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Does New Infrastructure Influence Corporate ESG Performance?

-- An Empirical Analysis from a Quasi-Natural Experiment on "Smart City" Policies

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Abstract

Based on the data of China's A-share listed companies from 2009 to 2021, this paper examines the relationship between new infrastructure construction and corporate ESG performance and its mechanism of action using a multi-period double-difference model and a mediation effect model based on a quasi-natural experiment with the pilot policy of "smart city". The results of the study show that new infrastructure construction has a significant contribution to corporate ESG performance, and the conclusion still holds after the robustness tests such as multi-period parallel trend test, PSM-DID, and placebo test. Heterogeneity analysis reveals that new infrastructure construction has a stronger enhancement effect on the ESG performance of state-owned enterprises, large enterprises and enterprises in light pollution industries. The results of the impact mechanism test show that new infrastructure construction promotes the ESG performance of enterprises through three channels, namely, facilitating the digital transformation of enterprises, increasing the R&D investment of enterprises, and improving the government's concern for the environment. The findings provide countermeasure suggestions for optimising new infrastructure construction and promoting enterprises' green transformation.

Keywords

New Infrastructure Construction; Smart City; Corporate ESG Performance; Digital Transformation.

1. Introduction

In recent years, new infrastructure has increasingly become an important force for China to achieve high-quality development.At the end of 2018, the Central Economic Work Conference proposed for the first time to "accelerate the pace of 5G commercialisation, and strengthen the construction of new infrastructure such as artificial intelligence, industrial Internet, and Internet of Things". Marking the shift from traditional infrastructure to new infrastructure, China has elevated information technology and intelligent development to the new focus of infrastructure construction.In 2020, the Development and Reform Commission formally clarified the three major directions of new infrastructure, namely, information infrastructure, convergence infrastructure, and innovation infrastructure, and the State Council's government work report emphasised the need to strengthen the construction of new infrastructure at the same time. The important role of new infrastructure is further highlighted. 2021, the Central Economic Work Conference clearly put forward to "accelerate the construction of new infrastructure" as an important means of expanding domestic demand and promoting scientific and technological innovation. The construction of new infrastructure has begun to rise to the level of national long-term strategy, and its impact has gradually penetrated into many areas of the economy and society. Cities are the core carriers of new infrastructure construction and

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technological innovation, and in 2012, the General Office of the State Council issued the "National Pilot Programme for the Construction of Smart Cities", which initiated the pilot work of smart cities nationwide, which can be regarded as one of China's early attempts in the field of new infrastructure construction [1]. This is because the two are consistent in their strategic objectives, as both are committed to promoting the modernisation of urban governance, enhancing public service efficiency, optimising resource allocation and promoting green and low-carbon development through technological innovation; they are coordinated in their development direction, as the digital and informatised construction of new infrastructures is able to meet the demand for the transformation of the smart city from traditional infrastructures to smarter, informatised systems; and they are coordinated in their green and low-carbon development. Demand; in the green low-carbon development has linkage, the green development goal of the smart city can not be separated from the support of the new infrastructure, smart grid, green building, smart water and other new infrastructure construction for the smart city to achieve the green development of the technology and resources to provide protection. Therefore, smart cities and new infrastructure construction are complementary and inseparable, and can be regarded as a pioneer exploration and useful attempt of "new infrastructure". Based on this, this paper takes the national "smart city" pilot policy as a quasi-natural experiment of new infrastructure construction, and applies a multi-period double-difference model to effectively identify the causal relationship between new infrastructure construction and corporate ESG performance.

As an important indicator of corporate sustainability, ESG (environmental, social and corporate governance) is one of the most popular topics in contemporary research. Against the backdrop of global climate change and sustainable development becoming an international consensus, low carbon economy has become a new focus of cooperation and competition among countries. In the United Nations General Assembly in September 2020, China explicitly proposed the "dual-carbon" goal of achieving carbon peak by 2030 and carbon neutrality by 2060, which is a major strategic decision for China to promote the transformation of its economic structure and to achieve sustainable development [2].The Government Work Report of 2023 further proposed that we should adhere to green development, promote the construction of a green and low-carbon economic system, and endeavour to promote a comprehensive green transformation of economic and social development. Green development is not only a national strategy, but also an intrinsic requirement of the economy and society, and green low-carbon will become an important engine to promote high-quality economic development. In this context, enterprises are not only the consumers of natural resources, the emitters of pollution, but also the promoters of low-carbon transformation, the realiser of low-carbon economy, and also the builders and operators of smart cities, so it is particularly important to comprehensively enhance the role of enterprises in low-carbon transformation. With the practice and development of ESG concept, enterprises and investors pay more and more attention to sustainability indicators in the process of investment decision-making, and improving ESG performance of enterprises has become an important way for green transformation and sustainable development of the real economy [3]. Does new infrastructure development promote corporate ESG performance? What are the main pathways through which it works? Exploring these questions will provide theoretical support for the construction of the intrinsic link between new infrastructure construction and corporate ESG performance, and exploring the possible paths to enhance corporate ESG performance from the perspective of new infrastructure will provide new ideas for the comprehensive green transformation of the economy.

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2. Literature Review

(1) Policy Background

The concept of smart city was first systematically proposed in the 12th Five-Year Plan. In this plan, the state explicitly proposed to "strengthen the construction of urban infrastructure, promote the construction of smart cities, and use information technology to improve the intelligent level of urban management". In 2012, the General Office of the State Council issued the National Pilot Programme for the Construction of Smart Cities, officially launching the pilot programme for smart cities. The programme states that the construction of smart cities should be based on informatisation, with an emphasis on intelligent urban management, public services and economic and social development. The implementation of the pilot programme has promoted the practice of smart city construction by local governments, accumulated a large amount of experience in smart city construction, and laid the foundation for the nationwide promotion of smart cities.In 2016, the State Council released the "13th Five-Year Plan for National Science and Technology Innovation", which proposes to "speed up the the deep integration of information technology and urban construction, and promote the development of smart cities". At this stage, the concept of smart city is not only limited to infrastructure construction, but also emphasises the in-depth application of information technology and the intelligent transformation of urban management. The report of the 20th National Congress clearly pointed out that "we should promote the green transformation of urban and rural construction methods and build livable, resilient and smart cities". It can be seen that the construction of smart cities is a systematic, long-term strategic initiative that not only focuses on solving the sustainable development problems of the current urbanisation process, but is also a core development path for future socio-economic transformation and technological change.

(2)Theoretical analysis and hypothesis research

New infrastructure relies on digital technology and intelligent technology to serve the modern infrastructure system of high-quality development, which is the key to distinguish it from traditional infrastructure. Sheng Lei et al. [4]found that the new type of infrastructure is supported by digitalisation and intelligence, which is a new structural force in the digital era. Shen Kunrong et al. [5]found that new infrastructure provides strong support for the transformation of China's industrial structure by nurturing new industries and empowering traditional industries. The new infrastructure provides a technical base and realisation path for the construction of the smart city, and the smart city is an important application scene and practice direction of the new infrastructure. Specifically: the information infrastructure 5G network, Internet of Things and data centres provide technical support for real-time data collection, transmission and analysis in smart cities. Smart traffic, smart energy scheduling and other scenarios in smart cities rely on the construction of converged infrastructure. The scientific and technological research and development results of new infrastructure then directly promote the upgrading of smart city technology applications. The construction of new infrastructure improves the technical level of smart cities, and the continuous iteration of smart cities provides rich practical needs for new infrastructure, forming a mutually reinforcing relationship between the two. Therefore, the smart city pilot provides a valuable quasi-natural experiment for this paper to carry out empirical research.

New infrastructure construction covers a wide range of fields such as 5G base station construction, extra high voltage, artificial intelligence, and industrial internet. By participating in new infrastructure projects, enterprises can, on the one hand, improve their R&D capability and technology level by taking advantage of the technological upgrades and market demand brought about by the new infrastructure. On the other hand, they can obtain tax incentives and special subsidies, etc., provided by the government to motivate enterprises to achieve

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breakthroughs in key technologies of new infrastructure[6]. R&D innovation can not only drive the growth of business performance but also play an important role in the low-carbon green development of enterprises. Pan Yaru et al. [7]argued that the construction of new infrastructures can promote the full flow of technological knowledge in the innovation system, and promote innovation sharing, synergy and spillover. Meanwhile, R&D innovation is an important means for enterprises to improve their environmental performance. Yu Desheng et al. [8]believe that the construction of new infrastructure can promote the incremental quality of enterprise green innovation. By developing more environmentally friendly products and production processes, enterprises can reduce energy consumption and waste emissions, and reduce the negative impact on the environment. In addition, R&D innovation empowers firms with high levels of R&D innovation with stronger information collection and screening capabilities, enabling them to integrate and utilise existing resources more effectively to improve their ESG performance [9].

Compared with traditional infrastructure, new infrastructure pays more attention to the deep integration of information technology, scientific and technological innovation and the real economy, and provides solid support and strong power for digital transformation by building an efficient, intelligent and sustainable infrastructure system. This paper explores how new infrastructures act as a catalyst for digital transformation and empower corporate ESG performance. New infrastructures are centred on advanced technologies such as 5G, artificial intelligence, big data centres, and industrial internet, which not only represent cutting-edge developments in information technology, but are also key drivers of digital transformation. Wang Hai et al. [10]found that the construction of digital infrastructure can promote market competition in the region and promote the development of software and information technology services, as a way to provide support for enterprises to digital transformation. The digital transformation of enterprises can achieve accurate management and optimisation of operational processes, which can significantly improve the productivity of enterprises and reduce operational costs, enabling them to provide higher quality products and services at lower costs. At the same time, digital transformation can also help enterprises achieve transparency and intelligence in the supply chain and improve the responsiveness and flexibility of the supply chain, and this efficient and flexible operation mode provides enterprises with more resources so that they can more actively invest in the fulfilment of their ESG responsibilities. Digital transformation also greatly improves the perceptive ability of enterprises. With advanced technologies such as the Internet of Things (IoT) and sensors, enterprises are able to obtain detailed data on production, logistics, sales, and other aspects in real time, so that they can more accurately grasp market dynamics and customer needs. This strong perceptual ability enables enterprises to identify and solve problems that may affect ESG responsibilities in a timely manner[11].

The government often needs to consider factors such as environmental protection, resource conservation and ecological balance during the planning and implementation of new infrastructure construction, thus indirectly increasing the government's concern for the environment. When the government pays high attention to environmental issues, it often introduces a series of environmental policies and regulations or incentives, such as environmental tax incentives and green credits, to prompt enterprises to pay attention to environmental protection. As an important external stakeholder of enterprises, the government can play the role of leading, restraining and supervising the behaviour of enterprises [12], and enterprises, out of the considerations of maintaining a good relationship between the government and enterprises and obtaining the support of investors, will produce the behaviours and motives of catering to the environmental regulation and restraining their own emission behaviours, which will promote the improvement of the performance of enterprises' ESG.

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Based on the analysis of the above theoretical mechanisms, this paper proposes the following research hypotheses.

Hypothesis 1: New infrastructure construction can enhance corporate ESG performance.

Hypothesis 2: New infrastructure construction can improve corporate ESG performance by increasing corporate R&D investment.

Hypothesis 3: New infrastructure construction can improve corporate ESG performance by promoting digital transformation and upgrading of enterprises.

Hypothesis 4: The construction of new infrastructure can improve corporate ESG performance by increasing the government's concern for the environment.

3. Research Design

(1)Sample Selection and Data Source

The sample used in this paper is the data of all A-share listed companies during the period of 2009-2021, and the samples of financial industry, ST, PT and other industries and those delisted during the period and those with serious missing main variables are excluded. Meanwhile, in order to control the influence of extreme values, this paper carries out the shrinking treatment of 1% up and down on the continuous variables involved, and finally obtains a total of 19,903 observations from 1,531 enterprises. In this paper, the relevant data at the enterprise level are mainly from the Cathay Pacific database (CSMAR), and the CSI ESG rating data are from the Wind database.

(2)Model Construction

Since China's smart city construction is carried out in annual batches, the traditional "one-size-fits-all" double-difference method is not suitable for assessing the effects of multi-temporal policies. In order to effectively identify the impact of new infrastructure on the ESG performance of enterprises, we borrowed the practice of Fang Fuzian et al. [13]to construct a multi-period double-difference fixed-effects model. model:

$$ESG_{i,t} = \alpha_0 + \alpha_1 NI_{i,t} + \sum \alpha Controls_{i,t} + YearFM + FirmFE + \varepsilon_{i,t} \tag{1}$$

Where, i represents firms, t represents time, the explanatory variable is ESGi,t, measured by CSI ESG rating index; NIi,tis the core explanatory variable, if the city where a firm is located is selected as a pilot city for the "smart city" policy, NIi,twill take the value of 1 in the current year and the following years, and the rest of the years will be 0; Controls (i,t)is the core explanatory variable; NIi,tis the core explanatory variable. Controls i,tis the set of control variables, including equity concentration, cash ratio, financial leverage, etc.; εi,tis the random error term; this paper controls for annual and individual fixed effects in the regression, and in order to make the statistical results more robust, the standard error is adjusted for clustering at the enterprise level.

(3)Variable Selection and Data Description

1) Corporate ESG performance

This paper draws on Fang, Xianming and Hu, Ding [14], and adopts the CSI ESG rating system index to measure corporate ESG performance. The CSI ESG rating system index is firstly derived from the three ratings of Environment (E), Society (S) and Governance (G) to obtain the total scores, and the ratings are divided into nine grades from C-AAA, with each grade being assigned with a score from 1 to 9, and the total scores are then aggregated according to the weighting of the index to determine the corporate ESG specific index. The total score is then aggregated by weighting to determine the corporate ESG specific index.

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2) Smart City Pilot Policy

Smart city construction is an important policy for the state to promote digital transformation and enhance urban governance capacity. The state has started smart city pilot construction since 2012, and as of 2015, there have been three batches with a total of multiple cities (districts, counties and towns) included in the pilot list. Smart city construction is an important practice of new infrastructure construction and a strategic direction for the state to promote modern urban development. [15]Based on this, this paper takes the smart city pilot policy as a proxy variable for new infrastructure construction, when a city becomes a smart city pilot city, NI takes the value of 1 in the current year and the following years, otherwise it is 0. This variable is the cross-multiplier of the pilot city grouping dummy variable treat and the pilot time dummy variable post.

3) Control Variables

According to the existing related studies[16][17] ,this paper sets the common control variables for enterprises, including equity concentration (Topl), cash ratio (Cash), management shareholding ratio (Mgshare), gearing ratio (Lev), book-to-market ratio (Mtb), independent directors' share (IDratio), two jobs (Daul), and firm size (Size). The definitions of the variables in this paper are shown in Table 1.

Table 1. Definition table of main variables

Variable Name	Variable Abbreviation	Variable Definition
Corporate ESG performance	ESG	Measured by the CSI ESG rating, which is divided into nine levels, with AAA assigned a value of 9 and C assigned a value of 1. The higher the value, the better the ESG performance of the enterprise.
Policy implementation dummy variable	NI	If the city where the enterprise is located has been selected as a pilot city for the "smart city" policy, the value will be taken as 1 in the current year and the following years, and the value will be 0 if it has not entered the policy.
Shareholding Concentration	Topl	Number of shares held by the first largest shareholder/total number of shares
Cash Ratio	Cash	Net cash flow from operating activities/total assets
Management shareholding	Mgshare	Number of shares held by management/total shares
Gearing ratio	Lev	Total liabilities/total assets
Book-to-market ratio	Mtb	Book Value/Total Market Value
Independent Director Ratio	IDratio	Number of Independent Directors/Total Board Size
Two positions in one	Daul	Chairman and Managing Director in one position take 1, otherwise take 0
Enterprise Size	Size	Ln (total assets)

4. Empirical Analysis

(1)Benchmark regression results

In this paper, the smart city pilot policy is used as a quasi-natural experiment, and a multi-period double-difference fixed effects model, i.e., equation (1), is used to test the impact of new infrastructure development on firms' ESG performance, which is also estimated using robust standard errors clustered to the firm level. The results are shown in Table 2, where (1) (3) columns show the regression results controlling for firm and year fixed effects, and the regression coefficients of the double-difference term NI are 0.130 and 0.113, respectively, which are significantly positive at the 1 per cent level, and (2) (4) columns show the regression results with the addition of firm, year, and city fixed effects, and the regression coefficients of the double-difference term NI are 0.120 and 0.101, respectively and passed the 5 per cent significance level test. In addition, columns (3)(4) add control variables to (1)(2), in terms of control variables, the regression coefficients of equity concentration (Topl), cash ratio (Cash), management shareholding (Mgshare), independent directors' ratio (IDratio), and firm size (Size) are all significantly positive, which indicates that the higher the equity concentration, the firms with more The regression coefficients of Mgshare, IDratio, and Size are all significantly positive, indicating that the higher the equity concentration, the more abundant cash flow, the higher the proportion of independent directors, and the larger the size of the enterprise, the better the ESG performance. The above results show that new infrastructure construction has a significant contribution to corporate ESG performance, which verifies the previous hypothesis 1.

Table 2. Regression results of new infrastructure development and corporate ESG performance

	(1)	(2)	(3)	(4)
VARIABLES	ESG	ESG	ESG	ESG
NI	0.130***	0.120**	0.113***	0.101**
	(3.07)	(2.73)	(2.74)	(2.33)
Top1			0.268**	0.263**
			(2.30)	(2.24)
(2.24) Cash			0.441*** (2.30)	0.432***
			(4.93)	(4.76)
Daul			-0.077***	-0.075***
			(-2.66)	(-2.56)
IDratio			0.700***	0.689***
			(5.55)	(5.49)
Mtb			-0.239*** (5.49)	0.250*** (-2.81)
			(-2.81)	(-2.81) (-2.95)
Lev			0.423*** -	-0.434*** (-
			(-4.89)	(-4.64)
Mgshare			0.008***	0.007***
			(3.48)	(3.22)
Mgshare 0.008***			0.008***	0.233***
			(14.10)	(14.10) (13.25)
Constant	3.966***	3.966***	-1.334***	-1.711***
	(227.42)	(34.90)	(-3.75)	(-4.54)
N	19903	19903	19903	19,903
R-squared	0.008	0.025	0.066	0.078
City fixed effects	No	No	No	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes

Note: t-values are reported in parentheses; *, **, *** denote significance levels of 10 per cent, 5 per cent and 1 per cent.Standard errors are clustered at the firm level.

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(2) Robustness tests

1) Parallel trend test

Satisfying the parallel trend test is the first prerequisite for assessing the effect of the smart city pilot policy using a multi-period double difference model, i.e., the treatment group selected as a smart city and the control group not established as a smart city do not have a significant difference in the ESG performance of firms or have the same development trend prior to the implementation of the policy. For this reason, this paper conducts a parallel trend hypothesis test, setting 0 for the current period of policy implementation, -1 for the year before implementation, 1 for the year after, and so on. And the samples of the fourth year before the implementation of the smart city pilot policy and the previous year are merged into -4, and the samples of the fourth year after the implementation of the policy and the subsequent year are merged into 4. The results are shown in Figure 1, from which it can be found that the confidence intervals of all periods before the implementation of the policy contain 0, indicating that none of the test results before the implementation of the policy is significant, proving that the evolutionary trend of ESG performance of the two groups of sample companies before the implementation of the policy is basically the same. After the first year of the implementation of the smart city policy confidence interval does not contain 0, the estimated coefficient is significant and positive, indicating that the ESG performance of enterprises in the treatment group and the control group is different, the above results show that the parallel trend test passed.

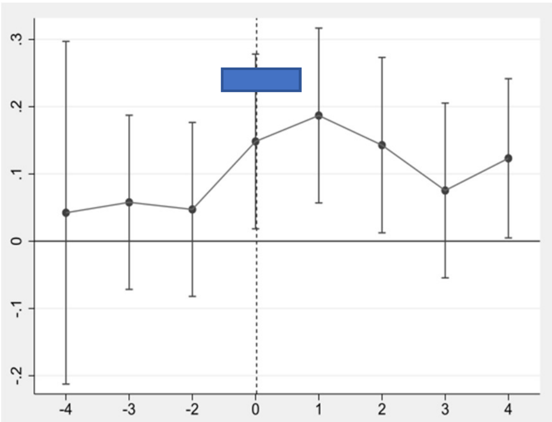

Figure 1. Parallel trend test results

2) PSM-DID

Since smart city is not a natural experiment in the strict sense, there may still be sample selectivity bias, in order to alleviate this interference, this paper firstly adopts the propensity score matching method (PSM) to re-match the samples, and then uses the double difference method to carry out the test. All control variables, i.e., equity concentration (Topl), cash ratio (Cash), management shareholding ratio (Mgshare), gearing ratio (Lev), book-to-market ratio (Mtb), percentage of independent directors (IDratio), two-employee (Daul), and firm size (Size) are firstly used as covariates, whereas, due to the small sample of the experimental group, the matching amount is large In order to avoid the missing information caused by the failure of matching with too many samples, we adopt the practice of [18]to match the experimental group firms to the appropriate control group firms by using 1-to-2 nearest-neighbour matching with put-back. The matching results and balance results are shown in Table 3, from which it can be seen that the absolute value of the standardised deviation after matching is less than 5%, indicating that there is no significant difference between the experimental group and the control group after matching, and the matching method is reasonable.

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Table 3. Balance test results

Variable	Sample	Mean value		Standard error (%)	Decrease in absolute value of standard error (%)	T-test	
		Treatment group	Control group			T-value	P-value
Top1	Unmatched	0.367	0.334	20	98.9	10.43	0.000
	Match	0.367	0.366	0.2		0.08	0.933
Cash	Unmatched	0.161	0.145	13.7	77.3	7.00	0.000
	Match	0.161	0.165	-3.1		-1.15	0.251
IDratio	Unmatched	0.377	0.373	6.5	74.1	3.41	0.001
	Matching	0.377	0.376	1.7		0.63	0.526
Lev	Unmatched	0.503	0.509	-2.2	62.6	-1.10	0.270
	Match	0.504	0.502	0.8		0.35	0.726
Daul1	Unmatched	0.163	0.183	-5.2	66	-2.58	0.010
	Match	0.163	0.170	-1.8		-0.70	0.486
Mtb	Unmatched	0.253	0.260	-4.7	88.2	-2.29	0.022
	Match	0.253	0.254	-0.6		-0.23	0.822
Mgshare	Not matched	2.428	3.643	-13	94.3	-6.12	0.000
	Match	2.429	2.498	-0.7		-0.32	0.749
Size	Unmatched	23.035	22.317	44.7	97.8	24.54	0.000
	Match	23.035	23.050	-1.0		-0.35	0.724

In the next step, the regression test is re-used based on the matched sample using a multi-period double difference model, and the results are shown in column (1) of Table 5, where the estimated coefficient of the smart city pilot policy on firms' ESG performance turns out to be 0.120 and is significant at the 5 per cent level. In addition, this paper also uses kernel density matching and radius matching with a caliper of 0.01, and the results are shown in columns (2) and (3) of Table 4, and the regression coefficients remain significantly positive, confirming that new infrastructure can enhance corporate ESG performance.

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Table 4. PMI-DID test results

	(1) Neighbourhood matching	(2) Kernel density matching	(3) Radius matching
Variable	ESG	ESG	ESG
NI	0.120**	0.111***	0.124**
	(2.11)	(2.69)	(2.18)
Top1	0.277*	0.274**	0.277*
	(1.74)	(2.36)	(1.74)
Cash	0.421***	0.437***	0.419***
	(3.33)	(4.88)	(3.31)
Daul	-0.057	-0.076***	-0.056
	(-1.29)	(-2.64)	(-1.27)
IDratio	0.649***	0.693***	0.655***
	(3.42)	(5.49)	(3.45)
Mtb	-0.513***	-0.267***	-0.514***
	(-3.56)	(-3.10)	(-3.57)
Lev	-0.612***	-0.471***	-0.619***
	(-5.17)	(-5.36)	(-5.17)
Mgshare	0.010***	0.008***	0.010***
	(2.69)	(3.47)	(2.68)
Size	0.231***	0.239***	0.232***
	(8.65)	(13.79)	(8.66)
Constant	-1.261**	-1.441***	-1.273**
	(-2.14)	(-3.87)	(-2.16)
Observations	7,462	19,895	7,458
R-squared	0.074	0.066	0.074
Year fixed effects	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes

3) Entropy balance test

Table 5. Entropy balance test results

	(1)	(2)
Variable	ESG	ESG
NI	0.203***	0.201***
	(4.17)	(4.17)
NI	-1.389**	-1.185*
	(-2.31)	(-1.88)
N	19,903	19,903
R-squared	0.674	0.677
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
City Fixed Effects		Yes

In the process of matching the samples using the propensity score matching method, it is easy to cause a large loss of research samples, for this reason, this paper draws on the research method of Hainmueller [19], using the entropy balancing method to match the samples of the pilot city and non-pilot city. The entropy balancing method can achieve the basic balance between the experimental group and the control group samples in terms of mean, variance and skewness by assigning different weights to the control group samples, so as to weaken the

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impact of inter-group differences on the regression results as much as possible [20]. The results of the weighted regression test are shown in Table 5, and as can be seen from columns (1) (2), the regression coefficients of the core explanatory variable NI are significantly positive at the 1% level, which indicates that the conclusion of the positive facilitating effect of the new infrastructure construction on the ESG performance of firms is still valid after the entropy balancing method is used to alleviate the effect of inter-group differences.

4) Placebo test

In order to exclude other potential interfering factors such as unobservable values, this paper further conducts a placebo test to verify the robustness of the model. This paper adopts a no-return approach, firstly, the placebo test is carried out by randomly assigning smart city pilot cities and pilot years, repeating this process 500 times, and carrying out double-difference regression analyses on the randomly selected data, and finally, the kernel density distributions of these 500 coefficient estimates are plotted. As shown in Figure 2, it can be seen from the graph that the regression coefficients are distributed around the value of zero. And the distribution pattern roughly coincides with the normal distribution, the true coefficient is 0.1127, which is much smaller than its true value, so there is no unobservable variable that will have an impact on the argument of this paper. It suggests that the smart city pilot policy is not a chance event, and that better construction of new infrastructures will indeed lead to an increase in corporate ESG performance.

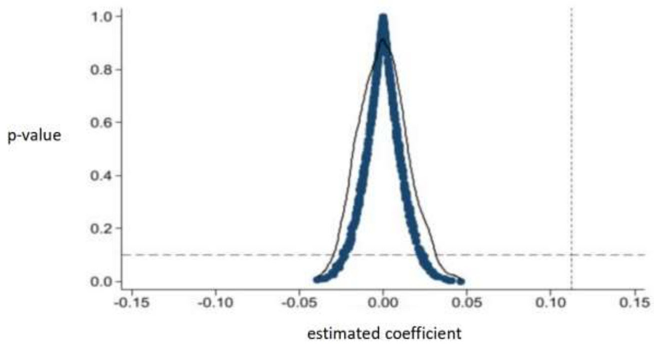

Figure 2. Placebo test

(3)Heterogeneity test

1) Heterogeneity test of enterprise ownership

Different enterprise ownership makes the policy implementation produce heterogeneous results, because there are significant differences between state-owned enterprises and private enterprises in policy acceptance, resource acquisition ability, policy goal fit and other aspects.

For this reason, this paper assigns a value of 1 to state-owned enterprises and 0 to the rest for group regression. From the regression results in columns (1)(2) of Table 6, it can be seen that the effect of new infrastructure of state-owned enterprises on corporate ESG performance is significant and positive at the 5% statistical level, while private enterprises are not significant. The reason for this may lie in the fact that SOEs have stronger institutional safeguards and are able to quickly adjust their internal mechanisms to comply with policy demands, while private firms are less responsive to policy due to their relatively weaker institutional environment and may require longer adjustment time or external support. Therefore, when designing policies, differentiated measures should be formulated according to enterprise types and regional characteristics in order to optimise policy effects.

2) Heterogeneity test for enterprise size

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Larger firms usually have more resources and capabilities to invest in ESG practices, such as research and development of environmentally friendly technologies and implementation of social responsibility programmes, while smaller firms may have limited resources to make the same level of investment in ESG as larger firms. Second, larger firms tend to receive more attention for their ESG performance due to their higher market position, which may prompt them to pay more attention to ESG practices, while smaller firms may face less pressure on their ESG performance due to their lower market influence. Finally, larger firms typically have more employees and wider social connections and are more likely to focus on social issues such as employee welfare, supply chain management and consumer rights, while smaller firms may focus more on relationships with specific communities or groups due to their smaller size. For this reason, this paper uses the median of the logarithmic value of total assets of a firm as a criterion for classification, with those above or equal to the median being large firms and vice versa for small firms. As can be seen from the regression results in columns (3) and (4) of Table 6, the regression results for new infrastructure for large firms are significantly positive, while they are positive but not significant for small firms. This suggests that when the size of the enterprise is larger, the new infrastructure construction has a more obvious role in promoting the ESG performance of the enterprise.

3) Heterogeneity test of industry pollution degree

Table 6. Heterogeneity test results

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Private enterprise	State-owned enterprises	Small enterprises	Large enterprises	Lightly polluted industry enterprises	Heavily polluted industry enterprises
NI	0.004	0.113**	0.040	0.130**	0.148***	0.045
	(0.06)	(2.31)	(0.71)	(2.17)	(2.94)	(0.62)
Top1	0.552***	-0.262*	0.518***	0.264*	0.284*	0.058
	(3.10)	(-1.95)	(2.78)	(1.66)	(1.92)	(0.29)
Cash	0.558***	0.083	0.314***	0.487***	0.409***	0.406***
	(4.63)	(0.68)	(3.09)	(2.70)	(3.37)	(3.00)
IDratio	0.579***	0.785***	0.633***	0.526***	0.696***	0.617***
	(2.96)	(5.11)	(3.55)	(3.10)	(4.60)	(2.70)
Lev	-0.316***	-0.672***	-0.354***	-0.983***	-0.424***	-0.611***
	(-3.47)	(-5.39)	(-3.46)	(-5.52)	(-3.39)	(-4.24)
Daul	-0.045	-0.117***	-0.092**	-0.035	-0.084**	-0.036
	(-1.11)	(-2.95)	(-2.35)	(-0.81)	(-2.38)	(-0.74)
Mtb	-0.203*	-0.318***	-0.159	-0.338**	-0.291**	-0.448***
	(-1.82)	(-2.69)	(-1.43)	(-2.37)	(-2.45)	(-3.64)
Mgshare	0.003	0.015	0.008***	0.009**	0.008***	0.008**
	(1.53)	(1.11)	(3.21)	(2.23)	(2.74)	(2.33)
Size	0.252***	0.269***	0.219***	0.406***	0.226***	0.265***
	(9.53)	(11.59)	(7.47)	(10.50)	(9.21)	(9.33)
Constant	-1.752***	-1.686***	-1.065*	-4.919***	-1.067**	-1.783***
	(-3.10)	(-3.40)	(-1.73)	(-5.64)	(-2.04)	(-2.92)
N	8,620	11,283	9,952	9,951	12,761	7,142
R-squared	0.093	0.090	0.069	0.074	0.063	0.058
Business Fixed	YES	YES	YES	YES	YES	YES
Year Fixed	YES	YES	YES	YES	YES	YES

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Heavily polluted industries are often accompanied by a large amount of pollutant emissions and resource consumption due to their production and operation activities, so the environmental performance of these industries is usually weak. In order to cope with environmental regulations, enterprises in heavily polluted industries may need to invest more resources and funds for pollution control and green innovation, which to a certain extent has an impact on their ESG performance. Based on this, this paper draws on the study of Pan Hailan et al. [21], and uses the "Listed Company Environmental Verification Industry Classification and Management Directory" published by the General Office of the Ministry of Environmental Protection in 2008, assigns a value of 1 to the 16 categories of heavy polluting industries that it classifies, and assigns a value of 0 to the rest of the industries that are not heavy polluting industries, and divides the sample firms into two groups for the regression test. The results in Table 6(5)(6) show that the positive effect of new infrastructure development on corporate ESG performance remains significant in light-polluting firms, but not in heavy-polluting industries. The reason may be that light polluting industries have less pressure on energy saving and emission reduction, and in comparison, they can put more resources and capacity on social responsibility and corporate governance, which in turn improves corporate ESG performance.

(4)Mechanism testing

The above empirical results verify that new infrastructure construction can significantly promote corporate ESG performance, and this conclusion still holds under various robustness tests. Based on the above theoretical analyses, this paper will further analyse the intrinsic mechanism of new infrastructure construction affecting corporate ESG performance from the perspective of increasing corporate R&D investment, driving corporate digital transformation and upgrading, and promoting corporate green innovation. Referring to the suggestion of Jiang Boat [22], we directly identify the impact of new infrastructure construction on the mediating variables and construct the following model:

$$M_{i,t} = \beta_0 + \beta_1 NI_{it} + \sum \beta_2 controls_{it} + \text{Year}FM + \text{Firm}FE + \varepsilon_{it} \tag{2}$$

In equation (2), Mit denotes three mediating variables, including enterprise R&D investment (RD), enterprise digital transformation (Digital), and green innovation (Green). When β1is significant, it indicates that new infrastructure construction can affect corporate ESG performance through this mechanism.

1) Testing the mechanism of enterprise R&D investment

Enterprise R&D investment (RD) is measured by the ratio of the amount of enterprise R&D investment to the total assets, and the test results in Table 7(1) show that the new infrastructure can significantly increase the enterprise's R&D and innovation investment. New infrastructure construction covers a variety of fields such as information, energy, transport, etc., and technological advances and innovations in these fields will require and motivate related enterprises to increase R&D capital investment to keep up with or lead the industry, and indirectly the increase in corporate R&D investment helps enterprises to achieve cost reductions and improve their ESG performance[23]. Hypothesis 2 is proved.

2) Enterprise digital transformation mechanism test

The degree of digital transformation (Digital) is measured using the sum of the frequency of enterprise digital-related terms. From the test results in column (2) of Table 7, it can be seen that the construction of new infrastructure can significantly promote the digital transformation of enterprises, the construction of new information infrastructure can promote the integration of the Internet and the real economy, and enterprises can integrate upstream and downstream resources through the industrial Internet platform to achieve the digital management and optimisation of the supply chain. Enterprises can also digital means of real-time monitoring and

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management of resources in the production process, to ensure the rational allocation and efficient use of resources. In addition, it has been found that enterprise digital transformation application can significantly improve ESG evaluation, and significantly affect the ESG comprehensive evaluation by improving information transparency and internal control (Pashu-Liu, 2024) [24]. Hypothesis 3 is proved.

3) Government concern mechanism test

In this paper, the mediating variable of government environmental concern (Gov) is measured by taking the logarithm of the sum of the number of documents and words related to the environment published on the government website. From column (3) of Table 7, the regression coefficient of new infrastructure construction on government environmental concern is 0.045, and it is positively significant at 5 per cent significance level, which indicates that new infrastructure construction improves the government's concern for the environment. The government's environmental concern is one of the important indicators of the local government's attention to environmental aspects, which will also have an important impact on the ESG rating of enterprises. Generally speaking, enterprises in regions with higher government environmental concern tend to have higher scores and recognition in ESG ratings, because the local government's attention to the environment will encourage enterprises to strengthen their awareness of environmental protection. In addition, the local government will encourage enterprises to adopt environmental protection measures through tax incentives, financial subsidies and other incentives, which in turn will enhance the ESG performance of enterprises. Hypothesis 4 is proved.

Table 7. Mechanism test results

	(1)	(2)	(3)
Variables	RD	Digital	Gov
NI	0.993***	0.112**	0.045**
	(2.77)	(2.45)	(2.39)
Constant	-4.312***	-3.321***	4.541***
	(-3.25)	(-7.64)	(20.23)
Observations	19,903	19,903	19,410
R-squared	0.048	0.041	0.097
Corporate Fixed	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes

5. Conclusion and Recommendation

This paper takes the data of China's A-share listed companies from 2009 to 2021 as the research sample, takes the smart city pilot policy as the quasi-natural experiment, and adopts the multi-period double-difference fixed effect model and the mediated effect model to explore the relationship between new infrastructure construction and corporate ESG performance and its mechanism of action. The research results show that: (1) new infrastructure construction has a significant contribution to corporate ESG performance, and the conclusion passed the multi-period parallel trend test, PSM-DID, placebo test and other robustness tests. (2) New infrastructure construction has a stronger effect on the ESG performance of state-owned enterprises, large enterprises and enterprises in light pollution industries. (3) New infrastructure development promotes corporate ESG performance through three channels: promoting corporate digital transformation, increasing corporate R&D investment, and increasing government concern for the environment.

Based on the above findings, this paper puts forward the following recommendations. First, the government should play a leading role in promoting the construction of new infrastructures by setting up reasonable evaluation standards and incentive policies, aiming to maximise the release of data potential and make full use of the advantages of smartness and interconnectivity of the new infrastructures, and thus improve the ESG performance of enterprises. Secondly, given that the investment in R&D and innovation, the degree of digital transformation and the government's concern for the environment are the key factors affecting the ESG performance of enterprises, enterprises should actively embrace the wave of development of the digital economy, proactively seek for innovation and change, accelerate the pace of digital transformation relying on the support of the new infrastructure, build a perfect information management system, break down the information silos, implement refined supervision and improve the ESG information disclosure system. Thirdly, the government should consider in-depth the value of the enterprise and its sustainable development objectives. Thirdly, the government should consider the diversity of enterprises, summarise successful cases and typical examples, and give full play to the role of state-owned enterprises (SOEs) and large enterprises as "leaders" in low-carbon transformation. At the same time, for small and medium-sized enterprises (SMEs), private enterprises and enterprises in traditional industries, the Government should provide more diversified policy subsidies and special support programmes to pave the way for their green transformation and sustainable development.

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