non-toll national road construction may be felt immediately or may take time for the community to realize. To obtain an estimate of this dynamic impact, the research model 1 was modified by adding variables representing post-treatment effects and anticipatory effects of non-toll national road construction, adopting the approach from Autor (2003). This study expects the coefficient estimate of the anticipatory effect to approach zero, and the post-treatment coefficient is expected to be dynamic, indicating that the policy has a significant effect.

The Dynamic Treatment Effect estimation was manually modified using the available PODES data. The anticipatory effect for the travel cost variable used data from 2006 and 2014, while the travel time variable used data from 2006, 2008, and 2014. For the post-treatment effect, 2018, 2019, 2020, and 2021 data were used for both the travel cost and travel time variables.

Figures 2 (a) and (b) show that non-toll national road construction strongly affects economic growth by reducing travel costs. The post-treatment coefficients for all years are negative. Meanwhile, the anticipatory effect coefficients for both travel cost variables for 2006 to 2014 are close to zero and statistically insignificant. This also indicates that the parallel trend assumption is likely valid.



(a) Travel costs to the sub-district office

(b) Travel costs to the district/city office

(c) Trave time to the sub-district office

(d) Trave time to the district/city office

Figure 2. Dynamic Treatment Effect Over Time Highway construction on travel cost and time

Notes: Point estimates show the annual impact of road construction policies at 95% confidence intervals. The intervals are represented by bars derived from the point estimates. A point estimate differs statistically from zero if the bar does not cross the horizontal line at 0.

Figure 2 (c) and (d) show that non-toll national road construction affects travel time to subdistrict offices compared to district/city offices. Road construction significantly reduced travel time for the variable of travel time to subdistrict offices. On the other hand, road construction did not significantly reduce travel time for district/city offices. For both travel time variables, the anticipatory effect coefficients were close to zero and statistically insignificant, indicating the validity of the parallel trend assumption.

These results indicate that the benefits of non-toll national road construction are delayed but significant, particularly for travel costs and travel time to subdistrict offices. However, the insignificant impact on travel time to district/city offices suggests that longer distances and reliance on additional transportation modes might play a role. Overall, the dynamic treatment effect results suggest that the benefits of road construction materialize gradually and vary across travel scenarios.

Two approaches were applied to evaluate the robustness of the estimations in this study. First, one of the main tests in the DiD model was the parallel trend assumption test between the treatment and control groups. According to the parallel trend assumption, in the absence of treatment, the difference between the treatment and control groups will remain constant over time, meaning that the only factor causing differences is the presence of the treatment or intervention (Angrist & Pischke, 2009). This study conducted an F-test and expected the p-value to be above 0.05, with the null hypothesis being that there is no significant trend difference before the treatment. Table 5. (1), (2), (3), and (4) below present the parallel trend p-values of the F-test for each treatment variable in this study. The results show that the treatment and control groups used in this study meet the parallel trend assumption, with all p-values above 0.1, supporting the null hypothesis that there is no significant trend difference before the treatment is applied.

Table 5. Parallel Trend Treatment and Control Groups

	Travel Cost		Travel Time	
	(1) Sub-District Office	(2) District/ City Office	(3) Sub-District Office	(4) District/ City Office
P-value Parallel Trend Test	0.2022	0.2532	0.1115	0.9544

Notes: Parallel trend test using Event Study Framework

The next robustness test in this study is the placebo test. Due to data availability, the pre-construction estimation used only the travel cost variable. Row (1) of Table 6 shows insignificant results for the estimation before 2016, when road construction began, with the treatment group being villages located within 10 km of the road. This indicates that the reduction in travel time to the subdistrict offices resulted from non-toll national road construction.

Row (2) of Table 6 shows the estimation results after road construction, specifically in 2019, 2020, and 2021. The estimation results show no significant impact of non-toll national road construction on all dependent variables. This shows that the reduction in travel costs and travel time for villages near non-toll national roads was caused by the road construction itself.

Subsequently, this study estimated by replacing the dependent variable with random variables available in PODES for the periods before and after the construction of non-toll national roads. In the 2019 and 2020 PODES, data on the number of village security officers (Linmas) were unavailable, resulting in the loss of a significant number of observations. The estimation results indicate no significant impact of non-toll national road construction on the age of village heads or the number of Linmas members.

Table 6. Impact of non-toll road construction, Placebo Test

	Travel Cost		Travel Time			Total number of Linmas members	Age of the village head
	Sub-District Office	District/ City Office	Sub-District Office	District/ City Office			
(1) Before construction			-0.0458	0.0828	(3) Placebo Variabel Dependent	-0.950	0.405
			(0.101)	(0.0887)		(1.122)	(0.938)
(2) After construction	0.282	-1.299	-0.0999	0.0315	Observations	11.421	17.182
	(0.580)	(1.581)	(0.0691)	(0.122)			

*Notes: The above regression uses sub-district level group standard errors reported in parentheses. In the placebo estimation of time differences, the specifications and control variables are shown in the last column of Table 3. While for the placebo estimation of the number of Linmas members and the age of the village head, no control variables are used. The data for the number of Linmas members and the age of the village head variables are PODES data. ***, **, *, indicate statistical significance at 1%, 5%, and 10%, respectively.*

This finding suggests that the impact of road construction on travel costs and travel time is not coincidental and that the model used in this study is appropriate. The absence of significant anticipatory effects before the treatment strengthens the credibility of the results. This also confirms that the Indonesian government's development policies are appropriate and significantly impact economic equity. Hopefully, these findings can be used as input in the planning process for Indonesia's development, especially for road infrastructure.

CONCLUSION

Many studies focus on the impact of toll road construction while overlooking the potential of non-toll national roads, even though they can provide significant local economic benefits by reducing travel costs and travel time beyond their role as regional connectors. This potential is even greater for areas that do not yet have toll road networks.

This study employs the Difference-in-Differences (DiD) model to estimate the impact of government investment in non-toll national roads at the village level. This study uses Indonesia, an archipelagic country with uneven infrastructure development across regions, to analyze the impact of non-toll national road construction. Over the past decade, the Indonesian government has gradually reduced regional development disparities by investing in both toll and non-toll national road construction, providing this study with the opportunity to evaluate such investment policies. Hopefully, this study can contribute to the literature in infrastructure economics.

The findings reveal that villages within 10 km of the non-toll national road construction have travel costs to subdistrict government centers that are IDR 2,834 lower than those located farther away after the road construction. Although the impact may seem small, the construction of non-toll national roads reduced travel costs by 30.9% from the average travel costs of treatment group villages before the policy was implemented. Additionally, the policy reduced travel costs to district/city offices by IDR 5,534, or 27.8% of the average travel costs of treatment group villages before implementation.

These findings align with Ghani et al. (2016), who demonstrated that national road construction positively impacts economic activity in areas near the roads. This study also finds that national road construction is negatively associated with travel time to subdistrict government centers. Furthermore, the study shows that national road construction can reduce travel costs and travel times over longer distances, such as trips to district/city government centers. However, these results are not statistically significant.

Behind the findings obtained, there are limitations in this study. There is potential bias in the PODES data used in this research. PODES data is collected by Statistics Indonesia (BPS) through interviews with village heads or urban ward leaders in Indonesia, and the responses from these interviews are subject to potential bias. A limitation of this study lies in using variables derived from PODES data to measure the impact of national road construction. While the results of this study may appear convincing, they may not fully capture all dimensions of economic shifts.

Nonetheless, further research on the impact of infrastructure investment in the transportation sector is crucial to ensure that development implementation can proceed effectively. Future studies on the effects of non-toll national road construction could explore changes in the employment structure of village residents, agricultural conditions, industrial conditions, and the environmental state of villages in Indonesia. These aspects were not considered in this study using PODES data. Further research could also examine the dynamic effects of road use, which are very extensive, and the impact of road infrastructure development on job availability, agricultural or industrial productivity, and its impact on local markets or other variables for which data is unavailable in the PODES data.

Another important issue that is difficult to address in this study is the possibility that, within the treatment group, travel to subdistrict or district/city offices does not necessarily require using newly constructed non-toll national roads. This study has not yet incorporated the variable of travel distance to explain the impact of non-toll national road construction. The calculated travel costs and times may include routes not involving newly built roads. Future research on the impact of road construction that considers travel distance can be conducted to provide a more accurate representation of the actual effects of road construction.

REFERENCES

Angrist, J. D., & Pischke, J.-S. (2009). Mostly Harmless Econometrics: An Empiricist's Companion. Economics Books. https://ideas.repec.org/b/pup/pbooks/8769.html

Aschauer, D. A. (1989). Is public expenditure productive? Journal of Monetary Economics, 23(2), 177–200. https://doi.org/10.1016/0304-3932(89)90047-0

Aschauer, D. A. (1993). Genuine Economic Returns to Infrastructure Investment. Policy Studies Journal, 21(2), 380–390. https://doi.org/10.1111/J.1541-0072.1993.TB01830.X

Audretsch, D. B., Dohse, D. C., & Dos Santos, J. P. (2020). The effects of highway tolls on private business activity—results from a natural experiment. Journal of Economic Geography, 20(6), 1331–1357. https://doi.org/10.1093/JEG/LBAA003

Autor, D. H. (2003). Outsourcing at Will: The Contribution of Unjust Dismissal Doctrine to the Growth of Employment Outsourcing. Journal of Labor Economics, 21(1), 1–42. https://doi.org/10.1086/344122

Bappenas. (2019). Laporan Kinerja Kementerian PPN/Bappenas Tahun 2018. https://birorenortala.bappenas.go.id/uploads/renortala/LKJ_2018.pdf

Baum-Snow, N. (2007). Did Highways Cause Suburbanization? The Quarterly Journal of Economics, 122(2), 775–805. https://doi.org/10.1162/qjec.122.2.775

Buys, P., Deichmann, U., & Wheeler, D. (2010). Road Network Upgrading and Overland Trade Expansion in Sub-Saharan Africa. Journal of African Economies, 19(3), 399–432. https://doi.org/10.1093/jae/ejq006

Calderón, C., & Servén, L. (2004). The Effects of Infrastructure Development on Growth and Income Distribution. The World Bank. https://doi.org/10.1596/1813-9450-3400

Cetin, V. R. (2024). When do public transport investments really matter? A CGE analysis for Türkiye. Economic Systems Research, 36(1), 1–23. https://doi.org/10.1080/09535314.2022.2122407

Chandra, A., & Thompson, E. (2000). Does public infrastructure affect economic activity?: Evidence from the rural interstate highway system. Regional Science and Urban Economics, 30(4), 457–490. https://doi.org/10.1016/S0166-0462(00)00040-5

Combes, P.-P., & Lafourcade, M. (2005). Transport costs: measures, determinants, and regional policy implications for France*. Journal of Economic Geography, 5(3), 319–349. https://doi.org/10.1093/jnlecg/lbh062

Donald, S. G., & Lang, K. (2007). Inference with Difference-in-Differences and Other Panel Data. Review of Economics and Statistics, 89(2), 221–233. https://doi.org/10.1162/rest.89.2.221

Duflo, E. (2004). Annual World Bank Conference on Development Economics.

Duranton, G., Morrow, P. M., & Turner, M. A. (2014). Roads and Trade: Evidence from the US. The Review of Economic Studies, 81(2), 681–724. https://doi.org/10.1093/restud/rdt039

Elburz, Z., & Cubukcu, K. M. (2021). Spatial effects of transport infrastructure on regional growth: the case of Turkey. Spatial Information Research, 29(1), 19–30. https://doi.org/10.1007/s41324-020-00332-y

Elburz, Z., Nijkamp, P., & Pels, E. (2017). Public infrastructure and regional growth: Lessons from meta-analysis. Journal of Transport Geography, 58, 1–8. https://doi.org/10.1016/J.JTRANGEO.2016.10.013

Faber, B. (2014). Trade Integration, Market Size, and Industrialization: Evidence from China's National Trunk Highway System. The Review of Economic Studies, 81(3), 1046–1070. https://doi.org/10.1093/restud/rdu010

Ghani, E., Grover Goswami, A., Kerr, W. R., Center, R., Ahsan, A., Baum-Snow, N., Griffith, R., & Mukhopadhyay, P. (2016). Highway to Success: The Impact of the Golden Quadrilateral Project for the Location and Performance of Indian Manufacturing. The Economic Journal, 126(591), 317–357. https://doi.org/10.1111/ECOJ.12207

Huang, Yukon., & Bocchi, A. M. (2009). Reshaping economic geography in East Asia. World Bank.

Jacoby, H. G. (2000). Access to Markets and the Benefits of Rural Roads. The Economic Journal, 110(465), 713–737. https://doi.org/10.1111/1468-0297.00562

Kantor Staf Presiden. (2021). Jalan Trans Maluku Dibangun untuk Pemerataan dan Keadilan Sosial – Kantor Staf Presiden. https://www.ksp.go.id/jalan-trans-maluku-dibangun-untuk-pemerataan-dan-keadilan-sosial.html

Keefer, P., & Knack, S. (2007). Boondoggles, Rent-Seeking, and Political Checks and Balances: Public Investment under Unaccountable Governments. The Review of Economics and Statistics, 89(3), 566–572. http://www.jstor.org/stable/40043049

Khoirunurrofik, & Anas, T. (2023). Massive Infrastructure Development and Its Impact on Indonesia's Economy (Vol. 1). https://www.eria.org/uploads/10-PSN-Book-vol_1-ch_5.pdf

Lall, S. V. (2007). Infrastructure and regional growth, growth dynamics, and policy relevance for India. Annals of Regional Science, 41(3), 581–

599. https://doi.org/10.1007/S00168-006-0112-4/METRICS

LIANG, K.-Y., & ZEGER, S. L. (1986). Longitudinal data analysis using generalized linear models. Biometrika, 73(1), 13–22. https://doi.org/10.1093/biomet/73.1.13

Mankiw, N. G. (2016). MACROECONOMICS.

Ossokina, I. V, van Ommeren, J., & van Mourik, H. (2023). Do highway widenings reduce congestion? Journal of Economic Geography, 23(4), 871–900. https://doi.org/10.1093/jeg/lbac034

Pindyck, R. S., & Rubinfeld, D. L. (2013). MICROECONOMICS. www.myeconlab.com

Pritchett, L. (2000). The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) Is Not Capital. Journal of Economic Growth, 5(4), 361–384. https://doi.org/10.1023/A:1026551519329

Rephann, T., & Isserman, A. (1994). New highways as economic development tools: An evaluation using quasi-experimental matching methods. Regional Science and Urban Economics, 24(6), 723–751. https://doi.org/10.1016/0166-0462(94)90009-4

Rodrigue, J.-P. (2020). The Geography of Transport Systems. Routledge. https://doi.org/10.4324/9780429346323

Rodrigue, J.-P. (2024). The Geography of Transport Systems (6th ed.). Routledge. https://doi.org/10.4324/9781003343196

Romp, W., & de Haan, J. (2007). Public Capital and Economic Growth: A Critical Survey. Perspektiven Der Wirtschaftspolitik, 8(S1), 6–52. https://doi.org/10.1111/j.1468-2516.2007.00242.x

Rosmeli, R., & Nurhayani, N. (2014). Studi Komperatif Ketimpangan Wilayah Antara Kawasan Barat Indonesia Dan Kawasan Timur Indonesia. Jurnal Manajemen Terapan Dan Keuangan, 3(1), 456–463. https://doi.org/10.22437/jmk.v3i1.1861

Small, K. A., & Verhoef, E. T. (2007). The Economics of Urban Transportation (First). Routledge.

Sukwika, T. (2018). Peran Pembangunan Infrastruktur terhadap Ketimpangan Ekonomi Antarwilayah di Indonesia. Jurnal Wilayah Dan Lingkungan, 6(2), 115. https://doi.org/10.14710/jwl.6.2.115-130

Tanzi, V., & Davoodi, H. (1998). Corruption, Public Investment, and Growth. In The Welfare State, Public Investment, and Growth (pp. 41–60). Springer Japan. https://doi.org/10.1007/978-4-431-67939-4_4

Udo, A., & Effiong, C. (2014). Economic Growth and Wagner's Hypothesis: The Nigerian Experience. In Journal of Economics and Sustainable Development www.iiste.org ISSN (Vol. 5, Issue 16). www.iiste.org.