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DOES INFRASTRUCTURE INVESTMENT REMAIN AN EFFECTIVE EXPANSIONARY TOOL? BASED ON THE GREEN ECONOMY GROWTH PERSPECTIVE

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ABSTRACT

In the post-COVID-19 pandemic era, boosting the economy through infrastructure investment has emerged as an imperative tool. Apart from coping with the downward pressure on the economy caused by the pandemic, governments are concerned about green economic growth. Using data for 30 provincial-level administrative regions in China, we examine the impact of infrastructure investment on green economic growth. Our findings are as follows. Infrastructure investment significantly inhibits green economic growth; we discover this outcome to be robust. The impact of infrastructure investment on green economic growth differs for different regions. The negative effect of infrastructure investment on green economic growth is substantial in the central-western region, but it is found to be statistically insignificant in the eastern regions.

Keywords: Post-epidemic era; Infrastructure investment; Green economic growth; Regional heterogeneity.
JEL Classification: O1; O18.

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I. INTRODUCTION

The outbreak of the COVID-19 resulted into a severe global public health emergency in early 2020 and it had a powerful detrimental impact on the world economy (see Narayan 2021; Phan and Narayan, 2020; Sha and Sharma, 2020, and Sharma and Sha 2020). The recovery of an economy in the post-COVID-19 period has become an international concern and challenge for governments. In this context, various economies have successively implemented various economic stimulus policies and targeted investment plans to impel the economy to return to regular operations faster. In China, the Central Political Bureau meeting in 2020 suggests that "*greater macro policy efforts should be made to hedge against COVID-19 shock, and active fiscal policy should be more positive and proactive*."[1] Also, large-scale infrastructure investment has been an essential fiscal tool for boosting economic growth and stimulating counter-cyclical economic adjustment. From the historical experience, the Chinese government, coping with the financial crisis and downward economic pressure, has repeatedly implemented policies to expand domestic demand and increase investment in infrastructure construction to ameliorate economic conditions in 1998, 2008, and 2012, respectively. Facing the current COVID-19 shock, China will reactivate a new round of infrastructure construction to ensure economic growth and employment stability and alleviate the pandemic's adverse effects on the economy.

Meanwhile, the global climate is under serious challenge. China officially declared at the UN General Assembly in September 2020 the "double carbon" goals of reaching a carbon peak by 2030 and neutral by 2060, demonstrating China's commitment and determination in tackling climate matters. The green economy is the inevitable path to crack the current carbon emission constraint and accelerate the economic transition. The Chinese government has consistently emphasized green development. The 19th National Congress has elevated the green development theory to the height of national development strategy. The 14th Five-Year Plan also explicitly requires sustained improving environmental quality, accelerating the green transformation of development mode, and vigorously developing green economy. Expansionary policies can effectively and quickly mitigate the negative economic impact of the new crown Pandemic. However, such economic stimulus that mainly focuses on infrastructure construction has hastened the expansion of high-emission and heavy-polluting industries such as construction, steel, and cement, which may impede green economy development. After evaluating the fiscal policies of nations around the world in response to the 2008 financial crisis, scholars have found that blindly implementing large-scale economic stimulus policies without green and low-carbon guidance can trigger a rapid rebound in carbon emissions during the economic recovery process (Peters *et al*., 2012). There is no such study which examines whether the current infrastructure development in China hinders the green economy development. Additionally, it is also important to understand if there is a heterogeneous effect of infrastructure development on green economy development at different geographic locations.

The above issues urgently require answers and solutions. Therefore, this paper quantifies the impact of infrastructure investment expansion on the green economy

[1] Sources: https://www.gov.cn/xinwen/2020-03/30/content_5496969.htm

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utilizing the dataset of 30 provincial-level administrative regions in China over the period 2011 to 2019, intending to contribute a helpful reference and judgment basis for economic policy practice and green economy development in China's post-COVID-19 era. It is clear from the analysis of existing studies that there is insufficient academic discussion on the impact of infrastructure investment on the green economy in the context of the epidemic. This study investigates the impact of infrastructure investment on green economic growth by utilizing a dataset of 30 provincial-level administrative regions in China. This not only provides strong empirical support for relevant decision-making, but also helps to deepen the understanding of the relationship between infrastructure investment and green economic development, and provides an important reference for local governments to formulate differentiated infrastructure investment policies, which is of great policy revelation significance.

The remaining structure of the research framework is as follows: Part 2 is a literature review. Part 3 will introduce the concept of constructing the empirical model, along with the measurement methods and data sources for relevant variables. Following this, Part 4 will delve into the empirical analysis and performing robustness tests. Finally, drawing from the existing findings, the study will conclude with comprehensive conclusions and policy recommendations.

II. LITERATURE REVIEW

A. Infrastructure Investment and Economic Growth

Infrastructure development is the critical base for economic development and the core driver of economic growth in a particular country or region at a particular stage. Adam Smith once argued in "The Wealth of Nations" that well-developed infrastructure is crucial in developing business and promoting economic growth and is one of the government's core functions (Tribe, 2008). As development economics emerged, several theories on the link between infrastructure construction and economic development were developed, the most well-known of which is the "Big-Push" theory proposed by Rodin (Xueliang, 2013). This theory considers infrastructure investment as a prerequisite for economic growth. Since then, scholars have widely adopted econometric methods to empirically investigate the relationship between infrastructure investment and regional economic growth, which has yielded into abundant research findings (Aschauer, 1998; Merriman, 1991; Bronzini and Piselli, 2009). Most scholars agree that infrastructure investment can significantly contribute to regional economic growth. For example, Bronzini and Piselli (2009) argue that infrastructure investment facilitates economic growth in both the short- and long-run. In the short-run, infrastructure investment is effective in generating employment, increasing income, and promoting economic expansion through multiplier effects; however, infrastructure in the long-run can both absorb long-term employment and increase income through operation and maintenance, and reduce transaction costs of enterprises, improve productivity, and thus, promote economic growth. A number of studies classified infrastructure and explored the promotion effects of different types of infrastructure investment such as transportation, energy, electrical, and communication on regional economic growth (Lakshmanan, 2011; Cook, 2011; Xu *et al.*, 2021; Heeks, 2010). Arndt (2001), from the perspective of international trade, argues that infrastructure investment can strengthen the interconnection between countries, effectively integrate the production supply chain of different countries, and thus, accelerate international and regional economic growth. Of course, some studies document that infrastructure investment does not always contribute significantly to economic growth. Bougheas *et al*. (2000) find an inverse U-shaped nexus between infrastructure investment and economic growth, i.e., when infrastructure investment size exceeds a certain threshold, its contribution to economic growth diminishes.

Nevertheless, most developing countries are still on the upward part of the curve because of the general underinvestment in infrastructure in developing countries. According to Scott's economic growth model, Riedel *et al*. (2020) verify that infrastructure investments of different sizes may have opposite effects on economic growth. This is because infrastructure investment is beneficial to economic growth and simultaneously has a crowding-out effect on other investment types. Therefore, when infrastructure investment reaches a specific size, it can hinder economic development for longer.

B. Infrastructure Investment and Green Economic Growth

Green growth was firstly defined by the United Nations in 2005, which identified the green economy as an environmentally sustainable economic process adopted to promote low-carbon, beneficial development for all members of society (Dogan *et al*., 2022). Compared with the traditional economy, the green economy incorporates the ecological environment and economic growth under the same objectives and aims at the balanced development of the two (Lin and Zhou, 2022). By analyzing the existing literature, it is found that the current research on the relationship between infrastructure investment and green economic growth is mainly performed based on the perspective of transportation infrastructure investment and communication infrastructure investment. From the perspective of transportation infrastructure investment, some studies document that the continuous improvement of transportation infrastructure will be beneficial to property prices, and facilitate real estate and construction industries, thus, promoting economic growth but also resulting in carbon dioxide emissions (Billings, 2011; Gibbons and Machin, 2005; Dubé *et al*., 2013). Moreover, as the transportation infrastructure improves, it can not only effectively stimulate labour flow in the region and raise work efficiency but also create a strong "siphon effect" to attract high-level talents to gather and elevate human capital level, thus improving green economic efficiency to a certain extent (Agénor and Neanidis, 2014; Ganda, 2022). However, some past studies also show that a moderate range of human capital aggregation contributes to green economic growth, but after a specific threshold is exceeded, it dampens green economic efficiency (Hao *et al*., 2021). Lastly, transportation infrastructure developments have altered the mode and intensity of public travel. As the popularity of personal automobiles and public travel frequency has risen, transportation's contribution to environmental pollution has become an essential source of environmental pollution after industrial production (Liang *et al*., 2019). At the communication infrastructure investment level, information infrastructure

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investment can improve green economy efficiency by alleviating information asymmetry problems, reducing transaction costs, improving management efficiency, and promoting industrial digital transformation (Lyu *et al*., 2022).

Along with the continuous improvement of the communication infrastructure, the ICT industry is also proliferating, but the ICT industry's development brings huge energy consumption problem. Simulation projections of energy consumption in the ICT sector by Andrae and Edler (2015) reveal that the ICT sector's electricity consumption share interval will increase to 8% -51% in 2030 under three different scenarios: high, medium and low. Under the least optimistic state, the ICT sector will account for 23% of total Green house gasemissions in 2030, severely hindering a green economy. Takase and Murota (2004) argue that ICT industry development, despite improving energy efficiency at the micro-level, still increases total energy consumption at the macro level.

III.METHODOLOGY

A. Economics Strategies

To investigate the impact of infrastructure investment on green economic growth, we refer to Hao *et al*. (2022), and propose the following benchmark regression model:

$$GE_{it} = \alpha_0 + \alpha_1 IN_{it} + \alpha_2 X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

The subscripts i and t represent regions and years, respectively; GE_{it} is the dependent variable, denoting the green economic growth level of region i in year t. IN_{it} is the core explanatory variable, indicating the infrastructure investment of region i in year t; X_{it} represent control variables, indicating a set of variables affecting green economic growth; μ_i and γ_t are individual and time fixed effects, controlling for the effects of unobserved individual characteristics and year characteristics, respectively.

B. Variables Selection

B. I. Dependent Variable

This paper employs green total factor productivity levels to characterize green economic growth (GE). To ensure the accuracy and rationality of the measurement as much as possible, the super-efficient SBM model is chosen to calculate the green economic growth for each province after comparing the existing measurement methods. The input-output variables are selected as follows. Capital input is denoted by the size of fixed assets at year-end. The total number of employees at year-end is represented as its labor input. The year-end total energy consumption is taken as its energy input. GDP is adopted as the desired output. Carbon emissions are considered as undesired outputs. Because of the potential impact of price variations on calculation results, this paper deflates the above data by taking 2010 as the base period.

B.II. Core Explanatory Variables

Infrastructure investment (IN) indicators are classified into two groups: flow and stock. Since this paper emphasizes on the marginal effect of infrastructure investment, the flow indicator is mainly adopted here given that the primary subject of the government's expansionary investment policy is infrastructure like transportation and communication. Therefore, annual data on transportation, warehousing, and postal and telecommunication industries from the China Fixed Asset Investment Statistical Yearbook are used as proxies for infrastructure investment.

B.III. Control Variables

We follow studies by Wu *et al*. (2021), Wang *et al*. (2022), and Yin *et al*. (2022) select the following control variables. (1) Technological Innovation (TI) is denoted by the number of patents granted. (2) Energy Structure (ES) is denoted using the share of coal consumption in primary energy consumption. (3) Industrial Structure (IS) is expressed using the ratio of the value-added of the three industries to the value-added of the second industry. (4) The urbanization rate (CI) is expressed using the ratio of year-end resident population to the total population. (5) Environmental regulation (Er) is expressed using the green rate of built-up areas.

C. Data Sources

This paper opts for balanced panel data of 30 provincial administrative regions in China over the period 2011 to 2019. The original data are all derived from the China Statistical Yearbook, China Energy Statistical Yearbook, China Population and Employment Statistical Yearbook, provincial statistical yearbooks, and relevant data issued by the National Bureau of Statistics in previous years. Detail description of all variables used in this study is given in Table 1.

Table 1.
Variables Descriptive Statistics

The table presents the descriptive statistics for the sample of this paper and lists the sample size, mean, standard error, maximum and minimum values together.

Name	Meaning	N	Mean	SD	Min	Max
GE	green economic growth	270	-0.459	0.369	-1.204	0.285
IN	Infrastructure investment	270	7.190	0.782	4.673	8.757
TI	Technological innovation	270	5.200	7.616	0.010	52.74
ES	Energy structure	270	0.399	0.148	0.010	0.690
IS	Industrial structure	270	1.178	0.667	0.520	5.150
CI	Urbanization rate	270	0.577	0.122	0.350	0.900
ER	Environmental regulation	270	0.394	0.036	0.280	0.490

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IV. RESULTS AND DISCUSSION

A. Baseline Regression Results and Discussion

Table 2 reports results obtained using an OLS regression model which examines the impact of infrastructure investment on green economic growth. The benchmark model without any control variables is presented in column (1), and control variables such as technological innovation, energy structure, industrial structure, urbanization rate, and environmental regulation are added sequentially from column (2) to column (6). When control variables are successively introduced, the coefficient of infrastructure investment remains negative and statistically significantly with decreasing coefficient values. In contrast, the significance and coefficient values of other control variables do not significantly change, which to a certain extent reflects the reliability of the estimated results. The above results imply that infrastructure investment in China at this stage significantly inhibits green economic growth. Large-scale infrastructure construction facilitates the expansion of high-carbon industries such as construction, metals, and cement exerts additional pressure to reduce emissions, thereby inhibiting green economic growth. Expansion of high-carbon industries will contribute to resource flows to those sectors where factor resources are reallocated, hindering low-carbon industries to a certain extent and inhibiting green economic growth. Moreover, traditional infrastructure has a more substantial carbon lock-in effect. For example, with the continuous improvement of transportation facilities, the consumption of private cars and trips by residents will be stimulated further. Moreover, with the deepening of communication and internet infrastructure, data centers are increasingly energy-intensive, thus contributing to carbon emissions.

Table 2.
Baseline Regression Results

This table presents the results of the baseline regression. Standard errors are reported in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% level, respectively.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
IN	-0.081***	-0.080***	-0.076***	-0.073***	-0.064**	-0.062**
	(0.024)	(0.024)	(0.024)	(0.025)	(0.027)	(0.027)
TI		-0.001	-0.001	-0.001	-0.002	-0.002
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ES			-0.175	-0.198	-0.200	-0.196
			(0.186)	(0.188)	(0.189)	(0.188)
IS				0.034	0.011	0.015
				(0.045)	(0.053)	(0.053)
CI					-0.491	-0.560
					(0.601)	(0.600)
ER						0.925*
						(0.537)
Constant	-0.065	-0.067	-0.011	-0.056	0.174	-0.162
	(0.156)	(0.156)	(0.167)	(0.177)	(0.333)	(0.385)
Individual fixed	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes	Yes	Yes	Yes
Observations	270	270	270	270	270	270
R-squared	0.410	0.411	0.413	0.414	0.416	0.424
Number of Regions	30	30	30	30	30	30

B. Robustness Test Results and Discussion

The public welfare attributes of public infrastructure determine its construction and operation without government financial subsidies, i.e., economic development is the basis for infrastructure investment. Regions will only have sufficient funds to support public infrastructure expansion when they are in a good economic position. Regions will only have sufficient funds to justify the expansion of public infrastructure when they are experiencing good economic development. Therefore, there may be a potential bidirectional causality link between infrastructure investment scale and green economic growth, which can potentially cause endogeneity problems. A popular technique to tackle bidirectional causality is to select appropriate instrumental variables for analysis, of which the selection of instrumental variables requires two essential conditions of correlation and homogeneity. Referring to Wu *et al*. (2021), this paper utilizes the lagged terms of the core explanatory variables as instrumental variables (see column (1) of Table 3). Judging from the first stage results, the coefficients of the instrumental variables are reported statistically significant at the 1% statistical level, meeting the instrumental variable correlation requirement (F-value > 10), which is not plagued by weak instrumental variables. Judging from the second stage results, the coefficient of infrastructure investment remains negative and statistically significant, confirming that the baseline regression model results are robust. Moreover, this paper also adopts the following three approaches for robustness test. First, the system generalized method of moments (SYS-GMM) method is employed to re-estimate the results. Since green economic growth is subject to multiple factors, the empirical analysis cannot include all the influencing factors thus, omitted variables issue may cause the estimation results to be biased (see column (2) of Table 3). Second, the core explanatory variables are replaced. The amount of infrastructure investment per capita is employed as a proxy for the core explanatory variables for robustness tests (see column (3) of Table 3). Finally, a tailoring method is used to test the results after intercepting the extreme values. To tackle the potential influence of outliers on the results, all variables are scaled down at the 5% level (see column (4) of Table 3). Columns (2) to (4) of Table 4 reveal significantly negative coefficients of core explanatory variables, confirming that the benchmark results are robust.

Table 3
Robustness Test Results

This table presents the results of the model robustness test. Standard errors are reported in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% level, respectively.

Variables	(1)	(2)	(3)	(4)
L.GE		0.750***		
		(0.026)		
IN	-0.087**	-0.026***	-0.053**	-0.075***
	(0.036)	(0.006)	(0.026)	(0.027)
AR(2)-p		0.895		
Hansen Test-P		0.314		
IV	0.725***			
	(0.052)			

Table 3
Robustness Test Results

Variables	(1)	(2)	(3)	(4)
Wald-F	195.34			
Control variables	Yes	Yes	Yes	Yes
Individual fixed	Yes		Yes	Yes
Time fixed	Yes		Yes	Yes
Observations	240	240	270	270
R-squared	0.355		0.421	0.428
Number of Regions	30	30	30	30

C. Heterogeneity Results and Discussion

Given the persistent socioeconomic disparities among regions in China, the impact of infrastructure investment on green economic growth can be heterogenous while considering different regions. Therefore, this paper divides the entire sample into two regions: eastern and central-western groups (see Table 4). Results reported in Table 4 shows that the coefficients of infrastructure investment are all negative, with coefficient values in the eastern region being more prominent than those in the central-western region. In contrast, the coefficient of infrastructure investment in the eastern region does reject the significance test. One potential explanation is that the economic development level of the eastern region is much higher than that of the central and western regions, whose technological reserves and technological innovation levels are more substantial. Therefore, it has a more robust green technology capability during infrastructure construction, which mitigates to a certain extent resulting into the negative impact on the green economy due to infrastructure investment. There are specific differences in the local governments' implementation of governmental functions. Due to the economic backwardness of the central and western regions, local governments emphasize their economic functions and tend to invest more in economic infrastructure, thus ignoring environmental infrastructure construction, which hinders green economy development. Finally, the competition effect impels local governments' infrastructure investments to extrude public spending on environmental protection, education, science and technology that can significantly facilitate green economic growth. However, since the eastern region is in a significantly better financial position than the central and western regions, it is less affected by the competition effect, so its infrastructure investment has a significantly smaller inhibitory effect on green economic growth.

Table 4.
Heterogeneity Results

This table presents the Results of the heterogeneity test for the study sample. Standard errors are reported in parentheses. ** denote statistical significance at 5% level.

Variables	(1)	(2)
	Eastern	Central-western
IN	-0.068	-0.071**
	(0.050)	(0.030)
Constant	-0.463	0.269
	(0.858)	(0.455)
Control variables	Yes	Yes
Individual fixed	Yes	Yes
Time fixed	Yes	Yes
Observations	108	162
R-squared	0.438	0.516
Number of Regions	12	18

V. CONCLUSIONS AND POLICY RECOMMENDATIONS

As a primary policy tool to combat the economic downturn, increasing infrastructure investment has been a critical tool to counter-cycle and stabilize economic growth. In addition to dealing with the downward economic pressure caused by the pandemic, the world's economies face the critical climate change issues. Therefore, to investigate the association between more assertive infrastructure investment behaviour and green economic growth in the post-pandemic era, this paper employs an OLS model to examine the effect of infrastructure investment on the green economy using data for 30 provincial-level administrative regions in China over the period 2011 to 2019. The main conclusions are as follows: The effect of infrastructure investment on green economy growth is significantly negative, suggesting that infrastructure investment significantly inhibits green economic growth. We have undertaken number of robustness check and our findings remain consistent and robust. Significant regional differences are observed while considering the impact of infrastructure investment on green economic growth for two regions. The negative effect of infrastructure investment on green economic growth is reported statistically significant in the central-western region but found to be statistically insignificant in the eastern region.

Based on the above findings, this paper suggests several policy recommendations. First, the scale of infrastructure investment should be sensibly managed. Appropriate investment should be provided in regions with inadequate infrastructure and urgent need for improvement to optimize local infrastructure and public convenience. In contrast, regions with infrastructure significantly above the optimal local scale should decrease infrastructure investment and switch to tax cuts and subsidies to stabilize economic recovery.

Second, expanding the share of green and low-carbon projects in infrastructure development. Infrastructure usually has a carbon lock-in effect in the long-run. As infrastructure has energy utilization and pollution emissions after completion, they will both exist in the long-term operation process. Therefore, policymakers should focus on green upgrading of infrastructure, including renewable energy, green infrastructure represented by forests, parks, green belts, greenways and ecological reserves, water purification facilities, sponge city facilities, etc. These green infrastructures may hinder green economic growth during construction, but they will significantly contribute to green economic growth in the long-run.

Third, policymakers should guide the industries associated with infrastructure construction to engage in green transformation. A primary factor that inhibits infrastructure construction's green economic growth level is the Pollution produced by its intermediate product in the construction process. Such railroad, highway and other road infrastructure construction, in addition to the construction process, directly produced a considerable amount of pollution. Meanwhile, it consumes many intermediate products such as cement and steel in their construction process, while these intermediate products will also produce a considerable amount of pollution in their production process. Therefore, policymakers should elevate the participation threshold of related industries and force green transformation to promote green economic growth.

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