

The Link between Road Infrastructure Quality and Fiscal Decentralization: Evidence from Subnational Indonesia

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Abstract

The study on road infrastructure and economic development has been widely discussed, but the relationship between road infrastructure and local fiscal decentralization is still limited. Fiscal decentralization is essential for ensuring sustainable public services and fostering economic development. The study enhances the existing literature by identifying the link between infrastructure development and local fiscal decentralization in Indonesia. The estimate employs a panel fixed-effect approach to address the constant unobservable variable bias. The results show that better road quality is positively and significantly associated with local fiscal decentralization. However, the association varies across subsamples, where districts in the Java region have more robust evidence than districts in the non-Java region.

Keywords: road quality; road infrastructure; fiscal decentralization; fixed-effect; toll roads; highways

JEL classification: E62; H70; O18

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1. INTRODUCTION

Infrastructure development could strengthen local fiscal decentralization through local revenue generation. According to the endogenous growth theory, human capital, innovation, and capital investment, such as infrastructure development, could promote productivity and economic growth (Alam et al., 2021; Bleaney et al., 2001; Maparu & Mazumder, 2017). Thus,

infrastructure development, particularly road infrastructure in underdeveloped areas, is expected to affect national and local economic growth positively (Alder, 2023; Asher & Novosad, 2020; Chen et al., 2023). The increase in local growth could spawn local revenue and result in regional (local) fiscal decentralization. According to the earlier study discussing the connection between road infrastructure and economic development (Estache and Garsous, 2012; Irawan *et al.*, 2012; Li and Qi, 2016; Banerjee, Duflo and Qian, 2020), the relationship between road development and fiscal decentralization could have different magnitudes across regions, depending on the other supporting factors, such as the region's development level, competitiveness, institution, and policy.

While the research on infrastructure development and economic growth has been widely discussed, the connection between infrastructure development and regional fiscal decentralization is limited. There are two critical points on why the relationship between road infrastructure and regional fiscal decentralization is important. First, increasing local government revenue may not be followed by increasing local fiscal independence due to the insignificant amount compared to the intergovernmental transfer. Thus, in reality, local fiscal independence does not necessarily increase. As shown in Figure 1, the local government revenue has had an upward trend over the years. However, the intergovernmental transfer also rises significantly, overshadowing the increases in local government revenue. Thus, in reality, local fiscal independence does not necessarily increase.

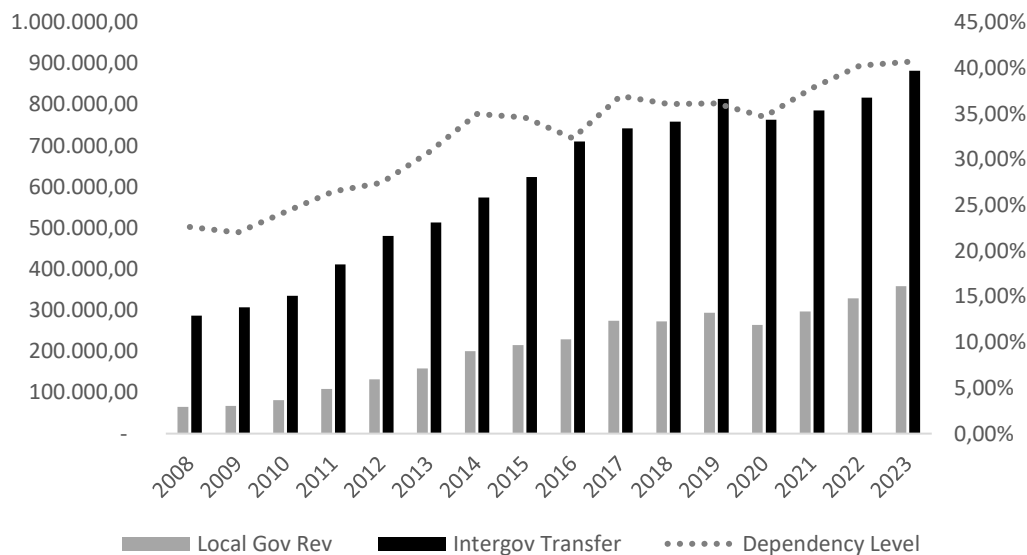


Figure 1. The local revenue, intergovernmental transfer, and dependency Level (%)

Source: Ministry of Finance

On the other hand, intergovernmental transfers are relatively less sustained depending on the central government budget and policies. Thus, the proportion of intergovernmental transfers should not be dominant. Second, despite having a positive

impact by raising the local revenue and growth (Masaki, 2018), the higher intergovernmental transfer could crowd out by replacing local tax revenue (Bradford & Oates, 1971a, 1971b; Buettner & Wildasin, 2006). Therefore, the study fills the gap in discussing road quality infrastructure and district fiscal decentralization.

The study focuses on road infrastructure, which is hugely used and developed across the regions, particularly road quality. Road quality infrastructure development is defined as the proportion of good quality district roads to the total road in each district (Laborda & Sotelsek, 2019). Meanwhile, we measure fiscal decentralization using the autonomy indicator approach (Akai & Sakata, 2002). As our study focuses on measuring the degree of fiscal independence of local government, the autonomy indicator is more suitable than other fiscal decentralization indicators. We chose Indonesia as the setting since the country has extensive decentralization and infrastructure development policies, reflected in the infrastructure's budget, which increased fourfold from 2010 to 2016 (The Ministry of Finance of The Republic of Indonesia, 2010, 2016).

The study employs a fixed-effects model to address the possibility of a time-invariant unobserved variable. The fixed-effect method could also reduce the endogeneity problems caused by reverse causality when estimating the nexus of road quality and fiscal decentralization. In contrast, the ordinary least square approach might yield biased and inconsistent estimators. Specifically, the estimate accounts for the year fixed-effect, provincial fixed-effect, and year-island fixed-effect to control the time-invariant unobservable. We cluster the standard errors at the district level to deal with the potential autocorrelation and heteroskedasticity problems.

Our research fills the gap in the existing study-related road infrastructure and fiscal independence by analyzing the link between infrastructure improvement and fiscal decentralization. The earlier research mainly links infrastructure and economic growth (Alder, 2023; Asher & Novosad, 2020; Banerjee et al., 2020; Chen et al., 2023; Li & Qi, 2016). The result of the study is beneficial for policy improvement both in central and local governments. For the central government, the link identification gives input to consider infrastructure development when allocating the intergovernmental transfer funds and defining the appropriate policy for road infrastructure development. From the local government's point of view, the result could help them determine their next strategy to improve their local fiscal independence through road infrastructure development.

Moreover, the study includes more refined fixed-effect controls that make the estimation result close to the causality identification, meaning improving the road quality might affect the district fiscal decentralization. The earlier study does not consider the potential endogeneity issue and unobserved variable bias (Laborda & Sotelsek, 2019). The fixed-effect method will produce more consistent results and more substantial causation than simple ordinary least squares.

The remainder of the research follows: Section 2 provides a research method. Section 3 discusses the results, and section 4 concludes.

2. RESEARCH METHOD

2.1 Data and Collecting Procedures

The research employs district budget data from the Realization of the local government budget from 2014 to 2019, provided by the Ministry of Finance, and toll road data is obtained from the Indonesia Toll Road Authority. As controls, social-economic indicators are sourced from Statistics of Indonesia, BPS.

We collected data at the subdistrict level from 2015 to 2019 and merged the data from different sources. The number of toll road data observations is limited as not all districts have toll roads. Since not all data is available in each district, thus we have unbalanced panel data capturing more than 500 districts from 2015 to 2019. The study also excludes the districts in Special Capital Region of Jakarta province since the districts did not receive the fiscal transfer during the study period, especially the general allocation fund.

2.2 The Measurements and Operationalizations of Variables

Several indicators measure fiscal decentralization, but since the study is concerned with local fiscal independence, we employ the autonomy indicator from 2015 to 2019, when the road infrastructure developed massively. The autonomy indicator is defined by dividing the district's own revenue by the total district revenue, called the fiscal decentralization ratio. The district revenues consist of the district's own revenue, transfer funds, and miscellaneous revenues. The fiscal decentralization ratio ranged from zero to one; the higher the ratio, the more independent the district.

Additionally, we employ alternative measurements of fiscal decentralization that still reflect fiscal autonomy or independence. The first alternative is calculating the ratio of the district's revenue and total transfer funds, called the independence ratio. The total transfer funds include national transfer, provincial transfer, and special autonomy funds. The ratio could be more than one if the district's own revenue is higher than the total transfer funds. A higher independence ratio indicates a more independent district.

Secondly, we calculate the ratio of total district transfer fund to total district revenue, called the dependency ratio. The higher the dependency ratio, the more dependent the district. It is important to highlight that the study does not account for village fund transfers as the funds go directly to the villages, not the districts. Hence, we expect that the effect on the district is limited. We also exclude grants when calculating total transfer funds due to the incomplete information on the grants' sources in the public budget financial report. Yet, the proportion of district grants to total district revenue is insignificant, ranging from 0.75 percent to 3 percent compared to total other transfers (including national and provincial transfers), ranging from 70 percent to 73 percent during 2015-2019.

Our interest variable, road quality, is a share of the length of the good quality road, including district highways and toll roads located in each district, to the total length of district roads and toll roads available in each district (Laborda & Sotelsek, 2019). In this study, highways are free highways under district government authority. We employ district highways as the highways connect the district and local activity centers, including local economic activity, which is expected to affect district independence. We also categorize toll

roads as good quality since the Indonesia Toll Road Authority maintains the roads. The higher the value of road quality, the better road quality in the district. Further, the study includes socioeconomic factors as control variables, such as poverty rate, population density, and human development ratio at the district level from 2015 to 2019. The socioeconomic data are obtained from Statistics of Indonesia, BPS. Table 1 summarizes the measurement of variables.

Table 1 Definition and measurement of variables

Variable	Measurement	Note
Main interest (Y)		
fiscal decentralization ratio	The district's own revenue is divided by total district revenue. The district's revenues consist of the district's own revenue, transfer funds, and miscellaneous revenues.	Range 0-1, the higher the ratio, the more independent the district.
independence ratio	The district's own revenue is divided by total transfer funds. Total transfer funds include national transfer, provincial transfer, and special autonomy funds.	The higher the value, the more independent the district
dependency ratio	Total district transfer fund divided by total district revenue District transfer funds exclude village fund transfers and grants.	The higher the dependency ratio, the more dependent the district.
Main interest (road quality)		
road quality	Share of the length of the good quality road, including district highways and toll roads, divided by the total length of district roads and toll roads Highways are defined as free highways under district government authority.	The higher the value of road quality, the better the road quality
Controls (X)		
poverty rate	The number of poor populations divided by the total population	
population density	The number of people divided by the total district area	
human development ratio		

2.3 Model Specification

When examining fiscal decentralization and road quality linkage, the research employs a fixed-effect model in Eq.1, following Gertler et al. (2024) . The study employs a fixed-effects model to address the possibility of a time-invariant unobserved variable. The fixed-effect method could also reduce the endogeneity problems caused by reverse causality when

estimating the nexus of road quality and local development, such as fiscal independence (Feng & Wu, 2018)

$$Y_{jt} = \alpha_0 + \alpha_1 roadquality_{jt} + \alpha_2 X_{jt} + \eta_j + \mu_j + \gamma_t + \delta_{jt} + u_{jt} \dots\dots\dots (1)$$

$$Y_{jt} = \frac{\text{district's own revenue}_{jt}}{\text{total district revenue}_{jt}} \dots\dots\dots (2)$$

$$roadquality_{jt} = \frac{\text{good quality road}_{jt}}{\text{total road}_{jt}} \dots\dots\dots (3)$$

The fiscal decentralization ratio of district j in year t is Y_{jt} . The ratio ranges from zero to one, with one being the highest ratio of fiscal decentralization and zero otherwise. Y_{jt} is obtained by dividing the district's own revenue by total district revenue (Eq. 2). $roadquality_{jt}$ is the share of good quality roads, including district highways and toll roads, to the total roads in district j and year t (Eq.3).

Coefficient α_1 estimates the magnitude of the relationship between the share of good quality roads and the fiscal decentralization ratio. X_{jt} is a vector of potential control variables that might explain fiscal decentralization. X_{jt} consists of a percentage of poor households or poverty rate, human development ratio, and population density following Alexeev & Mamedov (2017); Canavire-Bacarreza & Martinez-Vazquez (2012). Further, the study adds several fixed-effect controls, such as district fixed-effect, η_j ; provincial fixed-effect, μ_j ; year fixed-effect, γ_t ; and island-time fixed-effect, δ_{jt} to isolate the time-invariant unobserved variable.

The study applies the fixed-effect method because of its superior advantages in reducing bias from constant unobserved variables compared to the simple ordinary least square. Including several fixed-effect controls also reduces the endogeneity issue. The endogeneity issue might be sourced from reverse causality, where the district with a higher fiscal decentralization capability could provide better road quality than the district with a lower fiscal decentralization capability. (Alder, 2023; Mettetal, 2019) The district fixed-effect, provincial fixed-effect, and year-island fixed-effects are advantageous for absorbing districts' different socioeconomic and geographical characteristics. They could also handle the potential local and national policies affecting the relationship between road improvement and fiscal decentralization. The year-fixed effect captures the time trend effect of fiscal decentralization and road quality. All standard errors are clustered at the district level to deal with the potential autocorrelation from external disturbance across the districts that are uncorrelated with road quality but correlated with the fiscal dependency ratio. Therefore, the model estimates potentially close to the causality effect of road improvement on fiscal decentralization.

2.4 Estimation Procedures

The study initially estimates the relationship between road quality and fiscal decentralization ratio using an ordinary least square approach with several fixed-effect controls for baseline. We also check the possibility of various effects between regions and

islands as regions may have diverse policy-related budget allocation and infrastructure development.

Additionally, the study examines the per capita district's own revenue and per capita district's own revenue annual growth as a potential mechanism to explain the link between road quality and fiscal decentralization ratio. We compute the per capita district's own revenue yearly growth as the difference between the log per capita district's own revenue growth next year and this year for each district. Further, we conduct several robustness checks to test the baseline model consistency. Firstly, the study applies other dependent variables. We use fiscal independence and fiscal dependency ratios. The first is calculated by dividing the district's own revenue by total fiscal transfers, and the latter by dividing the district transfer fund by total district revenue. The study also tests the relationship of each type of road, i.e., the share of the toll road and good quality highways, to the fiscal decentralization to ensure the model's robustness.

3. RESULTS AND DISCUSSION

3.1. Recent Update of Decentralization and Infrastructure Development in Indonesia

3.1.1. Decentralization in Indonesia

After two decades of decentralization, the ability of local government to create local revenue is still limited. Between 2018 and 2022, an average of 88.2% of the Regional Revenue and Expenditure Budget (*Anggaran Pendapatan dan Belanja Daerah*-APBD) came from central government transfers, while local revenue (*Pendapatan Asli Daerah*-PAD) contributed only 13.9% on average (Direktorat Pembangunan Daerah Kedeputian Bidang Pengembangan PPN/Bappenas, 2024).

Figure 2 presents Indonesia's district fiscal decentralization map in 2015 and 2019. We calculate the fiscal decentralization ratio by dividing the district's own revenue by the total district revenue. The study classifies the ratio into six categories: poor if the ratio is less than or equal to 0.1; insufficient if the ratio ranges from more than 0.1 up to 0.2; sufficient if the ratio ranges from more than 0.2 up to 0.3; satisfactory if the ratio ranged from more than 0.3 up to 0.4, good if the ratio ranged from more than 0.4 up to 0.5 and very good if the ratio more than 0.5. The darker the color, the higher the fiscal decentralization ratio.

Overall, fiscal decentralization in Indonesia is still low or in the poor category. Districts in the Java region have dominated a higher fiscal decentralization ratio since 2015, and some districts are in satisfactory and good categories. Some districts in the Sumatra and Kalimantan regions have experienced fiscal decentralization ratio improvement, as shown by the darker color in 2019 than in 2015. In contrast, several regional districts also faced fiscal decentralization degradation in 2019. However, the fiscal decentralization ratio category in Maluku and Papua's districts remains the same.

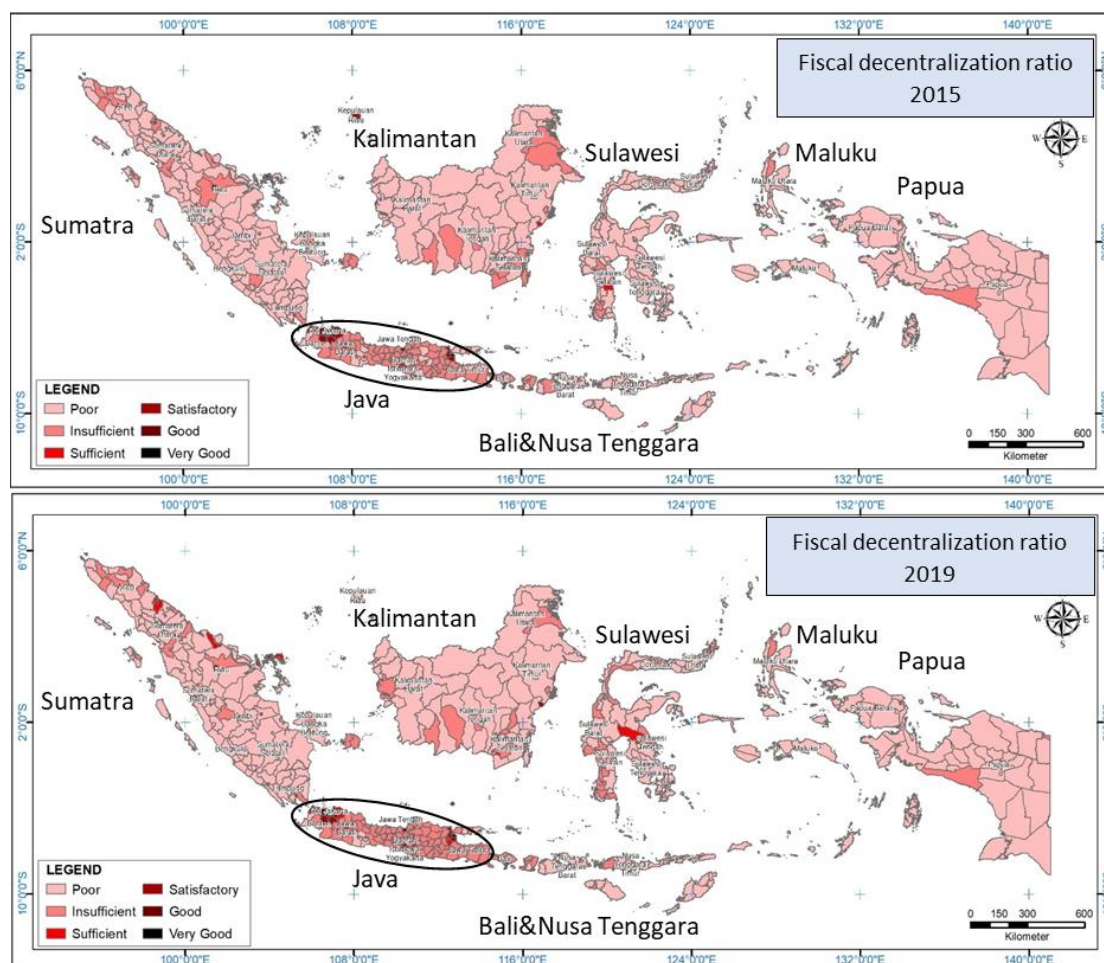


Figure 2 The district fiscal decentralization ratio in 2015 and 2019

3.1.2. Indonesia's Infrastructure Development

Since 2013, the Indonesian government has prioritized infrastructure development to support economic growth and national progress. In 2014, the government formally issued Presidential Regulation No. 75 year 2014 to accelerate the provision of priority infrastructure. Two years later, in 2016, under the new government, Presidential Regulation No. 3 of 2016 was introduced to expedite further the development of strategic infrastructure projects (Regulation of The President of The Republic of Indonesia Number 3 of 2016 Concerning Acceleration of the Implementation of National Strategic Projects, 2016; Regulation of The President of The Republic of Indonesia Number 75 year 2014 concerning Acceleration of Priority Infrastructure Provision, 2014). In terms of budget, from 2010 to 2016, the infrastructure's budget rose by four times, from around 87 trillion to 317 trillion rupiahs.

Table 2 shows the district road improvement in Indonesia. In Indonesia, district highways are defined by free roads connecting district capitals with sub-district capitals,

between sub-district capitals, district capitals with local activity centers, local activity centers, and district strategic roads. From 2015 to 2019, the total district highways in Indonesia increased by about 2.60 percent, and the district highway development between districts in Java and Non-Java is relatively similar. Overall, the percentage of good-quality district roads increased by 0.44 percent, with Java Island increasing by about 7.36 percent. In comparison, the district highways outside Java faced a decrease in quality of around 2.11 percent. Meanwhile, toll roads rose drastically by 115.41 percent, dominated by the toll road increase outside the Java region (1036.79 percent).

The district fiscal decentralization and infrastructure development of Indonesia could be interrelated. Therefore, in the RPJMN 2015-2019, one of Indonesia's development focuses on improving infrastructure connectivity, such as roads, to increase economic growth and reduce inequality between regions (Bappenas, 2015, 2019). Even until RPJMN 2020-2024, the government continues to improve the connectivity of the road infrastructure, and in 2024, it is expected to have about 3000 km of other new roads.

Table 2 Indonesia's road improvement

Growth 2015-2019	total highways	good highways	toll road
Java	2.83%	7.36%	70.80%
Non-Java	2.54%	-2.11%	1036.79%
Total	2.60%	0.44%	115.41%

Source: Statistics of Indonesia, BPS; Indonesia Toll Road Authority

Notes: The highways are free highways under district government authority. The Java region data exclude the Special Capital Region of Jakarta districts to fit the study locus.

3.2. Characteristics of the Variables

Table 3 explains the descriptive statistics of variables. The average fiscal decentralization and independence ratios are minor, meaning most districts still rely on central government transfers. In the meantime, the share of good quality roads is higher than 58 percent. Districts with a relatively higher share of good quality roads also have a higher number of fiscal decentralization and independence ratios or, in other words, more independent than districts with a lower share of good quality roads.

Table 3 Descriptive Statistics of Variables

	All			> median of share good quality road			≤ median of share good quality road		
	Obs	Mean	Std. dev	Obs	Mean	Std. dev	Obs	Mean	Std. dev
Dependent variables									
fiscal decentralization ratio	2,488	0.108	0.090	1,244	0.147	0.106	1,244	0.068	0.043
fiscal independence ratio	2,487	0.151	0.277	1,244	0.221	0.374	1,243	0.080	0.062
fiscal dependency ratio	2,487	0.843	0.100	1,244	0.804	0.111	1,243	0.882	0.068
Independent variables									
share of good road	2,488	0.589	0.212	1,244	0.763	0.107	1,244	0.415	0.134
share of good highways	2,488	0.583	0.208	1,244	0.753	0.105	1,244	0.414	0.134
share of toll road	234	0.061	0.036	212	0.061	0.035	22	0.067	0.043
Controls									
ln density	2,488	5.197	1.901	1,244	6.172	1.829	1,244	4.223	1.410
poverty rate	2,488	12.927	7.976	1,244	10.627	6.161	1,244	15.227	8.873
human development ratio	2,488	68.096	6.621	1,244	70.663	6.374	1,244	65.529	5.821

3.3. Statistical Estimation Results

Before we go to the estimation results, we display the relationship between the share of good-quality roads and the fiscal decentralization ratio graphically in Figure 3. Figure 3 and the Pearson correlation coefficient indicate a positive relationship between the share of road quality and the fiscal decentralization ratio. In other words, the district with a higher percentage of good-quality roads has a higher fiscal decentralization ratio.

3.3.1. Baseline Estimate

Table 4 estimates the link between road quality improvement and fiscal decentralization ratio based on equation (1). In column (1), we present the relationship between good quality road and fiscal decentralization ratio, including the year fixed-effect, but exclude the socioeconomic control. We include socioeconomic controls in column (2), then we gradually add fixed-effect controls, year and province fixed-effect in column (3), and full control in column (4). The results show a positive relationship between the share of good-quality roads and the decentralization ratio. The relationship is significant, at least at the 10 percent level. The coefficients imply that the increase of 1 percent share of the good quality road is positively correlated with the rise of the fiscal decentralization ratio from around 0.61 percent to 0.75 percent. However, including the province and year-island fixed effects in column (4) reduces the coefficient and significant value, implying that the unobserved variable bias could overestimate the results. The source of variable bias might be due to the variation of district characteristics, such as the district's good governance. The district with good governance could provide better road quality and higher fiscal decentralization than the

district with bad governance. Thus, the research will focus on the full controls specified in column (4) for the following estimation.

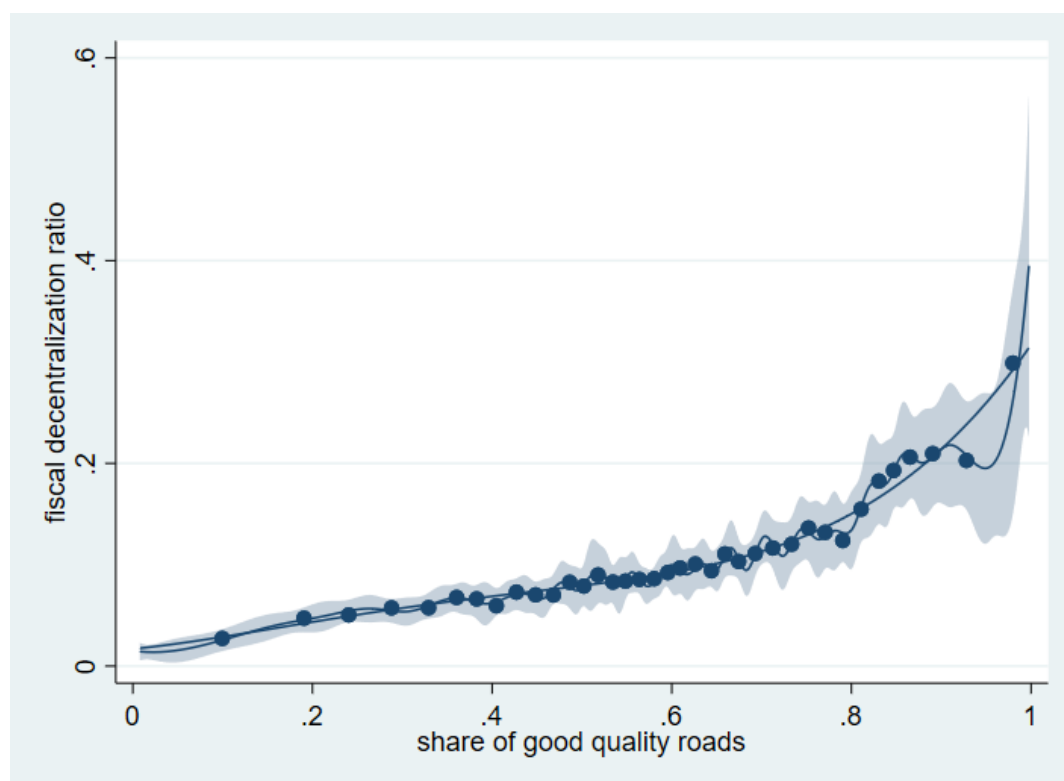


Figure 3 The link between the share of good quality roads and the fiscal decentralization ratio

Notes: The figure is a binned regression with a polynomial fit degree 4 of the share of total good quality roads and fiscal decentralization ratio from 2015 to 2019 at the district level. The Pearson correlation coefficient, r , is 0.5475.

Table 4 The relationship between road quality and fiscal decentralization ratio, baseline estimate

	Dependent variable: fiscal decentralization ratio			
	(1)	(2)	(3)	(4)
Share good-quality road	0.00691** (0.003)	0.00755** (0.003)	0.00755** (0.003)	0.00615* (0.003)
Adj R-squared	0.308	0.318	0.277	0.367
Observations	2523	2488	2488	2488
Mean of dep.variable	0.109	0.108	0.108	0.108
Controls	No	Yes	Yes	Yes

	Dependent variable: fiscal decentralization ratio			
	(1)	(2)	(3)	(4)
Year FE	Yes	Yes	Yes	Yes
Province FE	No	No	Yes	Yes
Year-island FE	No	No	No	Yes

Notes: All regressions are panel fixed-effect estimates that use an unbalanced district-year level panel. The control variables are the human development ratio, poverty rate, and logarithm of population density. Standard errors clustered at the district level were reported in parentheses.

Asterisks denoted significance: ***p< 0.01, **p< 0.05, *p<0.10.

3.3.2. Sample Heterogeneity

The previous literature finds that the link between road improvement and economic development could differ across regions or countries (Asher & Novosad, 2020; Banerjee et al., 2020; Laborda & Sotelsek, 2019; Li & Qi, 2016). The relationship between road quality and fiscal decentralization might have mixed results with similar logic. Hence, the study checks the relationship between road quality improvement and fiscal decentralization ratio in different subsamples in Table 5. The study defines the district status subsample to capture the various districts' geographic and socioeconomic characteristics. City and county generally have different characteristics. The city usually has a higher population, modern jobs, a wider area, and better public facilities than the county. Further, we exercise the Java versus Non-Java subsample to account for the different development levels, with districts in Java representing more developed areas than districts in the non-Java.

Table 5 The relationship between road and fiscal decentralization ratio across subsample

	Dependent variable: fiscal decentralization ratio			
	Administrative		Islands	
	City	County	Java	Non-Java
	(1)	(2)	(3)	(4)
Share good-quality road	0.0193 (0.012)	0.00389 (0.003)	0.0170* (0.009)	0.00446 (0.003)
Adj R-squared	0.486	0.344	0.537	0.300
Observations	447	2041	558	1930
Mean of dep.variable	0.191	0.089	0.192	0.083

Notes: All regressions control the human development ratio, poverty rate, the logarithm of population density, year, province, and year-island fixed effects. These estimates use an unbalanced district-year panel. Standard errors clustered at the district level were reported in parentheses. Asterisks denoted significance: ***p< 0.01, **p< 0.05, *p<0.10.

Table 5 demonstrates the relationship between good-quality roads and fiscal decentralization in various subsamples. The results show that the good quality road positively correlates to fiscal decentralization but is only significant at the 10 percent level in the Java subsample (column 3). In Java Island, a 1 percent addition of the good quality road share is associated with a higher fiscal decentralization ratio of as much as 1.7 percent. Thus, the strong relationship between road quality improvement and a higher fiscal decentralization ratio is more evident on Java Island (column (3)) than on Non-Java Island (column (4)). Meanwhile, city versus county subsamples in columns (1) and (2) show an insignificant correlation between road quality and fiscal decentralization ratio.

3.3.3. Potential Mechanism

We suggest the potential channel on how road quality correlates with fiscal decentralization ratio by estimating the link between road quality and per capita district's own revenue and annual growth of per capita district's own revenue in Table 6. The economic rationale for the transmission is that a better-quality road will increase district connectivity and reduce the transport cost for individuals and businesses, increasing their consumption and production capabilities and potentially increasing local tax revenue and retribution. The study mainly employs the district's own revenue and the detailed components of the district's own revenue, such as tax, retribution, segregated regional assets management, and miscellaneous revenue.

Our estimation results in Table 4 partly explain the mechanism of the relationship between road quality and fiscal decentralization, marked by positive and significant coefficients of per capita district's own revenue, per capita tax, per capita retribution, per capita segregated regional assets management, and per capita miscellaneous revenue in column (1)-(5). However, the growth channel is weaker in explaining the relationship shown by insignificant coefficients in columns (6)-(9), except for the annual growth of per capita miscellaneous revenue in column (10).

Table 6 Potential mechanism: The relationship between good quality roads and the district's revenue

	Ln (per capita)					Annual growth in Ln (per capita)				
	district's own revenue	tax	retribution	segregated regional assets management	miscellaneous revenue	district's own revenue	tax	retribution	segregated regional assets management	miscellaneous revenue
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Share the good quality road	0.0003*** (0.000)	0.418*** (0.149)	0.457** (0.212)	0.483** (0.205)	0.334*** (0.120)	0.000 (0.000)	0.008 (0.084)	0.140 (0.104)	0.141 (0.119)	0.153** (0.065)
Adj R-squared	0.330	0.633	0.335	0.332	0.267	0.095	0.186	0.008	0.112	0.181
Observations	2488	2461	2462	2282	2484	2472	2440	2437	2177	2464
Mean of dep.variable	0.000	11.340	10.140	9.638	12.090	0.000	0.001	-0.004	0.052	-0.001

Notes: All regressions are OLS estimates. We control the human development ratio, poverty rate, the logarithm of population density, year, province, and year-island fixed effects. These estimates use an unbalanced district-year-level panel. Standard errors clustered at the district level were reported in parentheses.

Asterisks denoted significance: ***p< 0.01, **p< 0.05, *p<0.10.

Table 7 Robustness tests: the relationship between road quality and alternative fiscal decentralization measurements

Independent variable: Dependent variable:	Fiscal decentralization measurements					Type of roads		
	Fiscal independence ratio			Fiscal dependency ratio		Fiscal decentralization ratio		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share the good quality road	0.0140** (0.006)			-0.0095 (0.008)				
Share of good quality highway		0.0128** (0.006)			-0.00882 (0.008)		0.00597* (0.003)	
Share of tolls road			0.514 (0.357)			-0.293* (0.164)		0.00112 (0.073)
Adj R-squared	0.211	0.211	0.871	0.147	0.147	0.364	0.367	0.538
Observations	2487	2487	234	2487	2487	234	2488	234
Mean of dep.variable	0.151	0.151	0.507	0.843	0.843	0.686	0.108	0.26

Notes: All regressions control the human development ratio, poverty rate, the logarithm of population density, year, province, and year-island fixed effects. These estimates use an unbalanced district-year-level panel. Standard errors clustered at the district level were reported in parentheses.

Asterisks denoted significance: ***p< 0.01, **p< 0.05, *p<0.10.

Table 8 Robustness tests: omitting observations

Omitting observations:	share of good quality roads			fiscal decentralization ratio		
Dependent variable: fiscal decentralization ratio	Omit 5% highest	Omit 5% lowest	Omit 5% highest and 5% lowest	Omit 5% highest	Omit 5% lowest	Omit 5% highest and 5% lowest
	(1)	(2)	(3)	(4)	(5)	(6)
Share the good quality road	0.0074** (0.004)	0.0080** (0.004)	0.0091** (0.004)	0.0051* (0.003)	0.0067* (0.004)	0.0054 (0.004)
Adj R-squared	0.343	0.377	0.353	0.357	0.376	0.367
Observations	2363	2363	2238	2362	2363	2237
Mean of dep.variable	0.0998	0.111	0.103	0.092	0.113	0.097

Notes: All regressions control the human development ratio, poverty rate, the logarithm of population density, year, province, and year-island fixed effects. These estimates use an unbalanced district-year-level panel. Standard errors clustered at the district level were reported in parentheses.

Asterisks denoted significance: ***p< 0.01, **p< 0.05, *p<0.10 *Robustness Test*

We perform robustness tests on whether the baseline results are affected by unobservable. The results in Table 7 imply that even though the coefficient's magnitude is not similar, at least we could maintain the coefficient direction in line with the baseline results. Column (1) applies the district's fiscal independence ratio in the same year as our baseline estimates. The ratio is measured by dividing the district's own revenue by the district's total fiscal transfers. Following column (4), we use the district dependency fiscal ratio, the ratio of district total transfer funds, and total district revenue. Overall, the robustness test results show a similar magnitude and direction to the baseline. Road quality is positively and significantly linked to the fiscal independence ratio at the 5 percent level. The result shows that a 1 percent increase in good quality road' share is associated with a 1.4 percent increase in the fiscal independence ratio. However, the link between road quality and the dependency ratio is insignificant.

Considering a different level of improvement in each road type, we also test the relationship between good quality roads and fiscal decentralization by road type in columns (7) and (8). The estimates show that good quality highways are positively and significantly related to the fiscal decentralization ratio at the 10 percent level. However, the toll road is insignificantly associated with the fiscal decentralization ratio. The insignificant could be because only a few districts have a toll road, which is 234 observations compared to more than 2400 observations, thus increasing the standard errors and lowering the significance power. Then, we estimate the relationship between the fiscal independence ratio and fiscal dependency ratio to road quality by type of roads in columns (2)-(3) and columns (5)-(6). Based on road type, the coefficient is also in line with the baseline estimate, where good-quality highways have a positive and significant association with fiscal independence. Although the

relationship between good-quality highways and the fiscal dependency ratio is insignificant, the direction corresponds to the baseline model.

In Table 8, the study conducts robustness tests by omitting some observations. We omit around 5 percent of observations that have the highest and the lowest value on the share of good quality roads in columns (1)-(3) or on the fiscal decentralization ratio in columns (4)-(6) to absorb the possibility of extreme values. The results indicate comparable coefficients to the baseline, where road quality positively correlates with the fiscal decentralization ratio. Omitting the extreme values of good quality roads in columns (1)-(3) yields a higher coefficient, around 0.7-0.9 percent, and significance power, at the 5 percent level, than the baseline results. On the contrary, omitting the extreme values of the fiscal decentralization ratio in columns (4)-(6) reduces the coefficient and significant level, but the direction still parallels the baseline results. Thus, the model is quite robust.

3.4 Discussion

Our results align with a previous study conducted by Banerjee et al., (2020) and Asher & Novosad, (2020), where the road development has no impact on more remote areas. Infrastructure might benefit the whole economy, hence the regional independence. However, the benefits might be limited in regions with no mobility, such as non-Java regions. The absence of a significant disparity between well-connected (city) and poorly connected areas (county) does not eliminate the possibility that infrastructure benefits all regions. However, limited factor mobility hindered the concentration of those benefits in the more well-connected areas.

Road quality also has a significant impact on Java. The dense population, advanced economic activities, and better integration into national and global markets in Java regions augment the benefit of infrastructure. Well-connected transportation networks and facilities in Java enhance resource distribution, support local industries, and attract investments, enabling regions to become more self-sufficient. In contrast, regions outside Java often lack the critical mass of economic activity and population density needed to fully leverage infrastructure, particularly roads. Weaker integration into national and global markets also reduces the capacity of roads to foster self-reliance in these areas.

The dominant effect in Java regions also might be due to the district characteristics and market structure. Road quality improvement may induce the district's competitiveness in the short term. Initially, developed districts have higher productivity, perhaps due to more advanced technology and human capital than less developed districts, thus making them more competitive than less developed districts. The higher connectivity through road quality improvement will increase their market dominance in their district and spread to the less productive districts. Therefore, the developed regions have higher economic benefits than the less developed regions. However, there is potential for long-term technology and human capital convergence because of better connectivity across districts. The existence of convergence will improve the economic integration and distribution between developed and less developed districts.

Second, the size of roads also matters when assessing the relationship between road improvement and the fiscal decentralization ratio. From Table 2, we see that although the percentage improvement of toll roads outside of Java is more significant than in the Java region, the size or length of the total road is much smaller than in Java's districts. Besides, outside Java, the development of the district highway roads connecting the local activity is limited, only growing around 2.5 percent from 2015 to 2019. As a result, the magnitude is higher in the Java region.

Moreover, despite the benefit of toll roads through connectivity, the pricing system of toll roads also potentially creates economic distractions, such as an increase in consumer prices, reduction of demand for input factors, location changes, and an increase in economic and accessibility inequality (Kleist & Doll, 2005; van Dijk et al., 2015). Those adverse impacts could crowd out the positive ones, causing a longer time and bigger size for the districts outside Java to yield the net benefit of toll roads.

3.5 Implication of the Study

The study found that road quality links to regional fiscal independence in Indonesia. However, road quality alone does not guarantee economic growth and fiscal independence for regions outside Java. The results underscore the need for integrated development approaches that combine infrastructure with investment in other fields, such as boosting local industries and enhancing factor mobility.

The infrastructure investments must consider local socio-economic contexts. In regions outside Java, where agriculture or resource extraction dominates, good quality roads may have limited association unless paired with efforts to diversify local economies and enhance market access. Better roads might reduce transportation costs, but the benefit remains marginal without sufficient demand for goods and services or the capacity to produce high-value products.

Limited factor mobility, such as labor and capital, in areas outside Java further restricts the impact of road improvements. Improve roads may facilitate travel, but if labor markets are not integrated, skilled workers cannot relocate to regions with better infrastructure, limiting economic growth and regional fiscal independence. Without enabling policies to encourage the flow of resources, the economic benefits of infrastructure improvements remain underutilized.

4. CONCLUSION

Numerous studies have highlighted the connection between infrastructure development and economic growth at both local and national levels. However, empirical evidence on the relationship between infrastructure development and local fiscal decentralization is scarce. Local fiscal decentralization is essential since it may determine the local sustainability of public services. The different fiscal relationships between central and local governments across countries could cause limited discussion of local decentralization. Therefore, this study examines the link between road quality and local

fiscal decentralization in Indonesia, which has had an ambitious infrastructure development policy since 2015.

The study uses a panel fixed-effect model to reduce the potential time-invariant unobservable and cluster the standard errors at the county level to handle the possible serial correlation. Empirically, we define road quality as the share of good quality roads to the total roads and describe fiscal decentralization as the ratio of the district's own revenue to the total district revenue. Our results suggest that road quality is positively and significantly associated with the fiscal decentralization ratio. The district with better quality roads experiences a higher fiscal decentralization ratio or less depending on intergovernmental transfers. Further, the relationship is more substantial in Java subsamples, where most districts in that region are more developed than outside Java. The results might contrast the previous study, finding a stronger positive association between road quality and economic development in less developed regions. We argue that varied district characteristics and policies could cause differences in results.

According to the research findings, road quality aligns with fiscal decentralization. However, the various results across districts indicate that road quality improvement is currently more beneficial for districts in the Java region, which generally develop more than districts outside the Java region. The difference could be attributed to varied district characteristics, road development policy, and road size. The results should not discourage people from considering that road development, particularly outside Java, can promote economic activities. Instead, the study suggests that road development should consider other supporting factors, such as the existing economic activities around the construction, social-economy aspects, and supportive policy to strengthen the positive association of road infrastructure development.

Further, the higher relationship between good-quality highways and fiscal decentralization than toll roads might be caused by the road's size and the shorter time effect of highways than toll roads. Especially in the districts outside of the Java region, highway development needs to get sufficient attention besides toll roads. The district highways could connect the district centers, the local activity centers, and the district strategic roads to improve local economic activities. The development of highways around toll roads could also reduce the economy and accessibility inequality due to toll road construction and increase the connectivity within the district's areas, which are expected to increase fiscal decentralization.

However, the research is limited to only five years, while the relationship between road infrastructure improvement and fiscal decentralization might happen over a more extended period. Second, the study does not calculate the transfer from grant and village funds to ensure that the grant and village funds are insignificant to the district's fiscal decentralization. We left the improvement for future research in assessing the impact of infrastructure on local fiscal independence.

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