

Solihin, Achmad et al.

## Article

# Infrastructure provision and economic growth: evidence from the longest bridge construction in Indonesia

Cogent Economics & Finance

## Provided in Cooperation with:

Taylor & Francis Group

*Suggested Citation:* Solihin, Achmad et al. (2024) : Infrastructure provision and economic growth: evidence from the longest bridge construction in Indonesia, Cogent Economics & Finance, ISSN 2332-2039, Taylor & Francis, Abingdon, Vol. 12, Iss. 1, pp. 1-19, <https://doi.org/10.1080/23322039.2024.2421887>

This Version is available at:

<https://hdl.handle.net/10419/321648>

### Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

### Terms of use:

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by/4.0/>

# Infrastructure provision and economic growth: evidence from the longest bridge construction in Indonesia

Achmad Solihin, Wahyu Wisnu Wardana, Iqram Ramadhan Jamil, Unggul Heriqbaldi, Nguyen Thi Thuy Ngan, Widya Sylviana & Nurul Istifadah

To cite this article: Achmad Solihin, Wahyu Wisnu Wardana, Iqram Ramadhan Jamil, Unggul Heriqbaldi, Nguyen Thi Thuy Ngan, Widya Sylviana & Nurul Istifadah (2024) Infrastructure provision and economic growth: evidence from the longest bridge construction in Indonesia, Cogent Economics & Finance, 12:1, 2421887, DOI: [10.1080/23322039.2024.2421887](https://doi.org/10.1080/23322039.2024.2421887)

To link to this article: <https://doi.org/10.1080/23322039.2024.2421887>



© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



Published online: 06 Nov 2024.



Submit your article to this journal [↗](#)



Article views: 1097



View related articles [↗](#)










View Crossmark data [↗](#)



Citing articles: 1 View citing articles [↗](#)

# Infrastructure provision and economic growth: evidence from the longest bridge construction in Indonesia

Achmad Solihin<sup>a</sup> , Wahyu Wisnu Wardana<sup>a,b</sup> , Iqram Ramadhan Jamil<sup>b,c</sup> ,  
Unggul Heriqbal<sup>a</sup> , Nguyen Thi Thuy Ngan<sup>d</sup> , Widya Sylviana<sup>a</sup>  and Nurul Istifadah<sup>a</sup> 

<sup>a</sup>Department of Economics, Universitas Airlangga, Surabaya, Indonesia; <sup>b</sup>Research Institute of Socio-Economic Development (RISED), Surabaya, Indonesia; <sup>c</sup>Department of Economics, Universitas Padjadjaran, Bandung, Indonesia; <sup>d</sup>School of Economics, Can Tho University, Can Tho City, Vietnam

## ABSTRACT

The construction of the Suramadu bridge, the longest bridge in Indonesia connecting the islands of Java and Madura, aimed to stimulate regional economic growth in Madura and reduce disparity. However, 13 years after the construction, significant economic progress in Madura has yet to be seen. This study examines the impact of the bridge construction on the economic growth of Bangkalan, a Madura Island district closest to the bridge from 2010 to 2017. This study employed the synthetic control method (SCM) to construct a synthetic control unit that mimics Bangkalan's economic growth trajectory in the absence of the Suramadu bridge. The SCM allows for comparison of Bangkalan's economic growth trajectory with its synthetic control unit post the Suramadu bridge operation. The finding indicates that the Suramadu bridge provision lower the economic growth in Bangkalan. The finding underscores the imperative for careful infrastructure planning to yield optimal returns. Moreover, it advocates for a holistic approach wherein hard infrastructure initiatives are complemented by investments in soft infrastructure, particularly in education and healthcare sectors. Such integrated strategies are essential for realizing the full potential of infrastructure projects in driving sustainable economic growth.

## IMPACT STATEMENT

This study examines the causal impact of infrastructure provision on regional economic growth in Indonesia. This research question is crucial for many developing countries like Indonesia, where public infrastructure is primarily funded through aid and public debt. The analysis indicates that infrastructure provision has, in fact, led to lower economic growth, challenging many previous studies that identify a positive impact of infrastructure development. This finding underscores the importance of effective infrastructure planning and suggests the necessity of complementary public investments to fully realize the potential benefits of infrastructure provision.

## ARTICLE HISTORY

Received 25 January 2024  
Revised 13 August 2024  
Accepted 22 October 2024

## KEYWORDS

Infrastructure provision;  
regional infrastructure;  
economic growth; impact  
evaluation; synthetic control  
method

## SUBJECTS

Economics; Development  
Studies; Development  
Policy; Economics and  
Development; Regional  
Development

## 1. Introduction

The Government of Indonesia (GoI) perceives infrastructure provision as a catalyst for economic growth and development (Damuri et al., 2019). The construction of transportation infrastructure, for example, will connect and integrate regions across the archipelago (Berawi et al., 2020), hence facilitating the movement of people and goods, promoting productive economic activities, and lowering regional disparities (Achour & Belloumi, 2016; Negara, 2016; Polyzos & Tsiotas, 2020). The GoI has allocated significant resources to physical infrastructure development in the past 5 years, from IDR 256.1 trillion in 2015 to IDR 399.7 trillion in 2019 (Ministry of Finance, 2019).

One of the vital infrastructure projects is the Surabaya-Madura (Suramadu) bridge, connecting Bangkalan District in Madura and Surabaya, the capital city of East Java, which was constructed in

**CONTACT** Achmad Solihin  [achmad-solihin@feb.unair.ac.id](mailto:achmad-solihin@feb.unair.ac.id)

© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group  
This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

August 2003 and officiated in June 2009. Suramadu spans 5.4 km (3.4 miles), making it the longest bridge in Indonesia. The construction was expected to improve connectivity and commute between Surabaya and Madura (Delphine et al., 2022), which used to be ineffective as it relied on ferries with frequent delays and long waiting hours (Hong et al., 2022). With better mobility, the bridge is also expected to decrease development gaps between Madura and the surrounding areas, especially Surabaya (Faoziyah, 2016). Before the bridge construction, the economic growth of Bangkalan was about 4% (2004), lower than Surabaya's growth, which stood at 6% (Statistics Indonesia, 2022a). This number was estimated to rise after the bridge construction.

However, what Madura has been facing is perpetual stagnancy instead. The regional gaps between districts in Madura and other districts in East Java, especially Surabaya, have not declined since the bridge was opened to the public 13 years ago. For instance, the economic growth of Bangkalan and Sampang in 2019 was 1.03% and 1.85%, respectively. In the same year, the growth in Surabaya remained high, at 6.09% (Statistics Indonesia, 2022b). Likewise, the poverty rate of Bangkalan in 2019 reached almost 19%, while the rate in Surabaya was only 4.51% (Statistics Indonesia, 2022c). Additionally, while the Human Development Index (HDI) of East Java reached 73.38 points in 2023, Bangkalan's HDI for the same year stood at 65.75 points, positioning it as the second-lowest region in East Java in terms of HDI (Statistics Indonesia, 2023). The empirical data present counterintuitive results, warranting further investigation.

On the empirical front, evidence of the infrastructure impact on development indicators remains inconclusive (Crescenzi et al., 2016; Khan et al., 2020). Prior works by Arbués et al. (2015), Khan et al. (2020), Saidi et al. (2018), Chin et al. (2021), and Zhang et al. (2021) found that infrastructure provision led to higher economic growth. By contrast, previous research by Crescenzi and Rodríguez-Pose (2012), Crescenzi et al. (2016), and Wang et al. (2020) claimed that the role of infrastructure provision on economic growth was insignificant. Elburz et al. (2017) argued that the conflicting findings of the economic return of infrastructure provision could be attributed to the research methodology employed in the analysis.

Early studies that exploring the impact of infrastructure provision on growth (see Aschauer (1989); Cook and Munnell (1990); Morrison and Schwartz (1996)) often employed standard models that might suffer from methodological flaws such as endogeneity and reverse causality problem (Timilsina et al., 2024). Further research on this topic is expanded to fix the methodological problem by using alternative methodology such as Generalized Method of Moment (GMM) and Pooled Mean Group (PMG) estimator (see Calderón and Servén (2010); Arbués et al. (2015), Kodongo and Ojah (2016), Crescenzi et al., (2016), Chakamera and Alagidede (2018); Ke et al., (2020); Rehman et al., (2020), Khan et al., (2020)). Nevertheless, Timilsina et al. (2024) argued that the employment of GMM and PMG might suffer from the problem of weak validity of internal instrument and exogeneity. Furthermore, current research on this topic is expanding by the employment of impact evaluation methods (See: Lai (2020); Kong et al., (2022), Chen (2023)). The method aims to construct a counterfactual to estimate particular impact of specific treatment or policy.

A past study by Hasul and Jayanti (2019) specifically examined the causal impact of the Suramadu bridge construction on socioeconomic development indicators using impact evaluation method, i.e. difference-in-difference (DiD). The study concludes that the bridge construction amplifies the centrifugal effect, i.e. driving the movement of production inputs from the core district (the capital city Surabaya) to the periphery districts in Madura, narrowing the regional development gaps. However, it is noteworthy that the study positions Surabaya as the control group in the analysis. It seems unrealistic to assume that the socioeconomic trends in Surabaya and districts in Madura were similar before the bridge construction. This indicates that the assumption of parallel time trend, the most fundamental assumption in the DiD analysis, is unsatisfied. As argued by Heersink and Peterson (2016), Barati and Adams (2019), and Roth et al. (2023), the violation of the parallel time trend assumption produces biased estimates.

This research aims to re-examine the impact of the Suramadu bridge construction on economic growth in Bangkalan, the closest district to the bridge on the Madura Island side. We chose this sample based on the assumption that the bridge's potential benefits would be most significant for the region closest to it. This study contributes to the literature on infrastructure provision in Indonesia by employing an alternative methodology, specifically an impact evaluation approach. We use the synthetic control method (SCM), proposed by Abadie et al. (2010), to estimate the causal impact of the bridge

construction more reliably. This method relaxes the assumption of a parallel time trend, which previous research could not address, and resolves the problem of simultaneity bias in the model (Newiak & Willems, 2017). Our findings indicate that the Suramadu bridge's infrastructure provision reduced the economic growth of Bangkalan. This finding enriches the debates on the economic impact of infrastructure provision on developing countries. The research also has crucial policy implications, advocating for careful infrastructure planning to yield optimal returns, stimulating the integrated regional development coordination, and promoting a holistic approach where hard infrastructure initiatives are complemented by investments in soft infrastructure. For many governments in developing countries like Indonesia, the questions whether the investment in infrastructure provisions reach the main objectives is crucial due to the financial constraints, making it relevant to evaluate the impact of the infrastructure provision on economic growth.

The remaining sections are organized as follows. Section two presents the literature review. The third section elaborates on the data and methodology. The fourth section presents and discusses the findings. The last section concludes the study.

## 2. Literature review

### 2.1. Theoretical framework

Theoretical framework for macro-level analysis of infrastructure provision and economic growth nexus generally divided into two main ways: direct and nondirect impact. The direct impact of infrastructure on economic primarily originated from Solow's (1956) neo-classical growth theory where output or Gross Domestic Product (GDP) is the function of capital, labor, and factor productivity (Zhang and Cheng, 2023; Timilsina et al., 2024). Particularly, many researchers model the functional relationship between the output and inputs following Cobb-Douglass production function (Holmgren and Merkel, 2017), as follows:

$$Y = A.K^{\alpha}.L^{\beta} \quad (1)$$

where Y is GDP, K denotes capital, L represents labor, and A shows factor productivity. A seminal work by Aschauer (1989) introduced the role of infrastructure in the growth equation by dividing capital into two: public capital and private capital as shown in the equation below:

$$Y = A.(K_{private})^{\alpha_1}.(K_{public})^{\alpha_2}.L^{\beta} \quad (2)$$

In this scenario, public capital ( $K_{public}$ ), which includes infrastructure, is regarded as an essential component in the production process. It is presumed to directly influence production levels with an elasticity coefficient of  $\alpha^2$ . Public capital can be categorized into various types, such as different forms of infrastructure. Aschauer (1989) classifies public capital into military capital, core infrastructure (such as highways, public transportation systems, airports), and other nonmilitary capital (Holmgren and Merkel, 2017).

Alternatively, some researchers model the link between infrastructure and economic growth through the role of factor productivity (A). It is argued that better access to infrastructure improves both capital and labor productivity. For instance, enhanced infrastructure might lead to a higher geographical concentration of firms (Holl, 2004), thereby increasing the likelihood of knowledge exchange among them, ultimately resulting in higher productivity (Malmberg and Power, 2005). Banister and Berechman (2003) explained that agglomeration is a benefit a firm gains due to its spatial proximity with other firms. The development of transportation infrastructure improves accessibility, which in turn enhances agglomeration because economic actors, i.e. firms, can access local public facilities and information, as well as share input factors because they are spatially close thanks to transportation infrastructure (Bilgili & Magazzino, 2022; Magazzino & Maltese, 2021). Additionally, firms' agglomeration may create a concentration of skilled labor, leading to more efficient labor market matching. As labor with similar skills and experience concentrates, firms can more easily hire better-qualified workers, resulting in higher labor productivity (Holmgren and Merkel, 2017).

## 2.2. Previous studies

A pioneer work by Aschauer (1989) provided a theoretical framework for the relationship between infrastructure investment and economic returns. The findings showed that core infrastructure (including transportation, e.g. highways, mass transit, and airports) significantly impacted economic growth and productivity. Aschauer (1989) believed that regions with well-developed public infrastructure tend to see an increase in private sector activities, which impacts productivity and labor costs (Crescenzi & Rodríguez-Pose, 2012). In other words, the provision of public infrastructure is key to the regional level of development. Public infrastructure development is considered a predictor of varying development levels across regions.

There are numerous empirical studies that analyze the impact of transport infrastructure provision on the economic growth (see Table 1). These previous studies, indeed, enrich the literatures on transport-led growth by provide scientific evidence within the issue. In general, their findings tend to agree that transport infrastructure provision promotes economic growth in various research settings. Based on the theoretical framework and previous studies, this research hypothesizes that the provision of Suramadu bridge improves Bangkalan's economic growth.

Nevertheless, despite these various attempts, however, previous research utilized prior tools that relatively sensitive to common econometrics problems. Meanwhile, the impact evaluation technique (i.e. synthetical control methods), which considered to be more robust tool is still underutilized in this topic. Therefore, the present study could offer a potential expansion on literature frontier by employing a reliable model (SCM) in analyzing the transport infrastructure impact on growth. Subsequently, with our research setting, we could also provide an evidence of the implication rural-urban connectivity on hinterland region growth, which also less-recognized by previous studies.

## 3. Methodology

### 3.1. Overview of the Suramadu Bridge

The Suramadu Bridge is the longest bridge in Indonesia. It spans 5.4 km, connecting Java Island through Surabaya (the second biggest city in Indonesia after Jakarta) to Madura Island through Bangkalan. The bridge crosses the Madura Strait. Construction of the bridge started in 2000, and it became fully operational in June 2009. Before the bridge was built, people relied on ferries to commute between two main ports: Ujung Port on the Surabaya side and Kamal Port on the Madura side. The time spent commuting by ferry was 30–45 minutes, with the ports operating from 6 am to 7 pm. In contrast, crossing the Suramadu Bridge takes around 10 minutes.

The one-way ferry tariffs varied depending on the type of transportation on board: adult passengers were charged Rp. 4,000; motorcycles Rp. 5,000; cars Rp. 70,000; and medium trucks Rp. 82,000 (Statistics Indonesia, 2010). In comparison, after the bridge officially opened, the tariffs for crossing the bridge were Rp. 3,000 for motorcycles, Rp. 30,000 for private cars and public transportation vehicles and ranged from Rp. 45,000 to Rp. 75,000 for various types of trucks and buses (The Jakarta Post 2009). However, in 2018, the government decided to make crossing the Suramadu Bridge free of charge (Government of Indonesia, 2018). The illustration of the bridge's location is shown in the Figure 1 below:

### 3.2. Synthetic control method (SCM)

This research uses the SCM to evaluate the causal impact of the construction of the Suramadu bridge on economic growth in Bangkalan. The reliable estimation of the impact of infrastructure provision is often hindered by problems of endogeneity and reverse causality (Timilsina et al., 2024). Infrastructure provision often occurs in regions with particular characteristics, and it is also common for infrastructure provision to be impacted by economic outcomes, for example, higher economic development results in more demand for infrastructure. Therefore, current research on the relationship between infrastructure and economic outcomes employs impact evaluation methods to address such problems. One of the impact evaluation methods is SCM, which has superiority over the DiD method due to its relaxed assumption of a parallel time trend. The SCM is a data-driven statistical method introduced by Abadie



**Table 1.** Recent studies on the transportation infrastructure impact on economic growth.

Authors	Transportation infrastructure measurement	Object analysis	Methods	Findings
Calderón and Servén (2010)	Quality and Quantity Index of Infrastructure (including quality and length of roads)	136 countries (1960–2005)	GMM	Infrastructure development (both in terms of quality and quantity) pose a strong association with higher economic growth in the long run.
Arbués et al. (2015)	Capital stock (i.e. roads and highways, ports, airports, and railways)	47 Provinces in Spain (1986–2006)	Spatial Durbin Model (SDM), with maximum likelihood and GMM estimators	Roads is the only transport infrastructure that could generate higher output at local context and its neighborhood. Meanwhile, the other infrastructure type insignificantly affects the output at any level.
Kodongo and Ojah (2016)	The African Infrastructure Development Index (AIDI), infrastructure quality index (AIQI), public spending on infrastructure	45 sub-Saharan African countries (2000–2011)	GMM	Public spending on infrastructure is correlated with economic growth, especially in less-developed countries in sub-Saharan Countries.
Crescenzi et al., (2016)	Investment on motorways and other roads	166 European Union region (1995–2009)	Panel Fixed Effect and GMM	Investment on motorways and other roads have an insignificant direct influence to economic growth. However, if the investment on other roads is supported by quality government, it could lead higher economic performance.
Chakamera and Alagidede (2018)	Aggregated infrastructure stocks and quality	43 sub-Saharan African countries (2000–2014)	GMM	Infrastructure stock posits a relatively strong relationship with growth, compared to quality. Meanwhile, the infrastructure quality has a greater effect on growth in long run rather than in short run.
Ke et al., (2020)	Road and railways density, quality of transport infrastructure, and structure of transport infrastructure	29 regions at province level in China (2007–2015)	GMM	Growth is significantly affected by the improvement on transport infrastructure quality and structure. On the other hand, quantity of transport infrastructure not necessary improve the regional growth.
Khan et al., (2020)	Transport Infrastructure Index	Six selected South Asian countries (1990–2010)	PMG	Transport infrastructure is insignificantly affected the economic growth, both in the short run and the long run.
Lai (2020)	Dongguan Humen Bridge	Dongguan City (treated) and 21 cities in Guangdong Province, China (1991–2007)	Synthetic Control Method (SCM)	The provision of Dongguan Humen Bridge promotes a long-term economic growth for Dongguan City.
Rehman et al., (2020)	Transport Infrastructure Index	Six selected South Asian countries (1990–2017)	PMG	Transport infrastructure lead to better international trade performance, where the export increase and the trade deficit become smaller.
Magazzino and Giolli (2021)	Length of railways networks	Italy (1861–1971)	Autoregressive distributive lag (ARDL) and wavelet analysis (WA)	The increase of railways infrastructure leads to a higher economic value added, both in short and long run.
Kong et al., (2022)	High-speed rail (HSR)	284 cities in China (2005–2018)	PSM-DID	Cities that introduced with HSR experienced higher economic growth than the other.
Chen (2023)	Belt and Road Initiative (BRI)	130 participating countries and 46 control countries (2006–2019)	DID	Participated in BRI promotes a higher economics growth for countries, especially for upper-middle countries and high-income countries.

(continued)

Table 1. Continued.

Authors	Transportation infrastructure measurement	Object analysis	Methods	Findings
Timilsina et al. (2024)	Length of road network and rail lines	87 countries (1992–2017)	Pooled Mean Group (PMG) Regression	The provision of road and rail lines generate a little impact on economic growth, compared with other infrastructure types (electricity and telecommunication).



Figure 1. Map of study area. Source: authors, processed (2024).

and Gardeazabal (2003) and Abadie et al. (2010). This method estimates the impact by forming a synthetic control unit from the weighting of several districts similar to Bangkalan (in socioeconomic conditions) but not impacted by the bridge construction. Then, the causal impact can be examined by comparing the economic growth trajectory in Bangkalan and the synthetic control unit postconstruction. According to Mao (2018), SCM has three advantages over other impact evaluation tools: (1) controlling the presence of time-invariant and time-variant cofounders; (2) applicable for causal analysis with an aggregate level analysis even for one or a limited number of treated units; (3) transparent and objective.

The setup of the SCM method is as follows. Suppose  $i$  denotes districts used in the analysis consisting of  $j + 1$  districts; the first district ( $i = 1^{st}$ ) serves as the treated district, which is directly impacted by the bridge provision, i.e. Bangkalan. Meanwhile, the remaining districts  $j$  are the selected donor districts. Donor districts are candidate districts with socioeconomic similarity to Bangkalan but not impacted by the bridge. According to Rao and Vidyattama (2017), the choice of candidate donor districts is arbitrary, depending upon the researcher's judgment.  $T$  represents the whole observed period, and  $T_0$  represents the pre-treatment period such that  $1 < T_0 < T$ . Meanwhile,  $y_{it}^1$  is the outcome (economic growth) that would be observed for unit observation  $i$  at the period  $t$  if the unit  $i$  is impacted by the treatment in period  $T_0 + 1$  to  $T$ . Finally,  $y_{it}^N$  represents the outcome (economic growth) observed for observation  $i$  at



period  $T$  in the absence of the treatment where  $i = 2, \dots, j+1$  and  $T = 1, \dots, T$ . The causal impact of the bridge construction is obtained by the equation below:

$$\lambda_{1t} = y'_{1t} - y'_{1t}^N \quad (1)$$

Nevertheless,  $y_{1t}^N$  is a counterfactual, i.e. the economic growth trajectory of the treated region that would be observed in the absence of the bridge. For the period of  $T > T_0$ , the SCM mimics the counterfactual by selecting an optimum vector of weight  $w^* = (w_2^* \dots w_{j+1}^*)$  that minimize the distance between pre-treatment economic growth predictors of the treated unit (denoted by  $X_1$ ) and for the remaining donor units (indicated by  $X_0$ ). Mathematically, the counterfactual is estimated by the equation below:

$$\hat{y}_{1t}^N = \sum_{j=2}^{J+1} w_j^* Y_{jt} \quad (2)$$

Particularly the minimized distance function of the optimum weight vector  $w^*$  is obtained by the formula as follows:

$$\|X_1 - X_0 W\|_\nu = \sqrt{(X_1 - X_0 W)' \nu (X_1 - X_0 W)} \quad (3)$$

where  $0 \leq W_j \leq 1$  for  $J = 2, \dots, J+1$  and  $\sum_{j=2}^{J+1} W_j = 1$ . Meanwhile,  $\nu$  is  $(k \times k)$  positive semidefinite identity matrix, whose optimal value is derived from the assignment of weights to a linear combination of  $X_0$  and  $X_1$  that minimizes the root mean of squared prediction error (RMSPE) of outcomes in the pre-intervention period (Mao, 2018; Rao & Vidyattama, 2017). Put differently, the algorithm constructs the synthetic control of Bangkalan by minimizing the discrepancy properties of the actual Bangkalan and its synthetic district unit as the control district prior to the bridge construction. The discrepancy is minimized by assigning weighted averages to the donor districts based on their similarity in the main outcomes and their covariates prior to the intervention (Mao, 2018). Once the synthetic Bangkalan is constructed, the causal impact of the bridge is calculated by differencing the actual economic growth trajectory in Bangkalan and its synthetic control's trajectory postintervention.

Statistical inference is conducted after estimating the impact of the bridge construction. Unlike other methods, SCM statistical inference is not based on  $t$ -statistics but the application of placebo tests, i.e. applying the SCM to the untreated districts as if they were the treated districts. Afterward, the result of the placebo tests can be compared to the baseline result (Abadie et al., 2010). The treatment effect is considered significant if infrequently greater in untreated units than in treated units (Mao, 2018). Following Galiani & Quistorff (2017), the placebo test results are reported using  $p$ -value, allowing to assess the statistical significance of the treatment effect by comparing the actual treatment effect with a distribution of effects obtained from placebo tests. Lower  $p$ -value (less than 10%) indicates that it is likely that the observed effect is caused by chance.

Furthermore, both an in-time placebo test and the DiD method are utilized to assess the robustness of the primary findings from the SCM analysis. The in-time placebo test involves assigning the intervention period to a random period prior to the actual intervention, similar to previous placebo tests. This test determines whether the observed treatment effect is statistically significant or merely the result of random fluctuations. Graphically, if the in-time placebo test is valid, the trajectory of the main outcome should not exhibit substantial gaps between the actual and synthetic units. If such gaps do appear, it suggests that any observed differences in outcomes between the actual and synthetic units during the real intervention period may not be attributable to the intervention itself (Rao and Vidyattama, 2017).

The DiD method is a statistical technique used to evaluate the effect of an intervention by comparing changes in outcomes before and after the intervention for both treated and control units. In this framework, the treated units are those that receive the intervention, while the control units, which do not receive the intervention, are similar to the treated units in relevant characteristics. The method relies on the assumption of parallel trends, which posits that in the absence of the intervention, the treated and control units would have experienced similar outcome trends (Baker et al., 2022). If the DiD estimate

aligns in direction and statistical significance with the results obtained from the SCM analysis, it suggests that the SCM results are robust and reliable.

### 3.3. Data and donor districts

In this research, the treatment is the Suramadu bridge construction, and the treated district is the district on Madura with the closest proximity to the bridge, Bangkalan. Practically, the SCM analysis starts by choosing the main outcomes and their covariates (McClelland & Gault, 2017). The main outcome was a gross regional domestic product at a constant price in 2010 (*GDP*). Meanwhile, the covariate in the model is constructed based on the prior theory, previous research, and data availability at the district administration level. Previously, Adhikari and Alm (2016) choose their set of covariates based on endogenous growth theory, which cover several determinants of economic growth (human capital, physical capital, and institutional quality). We also follow prior studies that utilized various macroeconomic indicators to applying the SCM analysis (Bonander et al., 2016; Muñoz, 2019; Possebom, 2017). Moreover, we reckon several determinants that could affect economic growth at Indonesia regional context (Andriansyah et al., 2023). Despite these considerable number of possible indicators that could be part of covariance set, however, we do acknowledge the limited data availability for many variables at district level in Indonesia.

After the profiling steps (theory, empirical researches, and data availability), the set of covariates in this study are the total value of investment at a constant price in 2010 (*investment*), the number of population (*population*), literacy rate (*literacy*), the share of the agriculture sector to the economy (*agriculture*), and share of the manufacturing sector to the economy (*manufacturing*). The data are sourced from Statistics Indonesia (Badan Pusat Statistik/BPS), the Indonesia Database for Policy and Economic Research (INDO-DAPOER) by the World Bank, and the National Single Window for Investment (NSWI) by the Indonesian Ministry of Investment/Investment Coordinating Board (BKPM). Our dataset spans from 2001 to 2017, with 2010 as the initial intervention period (we expected the impact of the bridge to emerge one year after it opened in 2009). We limit the period of analysis to up to 2017 to isolate the effect of the tariff exemption policy enacted in 2018. Detailed information on variables and their measurements are provided in Table 2. Meanwhile, the descriptive statistics for each variable are depicted in Table 3.

After the outcome variable and its covariates are determined, the candidate of donor districts is identified to create a synthetic unit. One condition to isolate the impact of Suramadu's construction on the economic growth in Bangkalan is ensuring that the regional units in the donor districts are not affected by infrastructure developments, including Suramadu. In the screening of the donors, areas with transportation infrastructure development similar to Bangkalan were excluded. Nevertheless, during the observation period, no mega projects in Indonesia were equivalent to Suramadu, so donor districts were chosen from those with an identical economic structure to Bangkalan, i.e. districts with a similar gross domestic product and the agricultural sector that outperformed the manufacturing sector. In addition, districts that experienced subdivisions during the observation were also excluded.

**Table 2.** Variables notation and measurement.

Variable	Notation	Measurement	Data period	Data sources
Gross Regional Domestic Product	GDP	Total output in Rupiah (transformed into natural logarithm)	2001–2017	BPS
Total investment	Investment	Total foreign direct investment, domestic investment, and public capital expenditure in Rupiah (transformed into natural logarithm)	2001–2009	INDO-DAPOER, NSWI
Number of population	Population	Total residents in 100,000 number of people.	2001–2009	INDO-DAPOER
Literacy rate	Literacy	Percentage of the population aged 15 years and above who can read and write.	2001–2009	INDO-DAPOER
Share of agriculture sector in economy	Agriculture	Contribution of agriculture sector on GDP (percentage)	2001–2009	INDO-DAPOER
Share of manufacture sector in economy	Manufacturing	Contribution of manufacture sector on regional GDP (percentage)	2001–2009	INDO-DAPOER

Source: authors, processed (2024).

## 4. Results and discussion

### 4.1. Results

The descriptive statistics for the variables used in the analysis are provided in Table 3. The average GDP is 15.741 with a standard deviation of 0.823. The minimum GDP value is 13.399 and the maximum value is 17.198. The average investment value is 11.972 with a standard deviation of 0.800. Additionally, the average population size is 728,400, with a minimum population of 165,300 and a maximum of 1,814,700. The literacy rate averages 82.68%, with a minimum value of 62.31% and a maximum value of 95.94%. The mean share of the agriculture sector is 40.50%, with values ranging from 17.53% to 60.35%. Meanwhile, the mean contribution of the manufacturing sector to GDP is 8.37%, varying between 0.65% and 57.10%.

The synthetic control unit (synthetic Bangkalan) needs to be compared with the characteristics of the treated district and donor districts before the intervention to ensure reliability. Table 4 shows the average characteristics of Bangkalan (treated district) and the 24 potential donor districts before the intervention. In general, Bangkalan had a higher gross domestic product (GDP), investment value (*investment*) and more inhabitants (*population*) than the potential donors. Meanwhile, the potential donor districts had a greater literacy rate (*literacy*) and more share in the agriculture (*agriculture*) and manufacturing sectors (*manufacturing*) than the actual Bangkalan.

Figure 2 depicts the gross domestic product (GDP) path of Bangkalan and the 24 potential donors from 2001 to 2017. Generally, the GDP paths in Bangkalan and the potential donor districts are identical prior to the bridge construction, despite the different levels (lower in the potential donor districts). Before the Suramadu bridge provision, Bangkalan's long-term GDP trajectory increased steadily. After the bridge opened, the path flattened with a few fluctuations. In contrast, the GDP trends in most potential donor districts were stable and rising before and after 2010. In other words, the potential donor districts seem suitable for constructing a counterfactual of Bangkalan after the infrastructure provision.

The SCM estimation starts by choosing the weight for potential donor districts to construct a synthetic Bangkalan. Table 5 reveals the result of the weighting of each potential district. The GDP path of the actual Bangkalan prior to the Suramadu bridge provision is best fitted by the weight combinations of four districts: Probolinggo, Blitar, Brebes, and Tulungagung. Particularly, Probolinggo constitutes 64.9% of Bangkalan's growth trajectory, followed by Brebes (26.8%) and Tulungagung (11.3%). Geographically, three donor districts. i.e. Probolinggo and Tulungagung are in East Java and Brebes is in Central Java.

**Table 3.** Descriptive statistics of samples.

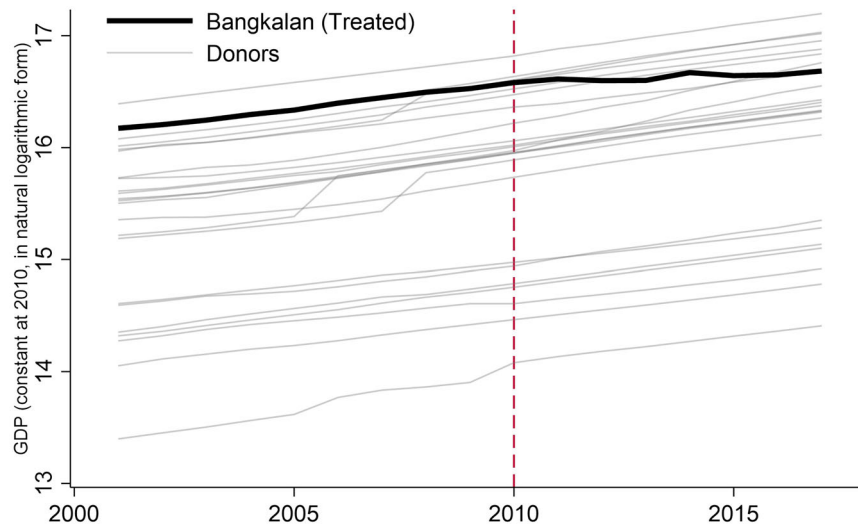
Variable	N	Mean	Standard deviation	Min	Max
GDP	425	15.741	0.823	13.399	17.198
Investment	225	11.972	0.800	8.782	18.130
Population	225	7.284	4.079	1.653	18.147
Literacy	225	82.677	6.523	62.310	95.940
Agriculture	225	40.504	9.746	17.535	60.345
Manufacturing	225	8.365	10.906	0.647	57.104

Source: BPS & INDO-DAPOER; authors, processed (2024).

**Table 4.** Comparison of the means of Bangkalan's and potential donors districts' characteristics before the intervention.

Variable	Bangkalan	Potential donor districts
GDP	16.480 (0.173)	15.710 (0.825)
Investment	12.117 (0.286)	11.966 (0.815)
Population	9.120 (0.383)	7.208 (4.145)
Literacy	74.920 (5.095)	83.000 (6.383)
Agriculture	37.178 (2.094)	40.643 (9.916)
Manufacturing	3.973 (0.093)	8.548 (11.094)

Source: authors, processed (2024). () denotes standard deviation.



**Figure 2.** Economic growth trajectory of the treated district and its potential donor districts. Source: authors, processed (2024).

**Table 5.** Districts' weight in the synthetic unit formation.

No	District	Weight
1	Probolinggo	0.649
2	Brebes	0.268
3	Tulungagung	0.113
4	Blitar	0.000
5	Ponorogo	0.000
6	Bondowoso	0.000
7	Situbondo	0.000
8	Treggalek	0.000
9	Pacitan	0.000
10	Ngawi	0.000
11	Lombok Timur	0.000
12	Sumba Timur	0.000
13	Timor Tengah Selatan	0.000
14	Timor Tengah Utara	0.000
15	Dompu	0.000
16	Alor	0.000
17	Sikka	0.000
18	Ende	0.000
19	Lamongan	0.000
20	Lumajang	0.000
21	Banjarnegara	0.000
22	Grobogan	0.000
23	Pangakeje Kepulauan	0.000
24	Bone	0.000

Source: authors, processed (2024).

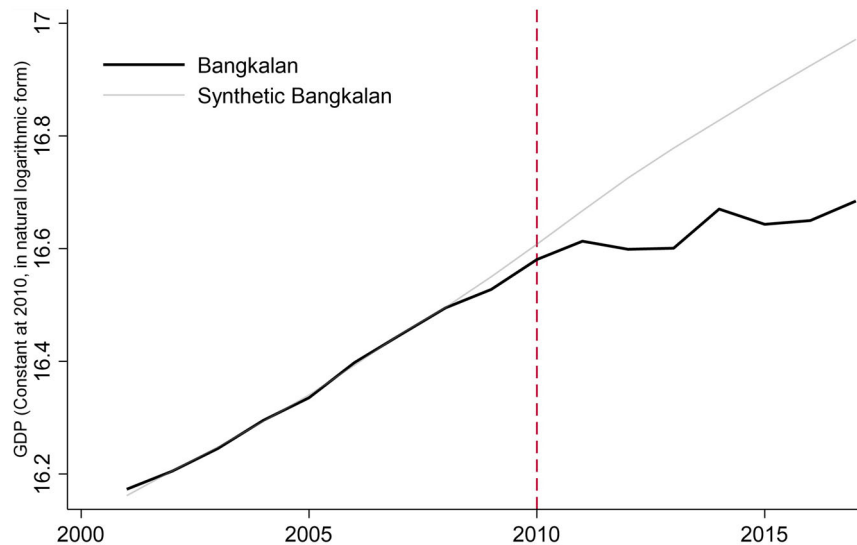
**Table 6** compares the pretreatment variables of the actual and synthetic Bangkalan and the v-weights, indicating the relative importance of each covariate in the construction of synthetic Bangkalan. The lagged value of the main outcome, i.e. *GDP* contributes the greatest to the construction of synthetic Bangkalan. Specifically, the GDP in 2004 contributed 68.18%, followed by GDP in 2008 (31.74%). Other covariates, such as population and literacy rate, contributed only 0.04% and 0.03%. Consequently, 2004 and 2008 growths between the actual and synthetic Bangkalan are closely similar. For instance, while the GDP of Bangkalan in 2004 was 16.295, the GDP of synthetic Bangkalan was 16.293. Similarly, the GDP of Bangkalan in 2008 was 16.495, meanwhile, synthetic Bangkalan's growth 2008 was 16.496.

**Figure 3** visually illustrates the growth trajectory in the actual Bangkalan and the control unit, i.e. synthetic Bangkalan. The GDP trajectory of Bangkalan before the infrastructure provision in 2010 fits its synthetic unit, suggesting that the synthetic resembles the actual. Such resemblance implies that any deviation of the GDP trajectory between the actual and the synthetic Bangkalan in 2010 onwards could be attributed to the Suramadu bridge provision. **Figure 3** also shows the widening GDP trajectory gap

**Table 6.** Comparison of actual Bangkalan, synthetic Bangkalan, and V-weights before the intervention.

Variable	Bangkalan	Synthetic Bangkalan	V-weight
Investment	12.117	13.221	0.0000
Population	9.121	12.034	0.0004
Literacy	74.920	78.703	0.0003
Agriculture	37.178	40.470	0.0000
Manufacturing	3.973	13.651	0.0000
Growth (2004)	16.295	16.293	0.6818
Growth (2008)	16.495	16.496	0.3174

Source: authors, processed (2024).

**Figure 3.** Economic growth trajectory of Bangkalan and its synthetic unit. Source: authors, processed (2024).

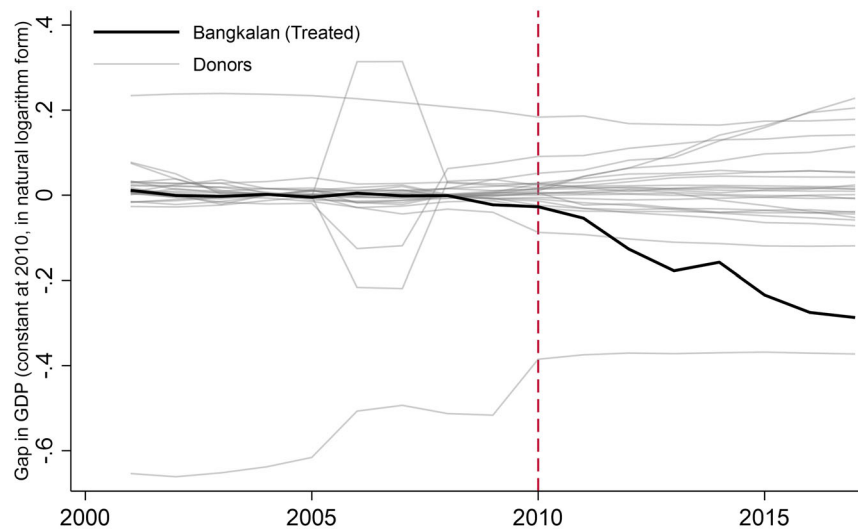
between the actual and synthetic Bangkalan post the Suramadu opening in 2010, with the actual Bangkalan achieving lower than the synthetic one. The GDP in the actual Bangkalan (indicated by the black line) fluctuated and then flattened, while the GDP trend in synthetic Bangkalan rose significantly (indicated by the gray line). It suggests that the Suramadu bridge construction has reduced Bangkalan's GDP. In other words, the infrastructure provision has worsened the regional income differentials across districts, particularly between Bangkalan and its neighboring districts.

Figure 2 also shows that the impact of the Suramadu bridge provision on the GDP path grows over time. At the beginning of the bridge operation, the GDP gap between Bangkalan and its synthetic Bangkalan seems smaller. The gap becomes larger over time. This fact highlights the presence of time lag in the impact of infrastructure provision. This finding aligns with the previous research by Li et al. (2021) on the impact of the Belt and Road Initiatives (BRI) on employment and maritime freight in German and Greece.

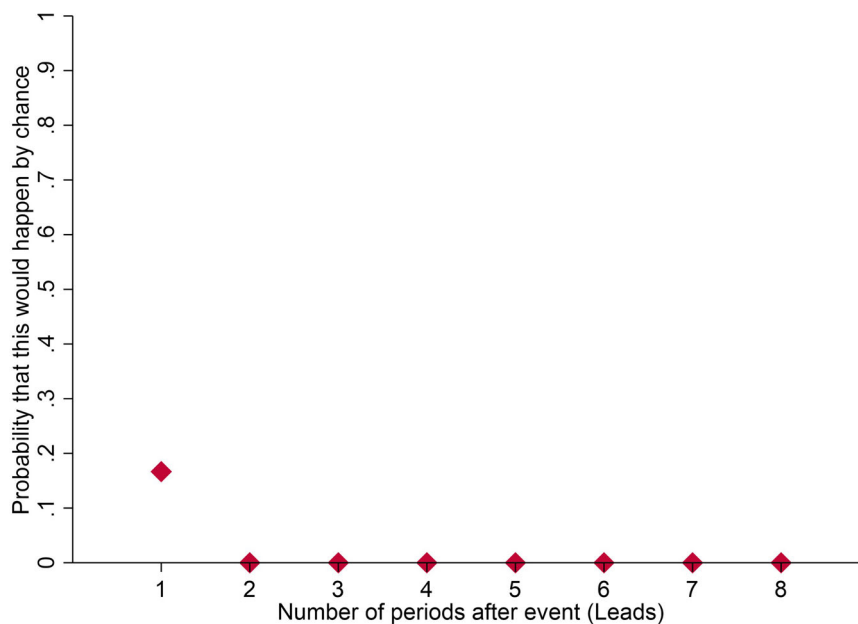
After confirming the impact of the bridge construction, the next step is to conduct a statistical test, ensuring that the findings in Figure 3 are not driven by chance. Figure 4 shows the results of the placebo tests. The solid black line represents the treated district, while the gray lines indicate the donor districts. The figure suggests that the decline in Bangkalan's GDP after the bridge opening in 2010 was unusually large relative to the placebo units. This finding is corroborated by the probability test shown in Figure 5, which examines if such an impact is caused by chance ( $p$ -value). The figure indicates that the probability of the impact of Suramadu, as observed in Figure 3, to happen by chance is extremely small, particularly since the second year of the construction. Thus far, it can be concluded that the result of the SCM estimation represents the real situation in Bangkalan, not by random data generation process.

## 4.2. Discussion

The finding challenges previous work by Hasul and Jayanti (2019), claiming that the impact of Suramadu bridge construction on Bangkalan's economy is positive. As mentioned earlier, such a past study may



**Figure 4.** Placebo tests. Source: authors, processed (2024).



**Figure 5.** Probability of the impact of Suramadu Bridge to happen by chance. Source: authors, processed (2024).

have suffered from the parallel time assumption as it employs Surabaya, the capital city of East Java, as a control unit. Surabaya and Bangkalan are not comparable socioeconomically. For example, Surabaya's contribution to East Java's GDP reached almost 25% in 2019, while Bangkalan contributed only 1% (Statistics Indonesia, 2022d). Additionally, while Surabaya's average years of schooling was 10.51 years in 2022, the average years of schooling of Bangkalan were only 5.97 years (Statistics Indonesia, 2022e).

The current study also contradicts previous studies by Zheng and Kuroda (2013) and Chen and Haynes (2017) in China. For example, Chen and Haynes (2017) found that the high-speed rail provision decreased regional income differentials through several mechanisms: better accessibility, improved connectivity, and reduced transportation costs, which then facilitated information dissemination, capital and labor mobility, and market access. The contradiction extends to a prior work by Elburz and Cubukcu (2021), claiming that transportation infrastructure promotes higher mobility and trade, hence fostering economic growth.

Meanwhile, our finding aligns with the research by Xu and Zhu (2024) in China. They concluded that high-speed rail construction had resulted in a worse regional income gap among rural and urban areas due



to the rising agglomeration. Further analysis indicates that the impact is more pronounced in small and backward regions caused by polarization. In other words, the current research confirms the impact of infrastructure provision on regional development dynamics. While infrastructure provision boosts the economy at the national level, it is not always the case at the regional level (Del Bo & Florio, 2012). Melo et al. (2013) argued that analyses of the impacts of infrastructure provision at the regional levels tend to produce negative results. The underlying assumption is the flow of production factors from backward districts to wealthier ones is facilitated by the infrastructure, pushing the backward districts even further behind. This means that the infrastructure provision reallocates resources from one district to another. In this context, the Suramadu bridge construction has pushed production factors away from Bangkalan to wealthier districts, such as Surabaya. This finding also confirms the dominance of centripetal forces—such as larger market sizes, variation in employment, and positive externalities—in richer or core districts that attract production inputs from backward districts to them (Despotović & Cvetanović, 2017).

This finding also suggests that the infrastructure provision did not produce the expected results, i.e. lowering the regional differentials between Bangkalan and its surrounding districts, particularly Surabaya. According to Komornicki and Goliszek (2023), infrastructure provision is necessary to improve a district's development. Nevertheless, other conditions need to be met. Rothengatter and Schaffer (2006) argued that backward districts would enjoy the benefits of infrastructure provision only if it is accompanied by other types of investment. Reallocation of production inputs, such as capital and labor, from wealthier districts requires sufficient investment in human capital (Bolter & Robey, 2020). In particular, Bolter and Robey (2020) believed the main drivers for a firm to locate in certain geographical areas are the availability of an educated and skilled labor force and a sufficient number of local suppliers. The current data shows that Bangkalan has a relatively low level of human capital. For instance, Bangkalan's average years of schooling was 5.97 years in 2022, one of the lowest among other districts in East Java (Statistics Indonesia, 2022e). The human development index was 65.05 points in 2022, one of the lowest in East Java (Statistics Indonesia, 2023) and way below the national human development index (72.91 points). These factors may discourage investors from considering Bangkalan in their expansion plan.

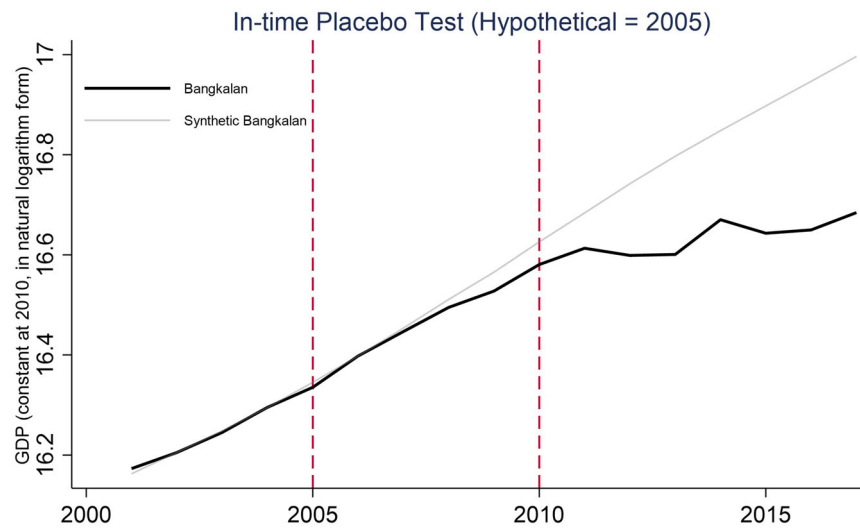
Another pre-condition to attract production inputs to locate backward regions is good governance (Younsi & Bechtini, 2019), which includes: (a) the process of choosing, monitoring, and replacing the government; (b) the production and implementation of sound policies; and (c) the respect of the citizens and the state to the institutions that govern them socially and economically (Kaufmann et al., 2011). Common indicators of good governance are political stability and the absence of violence, improvement in government's effectiveness, legal practices, and corruption control (Kaufmann et al., 2011). In line with the previous argument, prior work by Zergawu et al. (2020) also found that the optimum return on infrastructure investment is often influenced by institutional quality, such as political stability, high accountability, and an effective governance system. For example, infrastructure provision without secure private property rights and safety from civil conflicts may not have a powerful impact on economic performance. Prevalent corruption also incurs higher costs to investors, which discourages new investments.

Unfortunately, Bangkalan is considered one of the districts with a high level of corruption and low level of law enforcement. For instance, two former mayors of Bangkalan were arrested for corruption cases (Tempo, 2022; Kompas, 2022). Illegal fees are also often charged in many business activities, including tourism (Effendi & Windari, 2022). Additionally, Daulay et al. (2022) mentioned that Madura Island is often associated with high violence in its society. In short, lack of good governance often resulted in 'unfriendly' business environments, discouraging investors from starting their business in Bangkalan.

### 4.3. Robustness check

#### 4.3.1. In-time placebo test

An in-time placebo test is conducted by assigning the treatment year at a random point before the actual year of intervention (2010). This study chooses 2005 as a 'hypothetical' year of intervention. The criteria are as follows: if the GDP path gap between the actual and synthetic Bangkalan is similar to Figure 3, the conclusion from Figure 3 may not be caused by the Suramadu bridge provision. Figure 6 reports the in-time placebo test, showing the actual and synthetic Bangkalan GDP trend, assuming the bridge operation started in 2005



**Figure 6.** In-time placebo test. Source: authors, processed (2024).

**Table 7.** The estimation of DiD approach.

Variables	Coefficient
Time	0.450*** (0.055)
Treated	0.085 (0.054)
DiD	−0.167** (0.078)
Constant	16.262*** (0.038)

Source: authors, processed (2024). Note. () denotes standard error, while stands for \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

Figure 6 shows that the synthetic Bangkalan, where the Suramadu bridge was hypothetically opened in 2005, has a trajectory similar to the actual Bangkalan over the period of 2001 to 2010. No large gap is found in the GDP trajectory from 2005 onwards, as shown in Figure 3. Therefore, the GDP gap trajectory shown in Figure 3 is causally impacted by the Suramadu bridge construction, not other factors. The conclusion is the same: the finding is robust.

#### 4.3.2. Difference-in-difference approach

In addition to the SCM method, this research utilizes a DiD approach. In particular, the treatment district is Bangkalan, while the control group is a district of Probolinggo. The employment of the district of Probolinggo as a control district is motivated by their socioeconomic similarity. Furthermore, the district of Probolinggo also had the largest contribution in forming synthetic Bangkalan. Table 7 depicts the estimation result of the DiD approach.

The result above indicates that the coefficient of DiD is negative and statistically significant at a five percent level. It means that the Suramadu bridge provision reduces the GDP of the treated district. This result corroborates the main finding of this study: the infrastructure provision lowers the Bangkalan's GDP.

## 5. Conclusion

This study aims to estimate the causal impact of the Suramadu Bridge, the longest bridge in Indonesia, on the gross domestic product (GDP) of Bangkalan, a district on Madura Island closest to the bridge. Unlike previous work, this research employs a SCM that relaxes the assumption of a parallel time trend in the difference-in-difference (DiD) approach. The SCM estimation results show that the provision of the Suramadu Bridge lowers the GDP of Bangkalan, indicating that without the bridge, Bangkalan's GDP

would have been higher. This finding is statistically significant and robust across several robustness tests. It also implies that the construction of the Suramadu Bridge worsened the regional development differentials between Bangkalan and other districts in East Java.

It is argued that while hard infrastructure provision meets the necessary conditions for regional development in Bangkalan, it does not meet the sufficient conditions. The literature suggests that sufficient conditions for realizing regional development include a reliable supply of skilled and educated workers and good governance, such as secure private property rights and safety. Currently, Bangkalan suffers from low human capital quality and pervasive corruption. Additionally, the incidence of civil conflicts is relatively high. These unmet sufficient factors discourage investors from starting businesses in Bangkalan. Furthermore, the bridge's infrastructure provision, without accompanying regional development, causes people in Bangkalan to migrate to neighboring districts. In other words, this study highlights that infrastructure provision exacerbates centripetal forces, pushing production factors out of Bangkalan and into wealthier surrounding districts.

As a consequence from our findings, there are policy implications that could be recognized. The negative impact for the rural area (Bangkalan) is potentially roots on poor coordination to generate an equal regional development. Lai (2020) notes the probability of siphon effect from a better rural-urban connectivity, which could lead a region to experience the 'oversaturation' condition. This situation would affect the economic performance of rural areas, since they loss the production factors that flows to the urban areas. Henceforth, the government need to raise the concern in developing an integrated regional planning to avoid the similar unintended implication.

Additionally, the findings advocate for a holistic approach, where hard infrastructure initiatives are complemented by investments in soft infrastructure, particularly in education and healthcare sectors. These are needed to ensure sufficient availability of skilled workers in the less-developed area. It is also necessary to improve governance, especially in controlling corruption and mitigating civil conflicts. These strategies are essential for maximizing the potential of infrastructure projects in driving sustainable economic growth.

Lastly, this study has certain drawbacks. The ideal application of the SCM requires long-term observations of the main outcome trajectory prior to the intervention. Therefore, future research should use datasets with longer observation periods. Additionally, the current study analyzes the impact of the Suramadu bridge on Bangkalan, the closest region to the bridge. Future research could extend the analysis to other districts on Madura Island. Finally, it would be interesting to explore the impact of the Suramadu bridge on the socioeconomic development of Madura Island from a qualitative standpoint.

## Author contributions

Achmad Solihin: Reviewing literature and literature gap determination; designing research; writing article. Wahyu Wisnu Wardana: Data collection and data analysis; writing article. Iqram Ramadhan Jamil: Data collection and data analysis; writing article. Unggul Heriqbaldi: Data collection and data analysis; revising article. Nguyen Thi Thuy Ngan: Writing article. Widya Sylviana: Writing article. Nurul Istifadah: Writing article.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

We acknowledge the financial support from Universitas Airlangga.

## About the authors

**Achmad Solihin** is a senior faculty member in the Department of Economics at the Faculty of Economics and Business, Universitas Airlangga. He earned his doctoral degree in economics from Universitas Airlangga, and his research focuses on public economics.

**Wahyu Wisnu Wardana** is a faculty member in the Department of Economics at Universitas Airlangga and serves as a research associate at the Research Institute of Socio-Economic Development (RISED) in Surabaya - Indonesia. He holds a master's degree from the University of Illinois at Urbana-Champaign, USA, with a primary research focus on development economics.

**Iqram Ramadhan Jamil** is a research and program officer at RISED in Surabaya-Indonesia. He obtained his bachelor's degree in economics at Universitas Padjadjaran. His research interests include development economics, public economics, and environmental economics.



**Unggul Heriqbaldi** is a senior faculty member in the Department of Economics at Universitas Airlangga. He obtained his doctoral degree in economics from Brawijaya University, with research interests in development economics and international economics.

**Nguyen Thi Thuy Ngan** is a faculty member at the School of Economics, Can Tho University in Vietnam. She is currently pursuing her PhD at the University of Adelaide, Australia.

**Widya Sylviana** is a senior faculty member in the Department of Economics at Universitas Airlangga. She earned her doctoral degree in economics from Universitas Kebangsaan Malaysia, focusing her research on public economics.

**Nurul Istifadah** is a senior faculty member in the Department of Economics at Universitas Airlangga. She obtained her doctoral degree in economics from Brawijaya University, with a research focus on development economics.

## ORCID

Achmad Solihin  <http://orcid.org/0000-0003-3867-0942>  
 Wahyu Wisnu Wardana  <http://orcid.org/0000-0002-0768-552X>  
 Iqram Ramadhan Jamil  <http://orcid.org/0000-0002-6820-2720>  
 Unggul Heriqbaldi  <http://orcid.org/0000-0002-0221-6230>  
 Nguyen Thi Thuy Ngan  <http://orcid.org/0009-0008-1174-567X>  
 Widya Sylviana  <http://orcid.org/0000-0002-3689-4021>  
 Nurul Istifadah  <http://orcid.org/0009-0009-5367-5179>

## Data availability statement

The data of this study are available on request from the corresponding author.

## References

- Abadie, A., & Gardeazabal, J. (2003). The economic costs of conflict: A case study of the Basque Country. *American Economic Review*, 93(1), 113–132. <https://doi.org/10.1257/00028280321455188>
- Abadie, A., Diamond, A., & Hainmueller, J. (2010). Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. *Journal of the American Statistical Association*, 105(490), 493–505. <https://doi.org/10.1198/jasa.2009.ap08746>
- Achour, H., & Belloumi, M. (2016). Investigating the causal relationship between transport infrastructure, transport energy consumption and economic growth in Tunisia. *Renewable and Sustainable Energy Reviews*, 56, 988–998. <https://doi.org/10.1016/j.rser.2015.12.023>
- Adhikari, B., & Alm, J. (2016). Evaluating the economic effects of flat tax reforms using synthetic control methods. *Southern Economic Journal*, 83(2), 437–463. <https://doi.org/10.1002/soej.12152>
- Andriansyah, A., Nurwanda, A., & Rifai, B. (2023). Structural Change and Regional Economic Growth in Indonesia. *Bulletin of Indonesian Economic Studies*, (1) 5991–117. <https://doi.org/10.1080/00074918.2021.1914320>
- Arbués, P., Baños, J. F., & Mayor, M. (2015). The spatial productivity of transportation infrastructure. *Transportation Research Part A: Policy and Practice*, 75, 166–177. <https://doi.org/10.1016/j.tra.2015.03.010>
- 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](https://doi.org/10.1016/0304-3932(89)90047-0)
- Baker, A. C., Larcker, D. F., & Wang, C. C. (2022). How much should we trust staggered difference-in-differences estimates? *Journal of Financial Economics*, 144(2), 370–395. <https://doi.org/10.1016/j.jfineco.2022.01.004>
- Banister, D., & Berechman, J. (2003). *Transport Investment and Economic Development*. Routledge.
- Barati, M., & Adams, S. (2019). Enhanced penalties for carrying firearms illegally and their effects on crime. *Economic Analysis and Policy*, 63, 207–219. <https://doi.org/10.1016/j.eap.2019.07.001>
- Berawi, M. A., Susantono, B., Miraj, P., Sari, M., Saroji, G., Berawi, A. R. B., & Sidqi, H. (2020). *Accelerating Nation Competitiveness Through Economic Corridor Development: Indonesia Masterplan Revisited* [Paper presentation]. In

- Innovations in Digital Economy: First International Conference, SPBPU IDE 2019, St. Petersburg, Russia, October 24–25, 2019, Revised Selected Papers, (pp. 77–100). Cham: Springer International Publishing.
- Bilgili, F., & Magazzino, C. (2022). The nexus between the transportation sector and sustainable development goals: Theoretical and practical implications. *Frontiers in Environmental Science*, 10, 1055537. <https://doi.org/10.3389/fenvs.2022.1055537>
- Bolter, K., & Robey, J. (2020). Agglomeration economies: A literature review. <https://research.upjohn.org/cgi/viewcontent.cgi?article=1256&context=reports>
- Bonander, C., Jakobsson, N., Podestà, F., & Svensson, M. (2016). Universities as engines for regional growth? Using the synthetic control method to analyze the effects of research universities. *Regional Science and Urban Economics*, 60, 198–207. <https://doi.org/10.1016/j.regsciurbeco.2016.07.008>
- Calderón, C., & Servén, L. (2010). Infrastructure and economic development in Sub-Saharan Africa. *Journal of African Economies*, 19(suppl\_1), i13–i87.
- Chakamera, C., & Alagidede, P. (2018). The nexus between infrastructure (quantity and quality) and economic growth in Sub Saharan Africa. *International Review of Applied Economics*, 32(5), 641–672. <https://doi.org/10.1080/02692171.2017.1355356>
- Chen, Z. (2023). The impact of the belt and road infrastructure development on the economic growth of the partner countries. *Global Journal of Emerging Market Economies*, 15(2), 254–272. <https://doi.org/10.1177/09749101231167454>
- Chen, Z., & Haynes, K. E. (2017). Impact of high-speed rail on regional economic disparity in China. *Journal of Transport Geography*, 65, 80–91. <https://doi.org/10.1016/j.jtrangeo.2017.08.003>
- Chin, M. Y., Ong, S. L., Wai, C. K., & Kon, Y. Q. (2021). The role of infrastructure on economic growth in belt and road participating countries. *Journal of Chinese Economic and Foreign Trade Studies*, 14(2), 169–186. <https://doi.org/10.1108/JCEFTS-09-2020-0065>
- Cook, L. M., & Munnell, A. H. (1990). How does public infrastructure affect regional economic performance? *New England Economic Review*, (Sep), 11–33.
- Crescenzi, R., & Rodríguez-Pose, A. (2012). Infrastructure and regional growth in the European Union. *Papers in Regional Science*, 91(3), 487–513. <https://doi.org/10.1111/j.1435-5957.2012.00439.x>
- Crescenzi, R., Di Cataldo, M., & Rodríguez-Pose, A. (2016). Government quality and the economic returns of transport infrastructure investment in European regions. *Journal of Regional Science*, 56(4), 555–582. <https://doi.org/10.1111/jors.12264>
- Damuri, Y. R., Perkasa, V., Atje, R., & Hirawan, F. (2019). Perceptions and readiness of Indonesia towards the belt and road initiative. Center for Strategic and International Studies (CSIS). [https://mail.csis.or.id/uploads/attachments/post/2019/05/23/CSIS\\_BRI\\_Indonesia\\_r.pdf](https://mail.csis.or.id/uploads/attachments/post/2019/05/23/CSIS_BRI_Indonesia_r.pdf)
- Daulay, P., Raditya, A., & Khafsoh, N. A. (2022). Minimizing violence: A good practice local elite-based in the Madura Island, Indonesia. *Jurnal Pemberdayaan Masyarakat: Media Pemikiran Dan Dakwah Pembangunan*, 6(1), 91–110. <https://doi.org/10.14421/jpm.2022.061-05>
- Del Bo, C. F., & Florio, M. (2012). Infrastructure and growth in a spatial framework: Evidence from the EU regions. *European Planning Studies*, 20(8), 1393–1414. <https://doi.org/10.1080/09654313.2012.680587>
- Delphine, Witte, P., & Spit, T. (2022). Bridging the perception gap? When top-down built megaprojects meet bottom-up perceptions: A case study of Suramadu bridge, Indonesia. *Asian Geographer*, 39(1), 21–43. <https://doi.org/10.1080/10225706.2020.1750441>
- Despotović, D., & Cvetanović, S. (2017). The theoretical explication of the factors of regional growth and the economic convergence (divergence) of the region. *Ekonomski Horizonti*, 19(2), 109–123.
- Effendi, T., & Windari, R. (2022). Illegal levies as a negative element contributing to the decrease of the tourism potential on Madura. *International Journal of Business, Economics, and Social Development*, 3(1), 45–52. <https://doi.org/10.46336/ijbesd.v3i1.172>
- 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>
- Faoziyah, U. (2016). Who benefits? The case of the Suramadu Bridge construction. *Procedia - Social and Behavioral Sciences*, 227, 60–69. <https://doi.org/10.1016/j.sbspro.2016.06.043>
- Galiani, S., & Quistorff, B. (2017). The synth\_runner package: Utilities to automate synthetic control estimation using synth. *The Stata Journal: Promoting Communications on Statistics and Stata*, 17(4), 834–849. <https://doi.org/10.1177/1536867X1801700404>
- Government of Indonesia. (2018). Presidential Decree No. 98/2018. <https://peraturan.bpk.go.id/Details/97806/perpres-no-98-tahun-2018>
- Hasul, L. S. E., & Jayanti, A. D. (2019). Analysis of the impact of Suramadu Bridge development to the economic growth of its core and periphery regions. *East Java Economic Journal*, 3(1), 26–42.
- Heersink, B., & Peterson, B. D. (2016). Measuring the vice-presidential home state advantage with synthetic controls. *American Politics Research*, 44(4), 734–763. <https://doi.org/10.1177/1532673X16642567>



- Holl, A. (2004). Transport infrastructure, agglomeration economies, and firm birth: empirical evidence from Portugal. *Journal of Regional Science*, 44(4), 693–712. <https://doi.org/10.1111/j.0022-4146.2004.00354.x>
- Holmgren, J., & Merkel, A. (2017). Much ado about nothing?—A meta-analysis of the relationship between infrastructure and economic growth. *Research in Transportation Economics*, 63, 13–26. <https://doi.org/10.1016/j.retrec.2017.05.001>
- Hong, S. K., Hakim, L., & Faqot, A. (2022). Bridge and islandness: The case of Suramadu Bridge in Indonesia. In *Conserving Biocultural Landscapes in Malaysia and Indonesia for Sustainable Development* (pp. 63–76). Springer Singapore.
- Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The worldwide governance indicators: Methodology and analytical issues. *Hague Journal on the Rule of Law*, 3(02), 220–246. <https://doi.org/10.1017/S1876404511200046>
- Ke, X., Lin, J. Y., Fu, C., & Wang, Y. (2020). Transport infrastructure development and economic growth in China: Recent evidence from dynamic panel system-GMM analysis. *Sustainability*, 12(14), 5618. <https://doi.org/10.3390/su12145618>
- Khan, H., Khan, U., Jiang, L. J., & Khan, M. A. (2020). Impact of infrastructure on economic growth in South Asia: Evidence from pooled mean group estimation. *The Electricity Journal*, 33(5), 106735. <https://doi.org/10.1016/j.tej.2020.106735>
- Kodongo, O., & Ojah, K. (2016). Does infrastructure really explain economic growth in Sub-Saharan Africa? *Review of Development Finance*, 6(2), 105–125. <https://doi.org/10.1016/j.rdf.2016.12.001>
- Komornicki, T., & Goliszek, S. (2023). New transport infrastructure and regional development of central and eastern Europe. *Sustainability*, 15(6), 5263. <https://doi.org/10.3390/su15065263>
- Kompas. (2022). <https://www.kompas.com/tren/read/2022/12/08/173000165/abdul-latif-amin-dan-jerat-korupsi-di-pulau-madura>
- Kong, Q., Li, R., Jiang, X., Sun, P., & Peng, D. (2022). Has transportation infrastructure development improved the quality of economic growth in China's cities? A quasi-natural experiment based on the introduction of high-speed rail. *Research in International Business and Finance*, 62, 101726. <https://doi.org/10.1016/j.ribaf.2022.101726>
- Lai, Q. (2020). The transportation infrastructure and regional economic growth—evidence from Dongguan Humen bridge. *Modern Economy*, 11(12), 2055–2080. <https://doi.org/10.4236/me.2020.1112137>
- Li, Y., Kleimann, M., & Schmerer, H. J. (2021). Estimating causal effects of BRI infrastructure projects based on the synthetic control method. *Asia Europe Journal*, 19(S1), 103–129. <https://doi.org/10.1007/s10308-021-00621-7>
- Magazzino, C., & Giolli, L. (2021). The relationship among railway networks, energy consumption, and real added value in Italy. Evidence from ARDL and Wavelet analysis. *Research in Transportation Economics*, 90, 101126. <https://doi.org/10.1016/j.retrec.2021.101126>
- Magazzino, C., & Maltese, I. (2021). Transport infrastructures: Investments, evaluation and regional economic growth. *Research in Transportation Economics*, 88, 101125. <https://doi.org/10.1016/j.retrec.2021.101125>
- Malmberg, A., & Power, D. (2005). (How) do (firms in) clusters create knowledge? *Industry & Innovation*, 12(4), 409–431. <https://doi.org/10.1080/13662710500381583>
- Mao, Y. (2018). Does democratic transition reduce carbon intensity? Evidence from Indonesia using the synthetic control method. *Environmental Science and Pollution Research International*, 25(20), 19908–19917. <https://doi.org/10.1007/s11356-018-2165-1>
- McClelland, R., & Gault, S. (2017). *The synthetic control method as a tool to understand state policy*. Urban-Brookings Tax Policy Center.
- Melo, P. C., Graham, D. J., & Brage-Ardao, R. (2013). The productivity of transport infrastructure investment: A meta-analysis of empirical evidence. *Regional Science and Urban Economics*, 43(5), 695–706. <https://doi.org/10.1016/j.regsciurbeco.2013.05.002>
- Ministry of Finance. (2019). Advetorial APBN 2020. <https://data-apbn.kemenkeu.go.id/lang/en/post/12/anggaran-infrastruktur>
- Morrison, C. J., & Schwartz, A. E. (1996). Public infrastructure, private input demand, and economic performance in New England manufacturing. *Journal of Business & Economic Statistics*, 14(1), 91–101. <https://doi.org/10.1080/07350015.1996.10524632>
- Muñoz, E. (2019). Did They Hurt Growth? A Synthetic Control Estimate of the Impact of 'Bachelet's Reforms'. *A Synthetic Control Estimate of the Impact of Bachelet's Reforms* (January 19, 2019)
- Negara, S. D. (2016). Indonesia's infrastructure development under the Jokowi administration. *Southeast Asian Affairs*, SEAA16(1), 145–168. <https://doi.org/10.1355/aa16-1j>
- Newiak, M. M., & Willems, T. (2017). *Evaluating the impact of non-financial IMF programs using the synthetic control method*. International Monetary Fund. <https://doi.org/10.5089/9781475599039.001>
- Polyzos, S., & Tsiotas, D. (2020). The contribution of transport infrastructures to the economic and regional development. *Theoretical and Empirical Researches in Urban Management*, 15(1), 5–23.
- Possebom, V. (2017). Free trade zone of Manaus: An impact evaluation using the synthetic control method. *Revista Brasileira de Economia*, 71(2), 217–231. <https://doi.org/10.5935/0034-7140.20170011>
- Rao, M., & Vidyattama, Y. (2017). The economic cost of violent conflict: The case of Maluku province in Indonesia. *Bulletin of Indonesian Economic Studies*, 53(3), 281–308. <https://doi.org/10.1080/00074918.2017.1298720>



- Rehman, F. U., Noman, A. A., & Ding, Y. (2020). Does infrastructure increase exports and reduce trade deficit? Evidence from selected South Asian countries using a new Global Infrastructure Index. *Journal of Economic Structures*, 9(1), 1–23. <https://doi.org/10.1186/s40008-020-0183-x>
- Roth, J., Sant'Anna, P. H., Bilinski, A., & Poe, J. (2023). What's trending in difference-in-differences? A synthesis of the recent econometrics literature. *Journal of Econometrics*, 235(2), 2218–2244. <https://doi.org/10.1016/j.jeconom.2023.03.008>
- Rothengatter, W., & Schaffer, A. (2006). Impact of Transport Infrastructure and Other Immobile Production Factors on Regional Competitiveness (No. 06-0868).
- Saidi, S., Shahbaz, M., & Akhtar, P. (2018). The long-run relationships between transport energy consumption, transport infrastructure, and economic growth in MENA countries. *Transportation Research Part A: Policy and Practice*, 111, 78–95. <https://doi.org/10.1016/j.tra.2018.03.013>
- Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1), 65–94. <https://doi.org/10.2307/1884513>
- Statistics Indonesia. (2010). Bangkalan Dalam Angka 2010. <https://bangkalankab.bps.go.id/publication/2010/11/01/30cf0f268b7ac206a4c63b9d/kabupaten-bangkalan-dalam-angka-2010.html>
- Statistics Indonesia. (2022a). [Seri 2000] Pertumbuhan Ekonomi Menurut Kabupaten/Kota (Persen), 2004–2006. <https://jatim.bps.go.id/indicator/162/528/2/-seri-2000-pertumbuhan-ekonomi-menurut-kabupaten-kota.html>
- Statistics Indonesia. (2022b). [Seri 2010] Pertumbuhan Ekonomi Menurut Kabupaten/Kota (Persen), 2019–2021. <https://jatim.bps.go.id/indicator/162/527/1/-seri-2010-pertumbuhan-ekonomi-menurut-kabupaten-kota.html>
- Statistics Indonesia. (2022c). Jumlah dan Persentase Penduduk Miskin di Provinsi Jawa Timur Menurut Kabupaten/Kota, 2017 – 2021. <https://jatim.bps.go.id/statistable/2021/12/13/2289/jumlah-dan-persentase-penduduk-miskin-di-provinsi-jawa-timur-menurut-kabupaten-kota-2017-2021.html>
- Statistics Indonesia. (2022d). Distribusi Persentase PDRB Atas Dasar Harga Berlaku Menurut Kabupaten/Kota (Persen), 2019–2021. Diakses melalui: <https://jatim.bps.go.id/indicator/162/319/1/-seri-2010-distribusi-persentase-pdrb-atas-dasar-harga-berlaku-menurut-kabupaten-kota.html>
- Statistics Indonesia. (2022e). Rata-rata Lama Sekolah (Tahun). Diakses melalui: <https://jatim.bps.go.id/indicator/26/32/1/rata-rata-lama-sekolah.html>
- Statistics Indonesia. (2023). Indeks Pembangunan Manusia Menurut Kabupaten/Kota 2021–2023. <https://jatim.bps.go.id/indicator/26/36/1/ipm.html>
- Tempo. (2022). <https://en.tempo.co/read/1665831/kpk-names-bangkalan-regent-as-suspect-of-corruption>
- The Jakarta Post. (2009). <https://www.thejakartapost.com/news/2009/06/17/suramadu-toll-fees-go-effect-today.html>
- Timilsina, G., Stern, D. I., & Das, D. K. (2024). Physical infrastructure and economic growth. *Applied Economics*, 56(18), 1–16. <https://doi.org/10.1080/00036846.2023.2184461>
- Wang, C., Lim, M. K., Zhang, X., Zhao, L., & Lee, P. T. W. (2020). Railway and road infrastructure in the Belt and Road Initiative countries: Estimating the impact of transport infrastructure on economic growth. *Transportation Research Part A: Policy and Practice*, 134, 288–307. <https://doi.org/10.1016/j.tra.2020.02.009>
- Xu, Y., & Zhu, S. (2024). Transport infrastructure, intra-regional inequality and urban-rural divide: Evidence From China's high-speed rail construction. *International Regional Science Review*, 47(3), 378–406. <https://doi.org/10.1177/01600176231177672>
- Younsi, M., & Bechtini, M. (2019). Does good governance matter for FDI? New evidence from emerging countries using a static and dynamic panel gravity model approach. *Economics of Transition and Institutional Change*, 27(3), 841–860. <https://doi.org/10.1111/ecot.12224>
- Zergawu, Y. Z., Walle, Y. M., & Giménez-Gómez, J. M. (2020). The joint impact of infrastructure and institutions on economic growth. *Journal of Institutional Economics*, 16(4), 481–502. <https://doi.org/10.1017/S1744137420000016>
- Zhang, J., Zhang, R., Xu, J., Wang, J., & Shi, G. (2021). Infrastructure investment and regional economic growth: Evidence from Yangtze River Economic Zone. *Land*, 10(3), 320. <https://doi.org/10.3390/land10030320>
- Zhang, Y., & Cheng, L. (2023). The role of transport infrastructure in economic growth: Empirical evidence in the UK. *Transport Policy*, 133, 223–233. <https://doi.org/10.1016/j.tranpol.2023.01.017>
- Zheng, D., & Kuroda, T. (2013). The role of public infrastructure in China's regional inequality and growth: A simultaneous equations approach. *The Developing Economies*, 51(1), 79–109. <https://doi.org/10.1111/deve.12003>