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Investments in environmental preservation: is the government crowding in green enterprises? Evidence from a-listed companies in China

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ABSTRACT

Government investment in environmental protection (Govin) plays a key role in stimulating private green investment (Prinv) to preserve the ecological environment with economic profits. To examine the effect of Govin on Prinv, this study uses data from 2010 to 2020 on green A-listed companies in China and estimates a dynamic panel model by using both the difference generalized method of moments and system generalized method of moments. The results indicate that Govin has a crowding-in effect on Prinv, and this conclusion is confirmed by several robustness tests. Furthermore, we identify revenues as a potential mechanism variable to explain how Govin affects Prinv. In addition, this study finds regional and enterprise ownership differences in the crowding in effect of Chinese Govin. Finally, based on these outcomes, the study suggests that the government should rationally and dynamically adjust the contents of public environmental investment and optimise its structure to effectively promote the development of green, low-carbon, and circular economies.

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1. Introduction

Green investment is an important tool for addressing climate change and accelerating green transformation. It is also of great theoretical and practical significance in alleviating the contradictions between economic growth and ecological deficit as well as promoting sustainable economic development. As important undertakings of green investment, green enterprises play a vital role in the current economic transformation and ecological civilisation construction. Green enterprises' willingness and motivation

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to invest are, however, weakened by green investments' long-term framework, the externality of environmental benefits, the lack of information symmetry, high risk, and other constraints (Soundarrajan & Vivek, 2016), which significantly decrease the initiative and enthusiasm for green investment (Narbel, 2013). This situation has led to under-investment in green enterprises. The gap in green investment needed for sustainable development remains large. Unfortunately, most of the available literature discusses the promotion of green investment at the macro level, and few studies examine it from the perspective of green micro enterprises whose ability to achieve green transformation and sustainable development depends on their investment productivity. It is therefore important to examine how to promote green business investment (Borojo & Yushi, 2020).

To address the shortage of green investment, effectively stimulate the production incentives of green investment agents, and promote the development of a green, low-carbon circular economy, the Chinese government has adopted a series of top-down policies. Govin is an important environmental and financial policy that aims to direct private investment to promote green economic development and achieve neutrality (Pan et al., 2020). On the one hand, from the environmental policy perspective, the government influences the economic behaviour of business entities by changing the intensity of environmental regulation to achieve environmental governance goals (Gebre Borojo & Yushi, 2020). On the other hand, Govin is public finance expenditure. Barro (1990) suggests that public service spending reverses the trend of 'diminishing marginal returns' to business production. Therefore, Govin plays a demonstrative role in guiding green enterprises' investment. However, the effectiveness of Govin for Prinv and the extent to which it has met the government and environmental regulations' expectations remains to be assessed. Unfortunately, there are few discussions and analyses on this topic in the literature. This academic seam becomes precisely the key issue to be addressed. This study tries to answer the following three questions: How does Govin affect Prinv? Does Govin affect Prinv through a mechanism? Is there heterogeneity in the effects of Govin on Prinv?

Existing studies have reached a consensus on the positive effects of green investment. First, from a macro perspective, green investment can promote sustainable development goals (Eyraud et al., 2013), optimise industrial structure, increase well-being (Liao & Li, 2020), and improve energy efficiency (Pavlyk, 2020). From a micro perspective, the position of green enterprises as the main vehicle of investment in the transition to a green economy should be emphasised (Allet & Hudon, 2015; Kumari, 2012; Volz, 2018). Green investment can not only force more polluting enterprises to initiate green technology transformation but also attract the active attention of investors in the capital market and improve the market value of green enterprises (Chen & Ma, 2021; Martin & Moser, 2016), thereby maximising value for their shareholders (Friedman, 2007). Through green investment, micro enterprises can effectively augment their business performance and further enhance market competitiveness (Cilliers et al., 2010). Moreover, academics generally focus more on factors promoting green investments. These aspects can be divided into two categories. The first category comprises traditional variables that affect investment, including economic growth, interest rates, income levels (Eyraud et al., 2013), and production costs (Ley et al., 2016). Other studies have focused on the accumulation of green capital, public demand (Galant & Cadez, 2017; Lassala et al., 2021), legal factors (La Porta et al., 1997; Arouri et al., 2012) incentives, and informal institutions. Some

scholars have noted the impact of Govin on Prinv (Pearce & Palmer, 2005), However, this study focuses more on the role of the environmental regulatory function of Govin on macro green investment.

The literature on the effects of Govin addresses two key perspectives: environmental regulation and fiscal policy. Scholars have focused more on the role of environmental regulation of Govin. One strand of literature focuses on the macroeconomic and environmental effects of environmental regulation. This includes areas such as promoting economic growth (Jorgenson & Wilcoxen, 1990; Pearce & Palmer, 2005; Yu & Kong, 2015) and curbing pollution (Wang & Shen, 2016). Another strand of literature examines the role of environmental regulation mainly from the perspective of micro-polluting firms (Gans, 2012; Huang & Lei, 2021; Leiter et al., 2011; Ren et al., 2018). Research on Govin as a function of fiscal policy is also relatively scarce at present and mainly focuses on macro functions, overlooking green business entities.

Although the existing research has provided theoretical support and methodological basis for this study, the following shortcomings still exist.: First, the literature mostly focuses on general analysis of macro green investments; few studies have emphasised green micro-entity investments. Second, scholars studying the environmental regulatory function of Govin have focused on polluting firms but have ignored the impact on green firms. Third, the literature on government environmental spending as a macro function of fiscal policy is not concerned with the mechanisms by which fiscal policy affects micro green enterprises. The macroeconomic function of fiscal policy can only be realised through the economic behaviour of green business entities. To fill these gaps, this study analyses the mechanism of Govin in Prinv and makes several contributions to the literature. First, this study adds new micro evidence to the field of green investment and environmental regulation by examining green investment from a green micro-firm perspective. Second, the 'crowding-in' and 'crowding-out' effects of fiscal spending have been the subject of debate among scholars. This study provides further evidence from China to enrich the literature on fiscal expenditure by explaining the mechanisms by which Govin affects green business investment from a fiscal policy perspective. Third, this study tests the mechanisms through which Govin influences Prinv. It also examines the heterogeneity by region and type of enterprise. In doing so, it provides substantial support for the development of the government's environmental policy.

The rest of the paper is arranged as follows: Section 2 contains the mechanism analysis and the theoretical hypotheses; Section 3 introduces the data source, describes the statistics, and proposes the model design according to the research hypotheses; Section 4 includes the analysis of the baseline regression results, mediation mechanism analysis, heterogeneity analysis, and robustness tests; and Section 5 presents the conclusions.

2. Mechanism analysis and hypotheses

2.1. Government investment in environmental protection and green enterprise investment

We illustrate the crowding-in effect of Govin on Prinv from the aspect of both fiscal expenditure and environmental regulation. From the perspective of public spending,

it is clear that the increasing scale and restructuring of Govin will certainly have an impact on green private investment. The neoclassical view is that public expenditure and private investment have a fundamental relationship of complementarity. In a complementary relationship, Govin is below the optimal level required for green investment; an increase in Govin will raise the private sector's marginal output and enhance private investment incentives (Aschauer, 1989). The green economy is still in its infancy in China, with fast-growing but relatively low investment levels. The production curve for green investment firms is relatively steep, and marginal productivity is at an increasing stage; thus, increasing government investment in environmental protection can positively increase investment by private firms (Pietrucha & Zelazny, 2020).

Second, from the perspective of environmental policy, Govin is a market-based instrument in environmental regulation (Pearce & Palmer, 2005). The aim is to increase the efficiency of green investment through market mechanisms to encourage more market players to participate in green production and services. This role depends on effect of signal transmission and optimal choices to maximise the interests of micro enterprises (Baumol et al., 1988). On the one hand, environmental regulations have a direct impact on the production costs of polluting companies (Conrad & Wastl, 1995; Zhao & Sun, 2016); increasing production costs discourage them from producing, reducing the supply of polluting products on the market and making room for green products and increasing the incentive for green companies to invest. On the other hand, local governments will take measures to increase Govin to enhance environmental regulation to improve local competitiveness (Sigman, 2014). Thus, improving the quality of the local environment attracts more foreign capital to develop the local economy, and therefore, local green businesses will mention green investments because of the increased supply of local capital factors. Based on the analysis of the dimensions of public investment and environmental regulation, Hypothesis 1 is proposed as follows:

Hypothesis 1: Government environmental investment crowds in green business investment.

2.2. Analysis of intermediary mechanisms

Govin influences green business product revenues through direct and indirect channels, which in turn promotes Prinv. First, it has been argued in the literature that government purchases influence the economic behaviour of local market agents (Wen, 2017). The government influences the operating income of companies through direct purchases of green business products and services in the market. From the perspective of the internal structure of Govin, China's Ministry of Environmental Protection has released a budget line for environmental fiscal expenditure that includes expenditure on environmental infrastructure, expenditure on environmental services, and expenditure on environmental administrative services. The government purchases environmental infrastructure equipment, pollution control equipment, and other products and services in the market through tenders (Wang & Ying, 2021). Government purchases directly increase the revenue of green companies and stimulate green investment in companies. Second, government spending on environmental

protection influences the development of local green economies through spillover effects (Ruffing, 2020), further stimulating local demand for green products and increasing the sales scale of local green enterprises. Enterprises are induced by the expansion of the sales market size to increase the number of investments. Thus, Hypothesis 2 is proposed as follows:

> Hypothesis 2: Government environmental investment changes green investment by affecting the revenue.

2.3. Regional heterogeneity

Imbalances in China's regional economic development can influence the effectiveness of environmental policies (Lee et al., 2012). Owing to differences in the functioning of market mechanisms, human resources, innovation and technology, ecological endowment, environment, and public infrastructure, dissimilarities may exist in the marginal public service productivity caused by government investment in various regions (Zhang & Gu, 2011).Governments face a problem when making inter-regional environmental investments. There is an opportunity cost of increasing productive public expenditure in less-developed regions because the same scale of productive public expenditure will provide a stronger stimulus for economic growth in more-developed regions. Consequently, Govin in different regions does not have the same impact on local private investment.

Second, regional imbalances can affect fiscal decentralisation (Sacchi & Salotti, 2016). Government environmental preservation investment is composed of central and local financial sources. The level of economic development of each region, the degree of environmental pollution, and the local government's awareness of environmental protection affects the quantity and structure of local expenditure on environmental protection. Regional differences in the size and structure of public spending on environmental protection have a direct impact on green investment by private enterprises. Third, the classical theory of regional economics suggests that industries are structured differently in many regions (Krugman, 1991). Green companies are distributed unevenly among regions, and the contents of their green investments vary, leading to different responses to Govin. If their contents were similar to that of Govin, they would compete for resources given limited environmental capital. When the contents of Govin and regional green company investment are well structured, they will have a positive effect on green investment. Based on this analysis, Hypothesis 3 is proposed as follows:

> Hypothesis 3: Regional heterogeneity exists in the impact of government environmental investment on green enterprise investment.

2.4. Ownership heterogeneity

Different types of enterprise ownership determine diverse investment advantages, motives, and efficiencies (Boardman & Vining, 1989; Li & Zhou, 2005; Cuervo-Cazurra & Li, 2021; Grosman et al., 2016). Green enterprises can be divided into

state-owned enterprises (SOEs) and private enterprises (PEs). First, in terms of political affiliation, the strength of political connections constitutes the political capital of the enterprise. Having political capital can provide companies with access to more information and economic resources from the government. Top leaders of SOEs are usually appointed by the government (Pietrucha & Żelazny, 2020). SOEs are more politically connected than PEs. The political resource advantage of green SOEs therefore provides them with more information support as well as economic resources to make green investments. Second, in terms of corporate social responsibility, SOEs have the economic objective of improving their productivity and achieving profitability; simultaneously, as special business organisations of the state, they are also responsible for a series of political and social objectives, such as safeguarding national economic security and achieving social equity. Environmental protection is an important guarantee for the advancement of sustainable human development, and to achieve this social goal, green SOEs must increase the construction of green investment projects more actively than PEs. Based on the analysis given above, Hypothesis 4 is proposed as follows:

> Hypothesis 4: The impact of government investment in environmental protection on green enterprise investment varies according to the types of enterprise ownership.

3. Data and methodology

3.1. Data interpretation

This study uses the Prinv of Chinese A-listed companies from 2010 to 2020 as the study sample data. We define green investment according to Eyraud et al. (2013) definition and use the China Wind database to select green-listed companies whose main source of business income is new energy, 'green' China, green technology development, and innovation as green companies. Then, we select green investment, size, operating efficiency, leverage structure, and investment value as variables. Crude oil prices by province are also obtained from the China Wind database. This study also uses the China Statistical Yearbook to obtain data on China's Govin and gross domestic product (GDP). The time span of all the variables is from 2010 to 2020. This study uses unbalanced panel data.

3.2. Variable selection and description

3.2.1. Dependent and independent variables

This study analyses the size of green-listed companies' investment, which is represented by Prinv. In this study, the cash paid for the construction of fixed assets, intangible assets, and other long-term assets in the cash flow statement is selected as a proxy variable for the scale of enterprise investment (Malmendier & Tate, 2005; Stein, 2003)

Generally, Govin includes the human and material resources invested by government departments in environmental protection. Based on the relevant literature

(Zhang et al., 2022), this study selects Govin as the key independent variable for government investment in environmental protection.

3.2.2. Mediating and control variables

Based on the mechanism analysis in the study, the main revenue of enterprises (Rev) is chosen as the mediating variable to analyse the mechanism of the impact of Govin on Prinv.

A series of control variables are selected at the enterprise level and at the macro level. These control variables are as follows: (1) enterprise size (Size), measured as the enterprise's total assets at the end of the financial year (Collis et al., 2007; Lin et al., 2019; Orlitzky, 2001); (2) financing constraint level (Cash), measured by year-end monetary funds (Fazzari et al., 1987); (3) the enterprise's market value (Q), measured by the total market value of the enterprise's A shares and its total book equity at the end of the financial year (Richardson, 2006); (4) financial leverage (Lev), measured by the asset–liability ratio at the end of the financial year (Fazzari et al., 1996);(5) corporate profitability (ROA), measured as the return on assets (Flannery & Rangan, 2006); (6) economic development (GDP), measured as the GDP; and (7) environmental policies (Coil), measured as domestic oil prices because energy prices can identify the intensity of a country's environmental policies (Ley et al., 2016; Newell et al., 1999).

3.2.3. Data processing and descriptive statistics

First, logarithmisation is adopted to eliminate non-smoothness, heteroskedasticity, and covariance of continuous variables. We add one to the variable with a continuous value and then take the natural logarithm. Second, considering the interference of extreme values on model estimation, the data is subjected to 1% and 99% tailing.

Table 1 shows a basic statistical analysis of the sample's data from 2010 to 2020. The mean of lPrinv is 18.600 and the standard error is 1.666, which indicates that lPrinv does not fluctuate excessively every year. The mean of lGovi is 24.66 and the standard error is 0.627. However, the standard error of ROA is 0.060, indicating that the profitability of each company is highly variable.

Table 1. Descriptive statistics of variables.

Variable		Variable meaning	Obs	Mean	S.D.
Independent variable	lPrinv	Log of the investment that is used to pay for fixed, intangible, and other long-term assets	3,401	18.600	1.666
Dependent variable	lGovi	log of the government environment investment	313	24.660	0.627
Control variable	lSize	Logarithm of total assets	3,410	21.990	1.179
	lCash	Logarithm of the monetary fund	3,401	20.050	1.229
	lCoil	Log of crude oil price	313	4.687	0.256
	lGDP	Logarithm of GDP	313	28.950	0.694
	Q	Enterprise market value/book value	3,401	1.032	0.293
	ROA	Net profit/total assets	3,401	0.030	0.060
	Lev	Asset–liability ratio	3,401	0.438	0.204
	lRev	Logarithm of revenue	3,401	21.12	1.266

Source: Authors own calculations.

3.3. Model design

3.3.1. Empirical model

The stationarity of data is tested by a unit root test of the panel data before modelling to prevent false regression. This study applies Fisher's test to examine the stationarity of the selected variables. We carry out the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root tests on the time series data of the individual variables (Choi, 2001) and construct statistics and corresponding probability values, according to P values obtained from the Fisher ADF and PP tests, to test the stationarity of the variables.

After the unit root tests, the Pearson correlation coefficient test method is adopted to calculate the correlation coefficient between the dependent and independent variables. A significant coefficient indicates that there is an obvious correlation between the dependent and independent variables.

Considering that current investment behaviour will be influenced by lagged investment behaviour (Richardson, 2006), this study applies dynamic panel models to characterise the effect of the Govin on private investment in green firms:

$$lPrinv_{it} = \alpha_0 + \alpha_1\ lPrinv_{it-1} + \alpha_2 lGovin_{it} + \alpha_3 X_{it} + u_{it} \tag{1}$$

$lPrinv_{it}$ represent the investment amount of company i in period t. $\mathrm{lPrinv_{it-1}}$ represents the lag term of the dependent variable as the explanatory variables. $\mathrm{Govin_{it}}$ represents government investment in environmental protection of company i in the corresponding period t. X is a series of control variables, including total assets, income growth rate, Q value, return on total assets, asset–liability ratio, crude oil price, and GDP; α_2 is the elastic coefficient of the influence of the government's investment in environmental protection on green enterprise investment. When $\alpha_2 > 0$, Govin will be crowded in by Prinv, and when $\alpha_2 < 0$, Prinv will be crowded out by Govin; $u_{it}$is the random error term.

This study uses the generalised method of moments (GMM) (Hansen, 1982) to estimate the dynamic panel because it can fully consider the characteristics of dynamic models and overcome endogeneity among enterprises. The main GMM estimation methods are the differential GMM (DGMM) (Arellano & Bond, 1991) and system GMM (SGMM)(Arellano & Bover, 1995). The difference between the two is that the SGMM not only adopts the instrumental variables of the difference equation but also considers the instrumental variables of the horizontal equation. DGMM only uses the instrumental variables of the difference equation. Therefore, the two estimation methods are applied to perform an econometric analysis of the dynamic panel data and validate the outcomes.

3.3.2. Mechanism

To address the fact that Govin can affect Prinv by changing companies' revenue, we employ the mediation effect model for further analysis. The following two equations are constructed:

$$lRev_{it} = \beta_0 + \beta_1 lGovin_{it} + \beta_2 X_{it} + \varepsilon_{it} \tag{2}$$

$$lPrinv_{it} = \gamma_0 + \gamma_1\ lPrinv_{it-1} + \ \gamma_2\ lRev_{it} + \gamma_3 lGovin_{it} + \gamma_4 X_{it} + \mu_{it}, \quad (3)$$

where the meanings of $lPrinv_{it}$, $lPrinv_{it-1}$, $Govin_{it}$and X are the same as above. The main variable is lRev, which represents companies' revenue. This study adopts a static panel model to investigate the effect of Govin on mediating variables and uses the FE model to estimate its magnitude.

4. Research analysis and empirical results

4.1. Basic empirical results

Table 2 shows the results of the Fisher panel data unit root test estimation of the P value, Z, L *, and Pm. The probabilities that the dependent variable and the key independent variables are of a zero-order sequence are smooth, thus refuting the existence of the unit root null hypothesis and providing statistical support for panel data stationarity.

The correlations between the main and control variables are shown in Table 3. The correlation coefficient between *lPriv* and *lGovin* is 0.021, thereby indicating that lPriv has explanatory power for *lGovin*. The correlation coefficients between the two variables, *lRev* and *lGovin*, are 0.085, respectively, thus indicating that there is a correlation between *lGovin* and the revenue of green companies.

This study employs the dynamic panel model to compare and analyse the impact of Govin on private firms, using control variables. Table 4 summarises the regression results for the full sample. The first and second columns present dynamic regression results; The Sargan test results are accepted for DGMM and SGMM, and the assumption that the first-order series are correlated and second-order series are uncorrelated is met.

The empirical results show that, overall, the effect of the key dependent variable on the independent variable is consistent for both methods. The value of *lGovin* is

Table 2. The Fisher unit root test.

Variable	P	prob	Z	prob	L*	prob	Pm	prob
lPriv	3260.373	0.0000	−20.227	0.0000	−39.447	0.0000	61.509	0.0000
lGovin	1729.330	0.0000	−3.597	0.0002	−13.198	0.0000	23.233	0.0000

Note: The Fisher unit root test uses P, Z, L*, Pm statistics' values and the corresponding probabilities to indicate the result.
Source: Authors own calculations.

Table 3. Pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) lPriv	1.000									
(2) lGovin	0.021	1.000								
(3) lCoal	0.044	0.108	1.000							
(4) lGDP	−0.054	0.772	0.102	1.000						
(5) lSize	0.741	0.119	0.033	−0.021	1.000					
(6) lncash	0.631	0.010	0.024	−0.082	0.821	1.000				
(7) Q	−0.318	−0.061	−0.291	−0.039	−0.408	−0.339	1.000			
(8) ROA	0.127	−0.027	−0.062	0.010	0.025	0.149	0.054	1.000		
(9) Lev	0.281	0.066	0.052	0.000	0.496	0.230	−0.215	−0.216	1.000	
(10) lRev	0.678	0.085	0.037	−0.001	0.895	0.753	−0.338	0.101	0.484	1.000

Source: Authors own calculations.

Table 4. Baseline regression results.

	Dynamic Models	
Variables	(3) DGMM	(4) SGMM
L.lPrinv	0.226**	0.493***
	(2.09)	(12.52)
lGovin	0.467**	0.350**
	(2.05)	(2.26)
lCoil	0.230	0.123
	(1.55)	(1.25)
lGDP	−4.398***	−1.203***
	(−3.54)	(−4.23)
lSize	1.037	−0.152
	(1.40)	(-0.65)
lCash	0.430**	0.600***
	(2.13)	(3.24)
Q	0.066	0.217
	(0.24)	(-1.40)
ROA	0.018**	3.409**
	(2.13)	(2.14)
Lev	0.058	0.004
	(1.43)	(0.38)
Constant	27.206***	7.622
	(4.76)	(1.13)
Observations	2,900	2,900
Sargan	0.901	0.119
AR (1)	0.000	0.000
AR (2)	0.768	0.340

Note: The z-statistics are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors own calculations.

positive and indicates that Govin and Prinv have a complementary relationship. The crowding-in effect of *lGovin* is apparent. This result confirms Hypothesis 1 and is contradictory to the studies of Turnovsky (1997) and Cebula (1978), based on the regression results in Column (2). At the 5% significance level, the influence coefficient of *lGovin* is 0.35 and indicates that an increase in the Chinese government's environmental expenditure by 1% can promote green private investment by 0.35%. The baseline regression results demonstrate that Govin increases market demand for green products and subsequently raises the motivation for investment in green production. Govin thus has a positive effect on Prinv.

The coefficient of Coil indicates a positive but not significant effect on *Prinv*. China's demand for crude oil is rigid. As the price of crude oil rises, the market will look for energy substitutes, resulting in a further increase in the demand for green energy. The effect of GDP on Prinv is negative at the 1% level of significance. For every 1% increase in GDP, *Prinv* will decrease by 1.203%. This is contrary to the result of (Eyraud et al., 2013). A possible explanation is that, according to the 'environmental Kuznets curve' hypothesis, the role of GDP in green investment is different at divergent stages of economic growth. *lCash*, Q, ROA, and Lev have positive effects on *Prinv*, with elasticities of 0.600, 0.217, 3.409, and 0.004, respectively; the results for *Cash* and ROA are significant. The cash flow sensitivity of investments is strong in green companies. The more profitable the company is, the greater the amount of investment will be. The results for lSize, Q, and Lev are not significant.

4.2. Mechanism

In Table 5, Column (1) estimates the relationship between Govin and companies' revenue. Column (2) tests the impact of companies' revenue on Govin. The results in Column (1) demonstrates that Govin is significantly and positively correlated with companies' revenue. The results in Column (2) indicate that Govin and companies' revenue are all significantly and positively correlated with green private investment. Therefore, the results of the mediation mechanism test show that government environmental investment can promote green business investment by increasing companies' revenue.

4.3. Heterogeneity analysis and robustness tests

4.3.1. Regional heterogeneity analysis

According to the National Bureau of Statistics' criteria for dividing economic regions, this study segregates China's Govin into three regions: eastern, middle, and western. According to the degree of economic development of the three regions, the eastern region is the most developed, followed by the central and western regions. The results in Columns (1), (2), and (3) in Table 5 show that there is a significant crowding-in effect in the western, middle, and eastern regions. The elasticity coefficients of environmental preservation investment for the western, middle, and eastern regions are 0.330, 0.265, and 0.277, respectively. The crowding-in effect of Govin in the western region is greater than that in the eastern region. This result differs from the findings of Chen and Zhang (2017), who showed that the impact of government public expenditure on the output of more-developed regions is greater than its impact on the output of less-developed regions. Based on the regional distribution of listed green companies in the Wind database, there are more green enterprises in the eastern and central regions than in the West, especially in the developed eastern regions, where the number of enterprises has an absolute advantage. However, the crowding-in effect of Govin in these two regions is smaller than in the lagging western regions, indicating that the green capacity in the eastern and central regions is not fully utilised. Although the number of green enterprises in the western region is small, they

Table 5. Mechanism test results.

	Dependent variable	
Variables	lRev (1)	lPrinv (2)
L.lPrinv		0.469***
		(12.00)
lGovin	0.076***	0.315**
	(2.88)	(2.01)
lRev		0.501**
		(1.97)
Observations	3,386	2,900
R-squared	0.739	
Sargan (p value)		0.164
AR (1)		0.000
AR (2)		0.202

Note: Column (1) t-statistics are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Column (2) z-statistics are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors own calculations.

Table 6. Heterogeneity analysis.

	Regional			Ownership	
Variables	West (1)	Middle (2)	East (3)	SOEs (4)	PEs (5)
L.lPrinv	0.560***	0.310***	0.525***	0.545***	0.433***
	(10.82)	(28.53)	(12.06)	(13.16)	(10.52)
lGovin	0.330**	0.265***	0.277*	0.369**	0.182*
	(1.98)	(3.76)	(1.89)	(2.95)	(1.73)
Control variables	YES	YES	YES	YES	YES
Observations	340	505	2055	842	1742
Sargan	0.520	0.533	0.164	0.610	0.152
AR (1)	0.000	0.000	0.000	0.000	0.000
AR (2)	0.631	0.670	0.504	0.154	0.892

Note. z-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors own calculations.

are all relatively large and predominantly state-owned, and so, the political resource and scale advantages make the crowding-in effect greater in the western region. Therefore, increased Govin has a higher crowding-in effect in the western regions than in the eastern and in the central regions.

4.3.2. Analysis of ownership heterogeneity

Enterprise ownership is an important factor that affects investment. In this study, enterprises are divided into SOEs and PEs to analyse the influence of Govin on their investment behaviour. The regression results in Columns (4) and (5) of Table 6 show that the Govin coefficients are significantly positive in the sub-samples for PEs and SOEs. This result indicates that Govin has a significant crowding-in effect on both SOEs and PEs. The coefficient of the key variable is 0.369 for SOEs and 0.182 for PEs, thus showing that the crowding-in effect on SOEs is greater than that for PEs. The possible reasons for this difference are as follows: (1) SOEs have the advantage of having more political capital compared to PEs, which facilitates access to information on green investment and economic resources for enterprise development from the government. (2) SOEs have a greater social responsibility and are therefore more motivated to make green investments, unlike PEs, which have a stronger path dependency on their original production operations in the face of constraints such as high risks and low returns on green investments (Xu & Cui, 2020). (3) The scale of SOEs is generally larger, and the advantage of scale provides more human, material and financial resources to support enterprise investment, which can reduce the risk of green enterprise investment to a certain extent.

4.3.3. Robustness tests

The following two methods were used to prove the robustness of the model's estimation. First, this study used the estimation of samples grouped by firm size as the basis of the robustness test (Faulkender & Wang, 2006). The regression results are summarised in Table 7 in Columns (1) and (2) and are consistent with the results of the benchmark model. The effect of Govin on Prinv is significantly positive for both the small (1) and large (2) sample groups. Second, we test the robustness of the model by varying the length of time, following the approach of Zhang et al. (2022). Table 7 reports the results of the role of Govin in Prinv during the different periods. Govin

Table 7. Robustness tests.

	Size		Different periods			
Variables	Small (1)	Big (2)	2011–2020 (3)	2012–2020 (4)	2013–2020 (5)	2014–2020 (6)
L.lGovin	0.448***	0.497***	0.558***	0.521***	0.531***	0.601***
	(11.90)	(11.01)	(14.04)	(11.68)	(10.84)	(8.10)
lGovin	0.250*	0.155*	0.189**	0.173*	0.229**	0.254*
	(1.80)	(1.74)	(2.06)	(1.81)	(2.22)	(1.83)
Control variables	YES	YES	YES	YES	YES	YES
Observations	1047	1563	2740	2542	2303	2060
Sargan	0.172	0.236	0.183	0.368	0.323	0.371
AR (1)	0.000	0.000	0.000	0.000	0.000	0.000
AR (2)	0.124	0.719	0.389	0.469	0.542	0.457

Note: z-statistics are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors own calculations.

has had a significant positive impact on Prinv in all periods, and the magnitude of this impact has tended to increase overall. This suggests that the positive impact of government investment in environmental protection on green businesses is growing.

5. Conclusions

Govin plays an important guiding role in promoting green investment: however, few studies have investigated this issue. This study investigates the effect of Govin on green enterprises using the data of listed green companies from 2010 to 2020. The Fisher panel data unit root test and the correlation coefficient test prove that the panel data are smooth at zero order and that there is a significant correlation between Govin and Prinv. DGMM and SGMM are used to test a dynamic panel model in the basic analysis. The results indicate that Govin, in general, has a crowding-in effect on Prinv. Furthermore, we use a mediating effects model to test the role of companies' revenue as a mediating variable to illustrate the mechanism by which Govin affects Prinv. The results show that Govin can increase companies' revenue and promote green private companies' investment motivation. This study investigates the regional heterogeneity and ownership heterogeneity in the role of Govin in Prinv. The crowding-in effect is significant in the three regions and between different ownerships. The western regions witness greater effects than the eastern and the central region, and SOEs have an edge over PEs. The robustness tests confirm the crowding-in effect of Govin to Prinv.

Based on the results, this study suggests that the government should take the market as a guide and dynamically adjust the content and structure of Govin according to the degree of green industry development. Govin should be biased towards areas where private investment is unaffordable or more socially public, reduce the appropriation of green resources in the market, and lower the costs of production and operation of green businesses. In contrast, the timeliness and completeness of the Govin information disclosure is important for private investment to make scientific and rational investment decisions. Only a well-informed private sector can make sound judgements to mitigate the risk of green investments. Moreover, considering regional and ownership differences, China's government should maximize the incentive for green investment in more economically developed regions and green PEs.

The eastern and middle regions, which have a higher level of economic development and greater marginal productive capacity than the western regions, should be more fully motivated to produce and further stimulate green investment. Green PEs are an important force in the development of green industries. The government should revise the restriction and incentive mechanisms to solve excessive restraint and insufficient incentive in PEs.

This study has certain limitations that provide directions for further research. First, the breakdown of data published by Govin is not specific enough to allow the detailed examination of the role of various environmental expenditures on private investment and thus, to scientifically adjust the structure of government environmental investment. This shortcoming can be remedied by the increased validity of statistical methods for data. Second, the length of time since the official publication of Govin data is still relatively short, limiting the study period. The changes in the role of Govin in green private investment over different time periods are yet to be effectively reflected. Therefore, future follow-up studies in this area could extend the time span of the sample to enrich the findings.

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