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Transport Infrastructure, Spatial Spillovers, and Regional Economic Convergence: Evidence from the Balikpapan-Samarinda Toll Road, Indonesia

Revy Fadly Robby Rachmadi[1*], Lilik Sugiharti[2]
[1,2] Airlangga University, Indonesia

** Corresponding Author: revyfadlyrr@gmail.com*

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ABSTRACT

Transport infrastructure is widely recognized as a key driver of regional economic growth. However, empirical evidence remains inconclusive regarding whether newly developed toll roads promote balanced regional development or reinforce existing spatial inequalities. While previous studies have documented the direct economic benefits of transport infrastructure, limited attention has been given to its spatial spillover effects and its role in accelerating regional economic convergence, particularly in resource-dependent regions of emerging economies. This study investigates the economic impacts of the Balikpapan-Samarinda Toll Road, the first intercity toll road developed on Kalimantan Island, Indonesia. Using balanced panel data covering ten regencies and municipalities in East Kalimantan from 2010 to 2024, the study applies the Spatial Durbin Model (SDM) with fixed effects to estimate both direct and indirect spatial effects. Spatial dependence is examined using Global Moran's I and Local Indicators of Spatial Association (LISA), while regional convergence is assessed through sigma convergence and conditional beta convergence analyses. The results reveal significant spatial dependence in regional economic performance in both 2018 and 2024. The Spatial Durbin Model indicates that the toll road generates positive direct effects on regional gross domestic product while simultaneously producing significant positive spatial spillover effects across neighboring regions. Furthermore, the findings suggest that the operation of the toll road contributes to faster conditional economic convergence, indicating that improvements in transport accessibility enhance the economic growth of relatively less developed regions when supported by human capital and structural economic capacity. This study contributes to the literature by integrating spatial spillover analysis and regional convergence within a unified empirical framework. The findings extend the New Economic Geography perspective by demonstrating how strategic transport infrastructure influences regional development in a resource-based economy undergoing institutional transformation

Keywords: Transport Infrastructure; Spatial Durbin Model; Spatial Spillover; Regional Economic Convergence; Toll Road

associated with the development of Indonesia's new national capital. The results also provide important policy implications for designing integrated transport infrastructure investments that maximize regional spillover effects while minimizing spatial inequality.

INTRODUCTION

Transportation infrastructure has long been recognized as one of the fundamental factors driving regional economic development because it is able to reduce transportation costs, increase market accessibility, and strengthen spatial interactions between regions (Baldwin et al., 2011; H. Li et al., 2025). In the perspective of endogenous growth theory, public infrastructure plays a role as productive capital that increases long-term productivity through the ease of mobility of goods, labor, and investment. As the transportation network develops, economic activities become increasingly integrated so that business actors gain benefits in the form of market expansion, supply chain efficiency, and the creation of economies of scale. Therefore, investment in transportation infrastructure is one of the most widely implemented policy instruments to encourage regional economic growth while reducing development gaps (Romer, 1990; Mankiw et al., 1992; Solow, 1956).

However, the economic impact of transportation infrastructure development remains a matter of debate, both theoretically and empirically. *New Economic Perspective Geography* (NEG) explains that increasing accessibility can produce two opposing mechanisms. On the one hand, reducing transportation costs can give rise to *a wider spread of effects* , namely the spread of economic activity to peripheral areas through increased market integration. On the other hand, increased connectivity can also strengthen *backwash effects* , namely the concentration of production, capital, and skilled labor in economic centers that have developed due to the increasingly strong agglomeration economy (Krugman, 1996; Fujita & Ois Thisse, 1996; Varghese & Pradhan, 2025; Yin et al., 2024). Thus, the success of transportation infrastructure in encouraging economic convergence or actually widening regional disparities depends heavily on the balance of these two mechanisms.

Various empirical studies have shown inconsistent results regarding this mechanism. A number of studies in China and several other countries have found that the development of transportation infrastructure produces *spatial spillover positive effects*, where increased connectivity can drive economic growth not only in directly connected areas, but also in surrounding areas (Wang et al., 2020; Yin et al., 2024; Sopiana et al., 2022; Sugiharti, 2014;. Lestari et al., 2025)Conversely, other studies show that infrastructure development can actually increase regional disparities if economic activity becomes increasingly concentrated in established growth centers (Fageda & Olivieri, 2021; ; Karim et al., 2020; Wardana et al., 2025. Dai & Link, 2025)The difference in results indicates that the effectiveness of infrastructure development is not only determined by physical investment alone, but is also

influenced by the regional economic structure, institutional capacity, and spatial interactions between regions.

This issue becomes increasingly relevant in the Indonesian context, where transportation infrastructure development has experienced significant acceleration over the past decade. Despite the rapid expansion of the national toll road network, development remains concentrated on the islands of Java and Sumatra, while Eastern Indonesia has relatively lower levels of connectivity. East Kalimantan Province is an interesting region to study because of its natural resource-based characteristics, its interregional development disparities, and its role as a strategic infrastructure development site following the relocation of the Indonesian capital city (IKN).

The Balikpapan-Samarinda Toll Road is a relevant research object because it is the first intercity toll road built on the island of Kalimantan. The presence of this toll road fundamentally improves regional accessibility by connecting Balikpapan City, Samarinda City, Kutai Kartanegara Regency, and the Indonesian Capital Region. In addition to shortening travel times, the toll road's construction also has the potential to change labor mobility patterns, investment distribution, interconnectedness between industrial sectors, and regional market integration. Therefore, the resulting economic impact is expected to be felt not only by the areas directly traversed by the toll road but also spread to surrounding areas through *spatial mechanisms. spillover* (Li et al., 2017*;* Chen & He, 2015).

Previous research on transportation infrastructure in Indonesia has generally focused on its direct impact on economic growth, investment, and accessibility, using conventional econometric approaches that assume each region is independent. On the other hand, research on regional economic convergence has largely utilized nonspatial panel data regression , thus failing to capture the economic interconnections between regions. Consequently, studies that integrate spatial dependence, *transport-induced spillover The analysis of regional economic effects* and convergence within a comprehensive analytical framework is still very limited. Furthermore, empirical evidence regarding natural resource-based regions undergoing structural transformation, such as East Kalimantan, is also relatively scarce, even though the economic characteristics of these regions allow for different responses to infrastructure development (Lestari et al., 2025).

This research gap highlights the importance of using an analytical approach capable of simultaneously capturing the various mechanisms of influence of transportation infrastructure. Ignoring spatial dependencies can potentially lead to under-identification of economic impacts that spill over into neighboring regions, while excluding convergence analysis will limit understanding of the ability of infrastructure development to reduce development disparities between regions. Therefore, an analytical framework capable of evaluating both the direct and indirect impacts of transportation infrastructure development on regional economic growth is needed.

Based on these conditions, this study aims to analyze the operational impact of the Balikpapan-Samarinda Toll Road on *spatial spillover effect* and regional economic convergence in East Kalimantan Province. Spatial dependence was analyzed using *Global Moran's I and Local Indicators of Spatial Association* (LISA). Next, *Spatial The Durbin Model* (SDM) with fixed effects is used to estimate the direct and indirect effects of toll roads on regional economic growth. Furthermore, *sigma convergence* and *conditional beta convergence analyses* are used to evaluate whether increased transportation accessibility can accelerate the process of economic convergence between districts /cities in East Kalimantan.

This study makes three main contributions to the growing literature. First, it presents empirical evidence on the regional economic impact of the first intercity toll road outside Java using a comprehensive spatial econometric framework . Second, it integrates *spatial estimates Durbin Model* with economic convergence analysis thus allowing simultaneous evaluation of *spatial spillover effects* and dynamics of regional economic growth within a single analytical framework. Third, this study expands the application of *New Economic theory*. *Geography* in a natural resource-based region undergoing institutional transformation due to the development of the Indonesian capital city. Thus, this research not only contributes to the development of theory on the relationship between transportation infrastructure and regional development but also generates policy implications for the government in designing infrastructure investments that can stimulate economic growth while reducing development disparities between regions.

RESEARCH METHODS

This study uses a quantitative approach with an explanatory research design to analyze the operational impact of the Balikpapan-Samarinda Toll Road on *spatial spillover The effect* and regional economic convergence in East Kalimantan Province. A quantitative approach was chosen because the study aims to test the causal relationship between transportation infrastructure development and regional economic growth using a spatial econometric model . This study utilizes secondary data in the form of a balanced panel. *(balanced panel)* consisting of ten districts/cities in East Kalimantan Province during the period 2010–2024, resulting in 150 observations.

The research data were obtained from various official sources, namely the Central Statistics Agency (BPS) of East Kalimantan Province and districts/cities, as well as the Directorate General of Highways of the Ministry of Public Works, and other government publications related to the construction of the Balikpapan-Samarinda Toll Road. The dependent variable in this study is the Gross Regional Domestic Product (GRDP) at constant prices expressed in natural logarithm form (LnGRDP). The independent variables consist of the operational dummy of the Balikpapan-Samarinda Toll Road, Gross Fixed Capital Formation (PMTB) as a proxy for physical capital, Average Years of Schooling (RLS) as a proxy for human capital, the number of employed workers, and the share of the

manufacturing industry sector in GRDP as an indicator of regional economic structure. All continuous variables were transformed into natural logarithm form to reduce heteroscedasticity and facilitate interpretation of model elasticity.

The research analysis was conducted in stages. The first stage aimed to identify the existence of spatial dependencies between regions using Global Moran's I and *Local Moran's I. Indicators of Spatial Association* (LISA). Spatial analysis was conducted in two representative years, namely 2018 as a condition before the Balikpapan-Samarinda Toll Road was fully operational and 2024 as a condition after several years of operation, so that changes in spatial interaction patterns could be observed more clearly. Global Moran's I was used to test the presence of spatial autocorrelation globally, while LISA was used to identify local spatial grouping patterns in the form of *High-High* , *Low-Low* , *High -Low* , and *Low- High clusters*.

The second stage analyzes the influence of the construction of the Balikpapan-Samarinda Toll Road on regional economic growth using *Spatial Durbin Model (SDM) with fixed* effects *effects*). Before the estimation is carried out, the research builds *a spatial weight matrix (spatial weight matrix)* based on *inverse distance* which is then normalized using the *spectral method normalization* . Spatial Selection The Durbin Model is based on its ability to accommodate spatial dependence on both dependent and independent variables, so that this model is able to estimate the direct influence *(direct effects),* indirect influence *(indirect effects* or *spatial spillover effects),* as well as the total influence *(total effects)* of toll road operations on regional economic growth. Furthermore, the use of fixed effects was chosen based on the results of model specification tests, which showed that the characteristics of each district/city correlated with the independent variables, resulting in more consistent estimates.

The third stage analyzes regional economic convergence using two approaches, namely *sigma convergence* and *conditional beta convergence* . Sigma convergence is used to evaluate changes in the level of GRDP dispersion between regions during the observation period through the development of the standard deviation of the GRDP logarithm. A decrease in the dispersion value indicates a tendency for a decrease in regional economic disparities. Furthermore, *conditional beta convergence* is used to test whether regions with lower initial GRDP levels are able to grow faster than regions that have developed after taking into account differences in structural characteristics such as physical capital, human capital, labor, industrial structure, and the existence of the Balikpapan-Samarinda Toll Road. A negative and significant beta coefficient indicates the occurrence of regional economic convergence.

The entire data processing process is carried out using several software tools according to the characteristics of the analysis. GeoDa is used to calculate Global Moran's I, construct the LISA *Cluster Map*, and identify spatial autocorrelation patterns . Next, the *Spatial Durbin Model, direct and indirect analysis effects*, and *conditional beta convergence testing* were conducted using Stata, while initial data processing and database preparation were conducted using Microsoft Excel.

Through these analysis stages, this study not only identifies the existence of spatial dependency between regions, but also evaluates how the construction of the Balikpapan-Samarinda Toll Road influences economic growth directly and through *spatial mechanisms. spillover* , as well as testing whether increasing transportation connectivity can accelerate the process of regional economic convergence in East Kalimantan Province.

RESULTS AND DISCUSSION

1. Descriptive Statistics

Table 1.1 1Statistics of Research Variables

Variables	Obs	Mean	Std. Dev.	Min	Max
GRDP (Billion Rp)	150	46,439.59	37,980.38	1,145.03	143,009.80
PMTB (Billion Rp)	150	12,404.78	11,833.39	219.30	51,543.50
Average Length of Schooling (Years)	150	9.00	1.15	6.86	10.99
Labor (Souls)	150	157,651.70	116,370.30	12,647	409,833
Added Value of the Processing Industry (Billion IDR)	150	9,402.78	15,698.96	8.53	54,532.52
Share of GRDP (%)	150	18.26	26.91	0.58	88.69
Dummy Toll Road	150	0.26	0.44	0	1
Longitude	150	116.56	0.68	115.31	117.47
Latitude	150	-0.14	1.03	-1.69	1.78

Based on Table 4.1, the average value *of Ln GRDP* is 10.227 with a range of 7.043 to 11.871 indicating a significant difference in the level of economic activity between regencies /cities in East Kalimantan Province. The variable *Ln PMTB* has an average of 8.846, while the average length of schooling (RLS) reaches 9.004 years, indicating that physical investment and human capital are important characteristics in regional economic development. Meanwhile, *Ln Labor* has an average of 11.630 and *the share* of the processing industry to GRDP is 18.255 percent, reflecting variations in workforce capacity and economic structure between regions. The average value of the toll road dummy variable is 0.26 indicating that approximately 26 percent of observations are in the period after the toll road began operating. Overall, the relatively high standard deviations in the GRDP, PMTB, and *share of* the processing industry variables indicate heterogeneity in economic characteristics between districts /cities during the observation period 2010–2024.

2. Spatial Dependence Analysis

Spatial dependency analysis was conducted to answer the first research objective, namely to identify whether economic activities between districts /cities in East Kalimantan Province show spatial dependency patterns before and after the operation of the Balikpapan-Samarinda Toll Road. Testing was conducted using Global Moran's I , Moran Scatterplot , and Local Indicators of Spatial Association (LISA) in 2018 as the period before the toll road is fully operational and 2024 as the period after the toll road is operational.

The results of the Global Moran's I indicate that there is no significant global spatial autocorrelation in both observation periods. The Moran's I value of -0.065 in 2018 (p = 0.402) and -0.047 in 2024 (p = 0.382) indicates that the distribution of GRDP between

districts /cities in East Kalimantan does not form a global spatial clustering pattern. Thus, regions with high GRDP levels are not systematically surrounded by regions with high GRDP levels, nor do regions with low GRDP levels form significant economic clusters.

a. 2018 b. 2024

Figure 1 Moran Scatterplot 2018 & 2024

Figure 1.1 shows Moran Scatterplots from 2018 and 2024 reinforce these results. In both periods, the regression line has a very gentle negative slope, and most observations are scattered around the central point without forming a clear pattern. The distribution of points across the four quadrants indicates that spatial relationships between regions are relatively weak, thus showing no indication of significant global spatial autocorrelation .

a. 2018 b. 2024

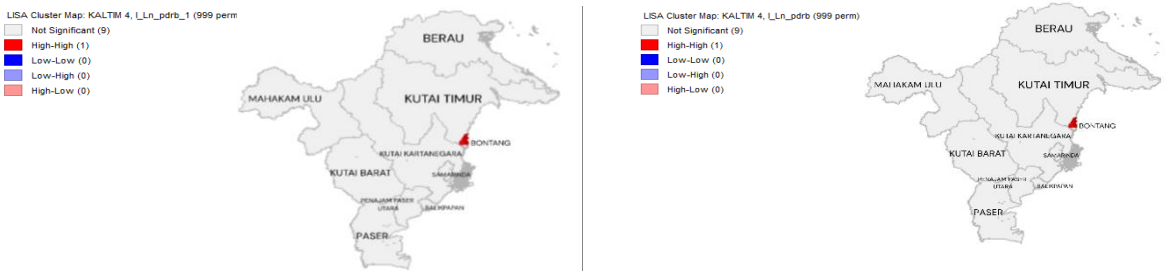

Figure 2 LISA *Cluster Map* 2018 & 2024

Figure 1.2 presents the results of the LISA *Cluster Map* for 2018 & 2024 to identify spatial patterns at the local level. In contrast to the results of Global Moran's I, the LISA analysis shows the presence of one significant High-High cluster , namely Bontang City, in both 2018 and 2024. Meanwhile, the other nine districts/cities are in the Not Significant category , thus not forming a strong local spatial clustering pattern. This finding indicates that although there is no spatial dependence at the global level, there is a concentration of economic activity in certain regions that act as local growth centers.

A comparison between the two periods shows that the operation of the Balikpapan-Samarinda Toll Road has not changed the structure of spatial economic dependence in East Kalimantan Province. The Global Moran's I value remains negative and insignificant, while the local cluster pattern is also relatively unchanged, with Bontang City remaining the only region included in the *High-High category* . This condition indicates that the distribution of regional economic activity is still more influenced by the internal characteristics of the region,

especially the dominance of the extractive sector, rather than by geographic proximity or improved transportation connectivity.

The findings of this study differ from several studies in China that reported positive global spatial autocorrelation following transportation infrastructure development, resulting in increased accessibility that could lead to stronger economic growth clusters. This difference is thought to be due to East Kalimantan's economic structure, which is still dominated by natural resource-based sectors with *enclave characteristics. economy* , so the benefits of infrastructure development have not fully created economic linkages between regions. However, these results do not indicate that spatial dependence does not exist at all. *Spatial Estimates The Durbin Model* in the next section actually shows significant spatial parameters, which indicate that economic interactions between regions are more reflected through *spatial mechanisms. spillover* rather than through global spatial clustering. Thus, the first research objective was successfully answered through a combination of Global Moran's I analysis, Moran Scatterplot , and LISA which show the absence of global spatial autocorrelation , but there are indications of spatial interactions at the local level and through spatial econometric mechanisms .

3. *Spatial* Estimation *Durbin Model* (SDM)

To analyze the operational impact of the Balikpapan-Samarinda Toll Road on regional economic growth by considering spatial interactions between districts /cities, this study uses *Spatial Durbin Model* (SDM) with a *fixed approach effects* . The selection of this model is based on the results of the Hausman test which shows that the specific characteristics of each region are correlated with the independent variables so that the *fixed model effects* provide more consistent estimates than *random models. effects* . *Spatial* estimation results *The Durbin Model* is presented in Table 1.2

Table 1.2 2Estimation Results Durbin Model (SDM)

VARIABLES	Coefficient	p-value
Direct Effects (Direct Effects) Effect)		
Dummy Toll	0.0678	0.200
Ln PMTB	0.3953	0.000***
Ln RLS	0.1065	0.001***
Ln Labor	-0.0429	0.506
Industry Share	-0.0082	0.093*
Spatial Effect of Independent Variable (Wx)		
W × Dummy Toll	-0.1538	0.009***
W × Ln PMTB	0.0426	0.787
W × Ln RLS	0.0835	0.101
W × Ln Labor	0.2778	0.156
W × Industry Share	-0.0700	0.000***
Spatial Dependent Lag (ρ)	-0.7255	0.000***
Log Likelihood	181,418	
Pseudo R^2	0.6735	
Wald Spatial Test	40.10	0.0000***

Based on Table 1.2, the operational dummy variable for the Balikpapan-Samarinda Toll Road has a positive coefficient of 0.0678, but is not statistically significant (p = 0.200). This indicates that toll road operations have not had a significant direct impact on regional

economic growth after controlling for physical capital, human capital, labor, industrial structure, and spatial interactions. This finding indicates that the economic benefits of toll roads require time and the support of other structural factors, especially investment and human resource quality.

The Gross Fixed Capital Formation (GFCF) variable has a positive and significant effect with a coefficient of 0.3953 ($p < 0.001$), indicating that physical investment is the main factor driving regional economic growth. This finding aligns with the neoclassical growth theories of Solow (1956) and Mankiw. et al. (1992) who placed capital accumulation as the main determinant of economic growth.

The Average Years of Schooling (ALS) variable also has a positive and significant effect ($\beta = 0.1065$; $p = 0.001$), indicating the importance of human capital in increasing productivity and economic growth. These results support the Endogenous Theory. Growth, as proposed by Romer (1990) and Lucas (1988), states that improving the quality of education can strengthen long-term economic growth.

In contrast, the labor force variable has a negative and insignificant coefficient ($\beta = -0.0429$; $p = 0.506$), indicating that increasing the labor force has not significantly driven economic growth. This indicates that labor quality plays a greater role than quantity, especially in regions still dominated by the mining sector.

share of the manufacturing industry variable shows a negative coefficient of -0.0082 and is significant at the 10 percent level ($p = 0.093$). This result indicates that the increase in the proportion of the manufacturing industry has not yet made a positive contribution to regional economic growth. This condition reflects that East Kalimantan's economic structure is still dominated by natural resource-based sectors, thus the role of the manufacturing industry has not yet developed optimally.

In the spatial aspect, the *Spatial parameters Lag Dependent* (ρ) has a value of -0.7255 and is significant ($p < 0.001$). This negative coefficient indicates the existence of competitive spatial interactions . *spatial interaction*), where an increase in economic activity in a region tends to be followed by a decrease in economic activity in the surrounding areas. This finding indicates that the benefits of toll road development are still concentrated in growth centers, thus reflecting more of *a backwash. effect* compared to *spread effect* . This result is in line with the *New Economic perspective Geography* , which states that infrastructure development does not always result in equality if it is not supported by an integrated economic structure.

In addition, *Wald Spatial A* significant *test ($p < 0.001$) confirms that Spatial The Durbin Model* is more appropriate than conventional panel regression because it captures spatial interactions between regions. A pseudo-R^2 value of 0.6735 indicates that the model can explain 67.35 percent of the variation in regional economic growth.

Overall, the estimation results indicate that regional economic growth in East Kalimantan is more influenced by physical investment and human capital quality than by direct toll road operations. Furthermore, the significance of spatial parameters indicates competitive economic interactions between regions. Thus, the second research objective was successfully addressed through *Spatial Durbin Model* , which is able to identify direct influences and spatial relationships that cannot be captured by conventional panel regression models.

4. *Direct, Indirect,* and *Total Effects*

To obtain a more comprehensive understanding of the impact of the Balikpapan-Samarinda Toll Road construction, this study not only interprets the coefficients of the *Spatial estimation results Durbin Model* , but also analyzes the direct effects (*direct effect*), indirect effect (*indirect effect* or *spillover effect*), and total effect . *This* effect decomposition is important because changes in a variable in one region not only affect that region but can also impact other regions through spatial interactions. The results of the effect decomposition are presented in Table 1.3.

Table 1.3 3of HR Effects

Variables	Direct Effect	p-value	Indirect Effect (Spillover)	p-value	Total Effect	p-value
Dummy Toll	0.0847	0.163	-0.1290	0.033**	-0.0443	0.001***
Ln PMTB	0.4155	0.000***	-0.1551	0.064*	0.2604	0.001***
Ln RLS	0.1060	0.003***	0.0040	0.919	0.1099	0.000***
Ln Labor	-0.0685	0.343	0.1962	0.144	0.1277	0.248
Industry Share	-0.0028	0.577	-0.0407	0.000***	-0.0435	0.000***

The estimation results in Table 1.3 show that the operation of the Balikpapan-Samarinda Toll Road has a positive direct effect, but it is not statistically significant (β = 0.0847; p = 0.163). Conversely, the indirect effect shows a negative and significant value (β = -0.1290; p = 0.033), resulting in a negative total effect (β = -0.0443; p = 0.001). This finding indicates that the benefits of toll road construction have not been able to directly increase economic growth in the areas through which it passes, but instead have had a negative impact on the surrounding areas. This condition indicates that increased accessibility is more likely to encourage the shift of economic activity towards growth centers than to create equitable growth between regions. Thus, the construction of the Balikpapan-Samarinda Toll Road is more a reflection of backwash. effect compared to *spread effect*, as explained in *the New Economic perspective Geography*.

The Gross Fixed Capital Formation (GFCF) variable shows a positive and significant direct effect (β = 0.4155; p < 0.001), while the indirect effect is negative and significant at the 10 percent level (β = -0.1551; p = 0.064). However, the total effect remains positive and significant (β = 0.2604; p < 0.001). These results indicate that physical investment primarily benefits the region where the investment is made, but at the same time has the potential to attract economic resources from surrounding areas. In other words, physical investment has not yet fully generated an even distribution of benefits, but still tends to strengthen the concentration of economic activity in certain regions.

In contrast to physical capital, Mean Years of Schooling (RLS) showed a positive and significant direct effect (β = 0.1060; p = 0.003), while the spillover effect was insignificant (β = 0.0040; p = 0.919). This finding suggests that improving the quality of human capital primarily increases productivity within the region itself without having a significant impact on neighboring regions. Thus, the benefits of education are still local and have not yet resulted in a process of knowledge diffusion. strong *spillover)* between districts/cities in East Kalimantan.

Meanwhile, the share of the manufacturing industry did not show a significant direct effect (β = -0.0028; p = 0.577), but produced a negative and significant indirect effect (β = -0.0407; $p < 0.001$) and a negative and significant total effect (β = -0.0435; $p < 0.001$). These results indicate that increased industrial activity in a region actually puts pressure on the economic growth of the surrounding regions. This phenomenon reflects the continued strong concentration of economic activity in certain areas so that the benefits of industrialization have not been distributed evenly. This condition is in line with the characteristics of the East Kalimantan economy, which is still dominated by natural resource-based sectors, so that increased industrial activity has not been able to produce strong inter-regional linkages.

Overall, the results of the effect decomposition indicate that the economic spillover mechanism in East Kalimantan is still dominated by negative spillovers . Although physical investment and improvements in human resource quality can boost economic growth in their respective regions, these benefits have not been optimally distributed to surrounding areas. Conversely, the construction of the Balikpapan-Samarinda Toll Road and the existing industrial structure tend to reinforce the concentration of economic activity in growth centers, resulting in backwash. effect that is more dominant than *spread effect* . This finding differs from various studies in China that show that transportation infrastructure development generates positive *spillovers* between regions. This difference indicates that the impact of infrastructure development is strongly influenced by the characteristics of the economic structure, the level of industrial diversification, and the region's capacity to capitalize on increased accessibility.

The results of this study indicate that transportation infrastructure development alone is not sufficient to create equitable regional economic growth. Therefore, toll road construction needs to be accompanied by industrial estate development, improved human resource quality, and strengthened connectivity to hinterland areas so that the benefits of infrastructure development can be more widely distributed and encourage the formation of *a spread of wealth*. stronger *effect*.

5. Economic Convergence

5.1 Sigma Convergence

To evaluate changes in the level of economic disparity between districts /cities in East Kalimantan Province, this study uses the Sigma Convergence approach, measured by the development of the standard deviation of the logarithm of GRDP during the period 2010–2024. The results of the analysis are presented in Figure 1.3 below.

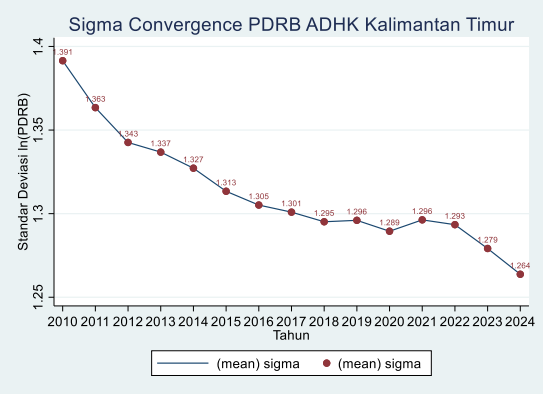

Figure 3*Sigma Convergence* Graph of East Kalimantan's GRDP ADHK, 2010–2024

Based on Figure 1.3, the standard deviation value of LnGRDP shows a downward trend, from 1.391 in 2010 to 1.264 in 2024. Although there was a slight increase in 2019 and 2021, the long-term trend continues to show a decrease in the level of regional income dispersion. This finding indicates the presence of sigma convergence (σ- convergence), which means that the gap in GRDP levels between districts /cities in East Kalimantan is narrowing during the observation period.

However, *sigma convergence* only indicates a downward trend in economic disparity and cannot explain whether regions with lower initial income levels actually grow faster than more developed regions. Therefore, the analysis continued using conditional beta convergence to test the mechanism of economic convergence and identify the influence of the structural and operational characteristics of the Balikpapan-Samarinda Toll Road on the regional convergence process.

5.2 Beta Convergence

Table 1.4 4Convergence Estimation Results

VARIABLES	2010–2020 (Before Toll Road)	2021–2024 (After Toll Road)
Initial GRDP	-0.0087 (0.632)	-0.1055 (0.000)***
Ln PMTB	-0.0119 (0.655)	0.1783 (0.000)***
RLS	-0.0376 (0.002)***	-0.0084 (0.745)
Ln Labor	0.0461 (0.091)*	-0.0826 (0.109)
Industry Share	0.0006 (0.251)	0.0010 (0.246)
Observation	100	40
Wald Chi²	15.54	49.85
Prob > Chi²	0.0083	0.0000

the conditional beta convergence estimation are presented in Table 1.4. In the period before the Balikpapan-Samarinda Toll Road was operational (2010–2020), the initial GRDP coefficient was negative but not significant (β = -0.0087; p = 0.632). This result indicates that there was no economic convergence process between districts /cities, so that regions with lower initial GRDP levels were not able to grow faster than regions that had developed.

In contrast, in the period after the toll road began operating (2021–2024), the initial GRDP coefficient became negative and significant (β = -0.1055; p < 0.001). This finding indicates that regions with relatively low initial income levels experienced faster economic growth than regions with higher initial income levels. Therefore, the study results indicate

that the operation of the Balikpapan-Samarinda Toll Road contributed to accelerating the process of regional economic convergence in East Kalimantan.

The findings show that increasing connectivity through the construction of toll roads not only facilitates the mobility of goods, services and production factors, but also increases the opportunities for relatively underdeveloped regions to catch up economically (*catching up)* . *process*). These results are in line with the convergence theory proposed by Barro and Sala-i-Martin (1992), which states that regions with lower initial income levels have the potential to grow faster when supported by increased accessibility and production factors. Compared to the period before the toll road was operational, these results indicate that strategic infrastructure development can accelerate the process of equitable regional economic growth in East Kalimantan.

Overall, *the sigma results convergence* and *conditional beta Convergence* provides complementary evidence. Sigma analysis indicates that interregional economic disparities tended to decrease during the observation period, while beta analysis confirmed that the process of decreasing disparities intensified after the operation of the Balikpapan-Samarinda Toll Road. Thus, the third research objective was successfully answered, namely that toll road construction contributes to accelerating regional economic convergence, although the previous section found that the benefits were still dominated by competitive spillovers.

CONCLUSION AND SUGGESTIONS

Conclusion

This study aims to analyze the operational impact of the Balikpapan-Samarinda Toll Road on *spillover*. *effect* and regional economic convergence in East Kalimantan Province using a *Spatial approach Durbin Model* (SDM **)** , spatial dependency analysis, and economic convergence. In general, the research results show that toll road construction has influenced the dynamics of regional economic growth, although the mechanism of influence does not fully align with expectations of equitable development.

First, the results analysis Global Moran's I **,** Moran Scatterplot , and LISA show that No there is autocorrelation significant global spatial Good before and after operational road toll road . Although Thus , the analysis local identify existence concentration activity economy in a particular region , which shows that interaction the economy in East Kalimantan is more nature local than form cluster spatial in a way comprehensive .

Second, the results estimate *Spatial Durbin Model* show that investment physical and human capital is factor the main driving force growth regional economy . On the other hand , the operation of the Balikpapan- Samarinda Toll Road Not yet give influence significant direct to growth the economy of the area through which it passes. However, the results decomposition effect show existence *spillover* **r** significant negative, so that benefit development road toll tend concentrated in centers growth and not yet spread in a way evenly to the surrounding area. Findings This indicates that development infrastructure transportation Still dominated by mechanisms *backwash effect* compared to *spread effect*.

Third , the results analysis convergence show that disparity economy between districts / cities in East Kalimantan tends to decrease during period research . In addition, conditional

beta convergence show that convergence economy new happen after operational of the Balikpapan- Samarinda Toll Road, which indicates that improvement connectivity transportation contribute in speed up the process of *catching up* in areas that have level income beginning more low.

In a way theoretical, research This expand implementation *New Economic Geography* on regional based source Power natural with show that development infrastructure transportation No always produce distribution benefit economy in a way automatic. Interaction spatial formation precisely can strengthen concentration activity economy if No followed by readiness structure regional economy. In addition, research This show that integration *Spatial Durbin Model* with analysis convergence give greater understanding comprehensive about impact development infrastructure compared to approach econometrics conventional.

From the side policy , results study indicates that development road toll need integrated with policy development area industry , improvement quality source Power humans , as well as strengthening connectivity towards the hinterland area for the benefits economy No only concentrated in the corridor main, but also capable push equality growth economy interregional.

Suggestion

Based on the research findings, the government needs to integrate transportation infrastructure development with regional economic development policies to ensure more equitable distribution of development benefits. Developing industrial areas outside the main corridors, increasing productive investment, strengthening human resource quality, and building a network of connecting roads to the hinterland are crucial steps to reduce *backwash. effect* and strengthen *the spread inter-regional effects*.

For future research, it is recommended to expand the analysis by including a longer observation period after the Balikpapan-Samarinda Toll Road's operation, so that the long-term impact on regional economic transformation can be evaluated more comprehensively. Furthermore, further research could integrate social, environmental, and sectoral investment indicators, and compare the Balikpapan-Samarinda Toll Road corridor with other strategic infrastructure corridors in Indonesia to gain a broader understanding of the effectiveness of infrastructure development in driving regional economic growth and equity.

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