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Can energy internet improve corporate ESG performance? -- Evidence from Chinese high energy-consuming companies

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ABSTRACT

Under the challenges of global crises such as climate warming, ESG performance, which represents sustainable development, has received widespread attention at home and abroad. Using the panel data from 2011 to 2020, comprising 726 high energy-consuming companies listed on the Shanghai and Shenzhen A-shares, this paper takes Energy Internet demonstration project in 2016 as a quasi-natural experiment and builds a difference-in-difference model to study its microscopic policy effects. The study found that, firstly, Energy Internet can markedly enhance ESG performance of high energy-consuming companies. Secondly, the mechanism test finds that Energy Internet can facilitate high energy-consuming enterprises to enhance their ESG performance through three mechanisms: increasing government subsidies for enterprises in energy conservation and environmental protection, absorbing talent employment and improving information environment within the enterprises. Finally, the heterogeneity analysis proves that Energy Internet's policy effects are more pronounced in regions with higher financial expenditures on local science undertakings and among state-owned enterprises. China ought to persist in advancing the development of Energy Internet and provide companies with adequate support on finance, talent and technology. Meanwhile, during the construction of Energy Internet, attention should be paid to adapting to local conditions and enterprises.

1. Introduction

Since the 21st century, corporate ESG performance has received much attention worldwide. ESG performance is a compositive assessment of companies on the basis of environmental protection, social responsibility and corporate governance, and in particular, companies' energy use and greenhouse gas emissions are receiving more and more attention from investors. ESG performance is also becoming a hot topic in the Chinese capital market. Since the reform and opening up, China has embarked on a new phase of rapid development. Nevertheless, the outdated development model of high energy consumption and low efficiency has also caused serious waste of resources and environmental pollution, which has limited the economy's sustainable development to a certain extent. In 2016, China's thermal power generation accumulated 439.58 billion kWh, occupying 74.37 % of total power generation. In China, industrial enterprises constitute the primary energy consumers, and their uncontrolled use of thermal power not only exacerbates energy consumption, but also creates serious carbon emission problems. Since 2006, China has had the highest carbon emissions of any country. In September 2020, China aims at achieving " CO2 emission peak" by 2030 and "carbon neutrality" by 2060. Therefore, how to optimize corporate energy use, especially to enhance the ESG performance of energy-consuming firms, is important for China to make the "double carbon" target come true.

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According to literature review, previous scholars largely focus on the consequences of ESG performance. Based on the financing perspective, ESG performance can markedly cut financing cost of companies and alleviate financing constraints [[1–3]]. Based on a risk perspective, ESG performance can enhance firms' risk resistance in capital markets [[4,5]]. Based on a corporate governance perspective, ESG performance can significantly inhibit manager misconduct [[6]]. Based on an employee perspective, Employee engagement experiences a notable positive influence from ESG performance [[7,8]]. Therefore, ESG performance can further improve corporate financial performance [[9,10]]. More importantly, existing studies generally agree that ESG performance can help companies achieve green and high-quality development [[11–13]. However, there is little literature on the antecedents of ESG performance, i.e., how to improve corporate ESG performance. Based on a digitalization perspective, Fang et al. found that corporate digitization can improve governance (G) scores by reducing agency costs and social (S) scores by improving corporate goodwill, but does not affect environmental (E) scores [[14]]. Based on the government institutional perspective, Wang et al. find that central environmental inspectors can significantly improve corporate ESG performance, and a potential channel for their effect is increased regulation by local governments [[15]]. Based on the green policy perspective, Sun et al. discovered that green finance policies can promote corporate ESG performance mainly by the environmental pillar [[16]]. Therefore, it is urgent to study whether enhanced energy management can be conducive to improve ESG performance of companies.

In view of this, this paper investigates the microscopic policy effects of the 2016 "Internet+" Smart Energy (hereafter "Energy Internet") demonstration project as a quasi-natural experiment using the difference-in-difference model (DID). The study found Energy Internet can markedly enhance corporate ESG performance of high energy-consuming firms, mainly through increasing government subsidies for enterprises in energy conservation and environmental protection, absorbing talent employment and improving the information environment within the enterprises.

This paper has three contributions. In the first place, this paper is the pioneer in examining the impact of China's Energy Internet construction on enterprises. Energy Internet is a key measure to reduce energy waste and optimize the structure of energy consumption by managing energy through new technologies such as big data, and it is of great significance in advancing the green and low-carbon transformation of China's economy. However, existing studies have not focused on this measure in China, and this paper evaluates its effectiveness from the perspective of corporate ESG performance. Besides, this paper makes recommendations for the assumptions and implementation of the future energy internet, which may also have certain reference significance for other countries.

Second, this paper expands the influential factors and their internal mechanisms that promote corporate ESG performance. Prior studies have predominantly explored the consequences of the influence of corporate ESG practices and performance, while neglecting strategies to assist companies in enhancing their ESG performance. This paper takes the macro pilot policy of Energy Internet as a quasi-natural experiment to explore how it can improve companies' ESG performance through government subsidies for environmental protection and energy conservation, promotion of companies' employment absorption, and improvement of companies' information communication. This paper delves into the impacts and paths of China's new energy infrastructures on enterprises in the new era from a research perspective that intersects macro and micro.

Finally, the paper explores the question of whether the effect of Energy Internet on companies' ESG performance stems from the motivation of impression management from both positive and negative perspectives. Both corporate practice and the literature suggest the existence of companies that embellish their behavior through ESG disclosure in order to create a greened corporate image. This paper answers this question by exploring whether Energy Internet elevates the actual green technology innovation capabilities of firms and whether it reduces real corporate surplus management.

2. Institutional background and theoretical mechanism

2.1. Institutional background

Due to the disorderly use of energy, Chinese enterprises generally have the problem of unreasonable energy structure and energy use inefficiency. In response to the challenges posed by growing energy demand and a highly carbonized energy mix, the Chinese government has proposed a sequence of laws and regulations. Specifically, in 1997, China passed the *Energy Conservation Law of the People 's Republic of China* to regulate the energy conservation management in key energy-using units. In 2007, China amended the law to explicitly limit the growing of industries characterized by high energy consumption and environmental pollution. During that year, the National Development and Reform Commission outlawed local preferential policies that supported high energy-consuming industries. It can be seen that in the early days, China mainly reduced the total energy consumption of enterprises through a sweeping and mandatory approach such as "closing, shutting down, merging and transferring". However, such policies failed to achieve energy structure optimization and efficiency improvement, and greatly discouraged enterprises to transform and upgrade.

In 2012, *The Third Industrial Revolution (Chinese Edition)* was published, and China also began to explore about the optimization of energy structure and industrial upgrading under the background of the Internet. On December 5, 2013, the State Grid proposed "Energy Internet", i.e. to build a smart grid with robust connectivity, extensive interlinkages, advanced intelligence and open interaction. In April 2015, the Energy Bureau organized a working meeting on Energy Internet, formally proposed a national Energy Internet action plan, and established the China Energy Internet Alliance. On September 26 of the same year, China announced at the United Nations Development Summit an initiative to explore building a global energy internet to facilitate cleaner and greener approaches to meeting global electricity demand. Based on the previous policy exploration work, building an energy internet has become a key step to support and promote China's energy revolution, and a key step to accomplish " CO2 emission peak and carbon neutrality".

In February 2016, the National Development and Reform Commission, the National Energy Administration, and the Ministry of Industry and Information Technology collaboratively formulated the "Guidance on Promoting "Internet+" Smart Energy

Development" was released, officially kicking off the construction process of the Energy Internet. In July 2017, the National Energy Administration publicly organized the declaration of Energy Internet demonstration projects. Subsequently, it officially declared the initial set of 55 Energy Internet demonstration projects, including Zhejiang Jiaxing City Energy Internet Integrated Pilot Demonstration Project and Urban Integrated Intelligent Energy Supply Service System,[1] covering a total of 9 categories. In August of that year, the initial set of Energy Internet demonstration projects commenced, marking the practical stage for China's Energy Internet.

Energy Internet application pilot demonstration projects are planned by the central government, supervised by local governments, led by market mechanisms, and implemented with the cooperation of enterprises and other parties. Specific features are as follows: (1) The pilot demonstration projects are selected by the National Energy Administration, and the 55 designated demonstration projects are distributed in the east, central and western regions with distinct economic conditions and energy endowments. Among the four municipalities directly under the central government and 293 prefecture-level cities in China, the percentage of the regions where the demonstration projects are located is 17.85 %. Among them, in 2021, the GDP and electricity consumption of Shanghai, Suzhou, Beijing, Guangzhou and Shenzhen are in the top 10 in China. (2) Local governments strictly supervise and manage the entire process of Energy Internet formation and operation. The provincial energy authorities need to do a good job in the organization, coordination and supervision of demonstration projects in the region, timely tracking of the progress of the project, after the completion of the acceptance of the normative process and reported to the National Energy Board. Moreover, local governments should continuously adjust the existing regulations and policy provisions that do not match the progress and management of Energy Internet, improve the safety supervision mechanism amid the profound integration of energy and information, and provide institutional guarantee for the implementation of each demonstration project. (3) Pilot projects to develop energy big data service applications to achieve energy big data integration and secure sharing. Local governments focus on building national energy data centers, strengthening energy information docking, sharing and transaction services for upstream and downstream enterprises, and optimizing the accuracy and effectiveness of energy statistics, analysis, forecasting and other business conducted by enterprises. (4) Pilot projects to increase support for innovative industries and guide the entry of social capital. Local governments include the Energy Internet in major engineering packages, support the development of basic, common and key technologies for the Energy Internet, and support Energy Internet project implementation entities in financing through low thresholds and multiple approaches.

As of October 2020, nearly half of the initial set of Energy Internet demonstration projects have completed acceptance work, and some projects are continuing to advance, and the pilot work has achieved obvious results. Taking Beijing as an example, the percent of renewable energy in the city's energy consumption has increased from 6.6 % in 2015 to 7.9 % in 2019. BBMG Corporation, as one of the pilot companies, has steadily improved its ESG rating data year by year from 25.62 in 2015 to 39.26 in 2019, an improvement rate of 53.24 %. The company's 2016 annual social responsibility report pointed out that the company has established a sound industrial energy-saving management system, consolidated the foundation of energy measurement, and consistently enhance the efficiency of energy utilization. It also promoted the construction of energy management system and strengthened the training of managers at all levels. It also made use of information technology and big data to continuously implement energy-saving diagnosis, energy audit, energy control center and other projects, thus realizing energy visualization and maximizing energy efficiency. In January 2021, the review of the summary report of the initial set of Energy Internet demonstration projects pointed out that the publicity and promotion of the experience of the demonstration projects should be expanded, and the work related to the second batch of Energy Internet demonstration projects should be launched in due course.

2.2. Theoretical mechanism

Energy Internet can increase government subsidies for enterprises in energy conservation and environmental protection, absorb talent employment and improve the information environment within the enterprises, contributing to an overall improvement in their ESG performance. The detailed analysis is outlined as follows:

Energy Internet can increase government subsidies for enterprises in energy conservation and environmental protection, thus promoting companies to improve ESG performance. Legitimacy theory states that business behavior needs to be in accordance with the law, custom and public will [17,18]. Environmental legitimacy means that a company's environmental behavior should be in line with the requirements of society, otherwise it will be subject to administrative penalties or public criticism [19,20]. If a company's behavior is in line with the needs of environmental protection and energy conservation, it will be able to obtain support from social resources [[21–23]]. Energy Internet enables high energy-consuming enterprises to digitally manage energy, monitor and regulate energy use in real time, thus realizing energy-saving and environmentally friendly transformation [24,25]. This will enable energy Internet companies to win the support of social resources, especially the special subsidies provided by the government to facilitate the development of Energy Internet. Government subsidies will promote high energy-consuming firms to increase investment in energy conservation and environmental protection, thus decreasing overall energy usage, optimizing the energy consumption structure, and ultimately enhancing their ESG performance [[26]].

Energy Internet can absorb talent employment, thus promoting enterprises to improve ESG performance. Any major strategic transformation of the enterprise will have a significant impact on the construction of the talent team [[27]]. In the first place, the construction of Energy Internet push high energy-consuming enterprises to increase the number of departments specializing in the management and operation of energy big data, and therefore need to absorb many professionals [[28]]. In addition, Energy Internet

[1] For details, please refer to the Notice of the National Energy Administration on the Organization and Implementation of "Internet+" Smart Energy (Energy Internet) Demonstration Projects.

enable high energy-consuming companies to form a more stable relationship between energy supply and demand, pushing them to expand into new business areas and expand the size of their business sector staff [[29,30]]. Promoting employment is of great significance in maintaining social stability, safeguarding social equity and increasing social well-being, so attracting talents for employment is a very important part of corporate social responsibility [[31]]. Energy Internet prompt high energy-intensive companies to expand their workforce, thus contributing to their improved ESG performance.

Energy Internet can improve the information environment within the enterprises, thus promoting enterprises to improve ESG performance. When there is internal information asymmetry, enterprises usually face more serious agency conflicts, and management may engage in a range of behaviors such as misappropriation of corporate assets, overconfidence, and irrational investment [[32,33]]. Research has shown that when environmental information is asymmetric, enterprises also experience serious agency problems [[34]]. Leveraging the capabilities of the Internet and emerging technologies, Energy Internet has realized intelligent management of enterprise energy use information [[35,36]]. Transparency of energy information is conducive to a comprehensive grasp of energy consumption within the enterprise, thus reducing irrational behavior of management in energy use and environmental protection [[37]]. Therefore, Energy Internet can improve the information environment, thereby optimizing the internal governance mechanism of companies, enhancing the operational and managerial efficiency of enterprises, and ultimately improving the ESG performance of firms.

3. Study design

3.1. Model design

Referring to the findings of Wing C et al. [[38]], a difference-in-difference model (DID) is formulated as follows:

$$ESG_{i,t} = \beta_0 + \beta_1 Time_t \times Treat_i + \beta_2 Controls_{i,t} + Year_t + Id_i + \varepsilon_{i,t} \quad (1)$$

Model 1 was tested using fixed effects (FE) model. Among it, $ESG_{i,t}$ means the corporate ESG performance, $Time_t \times Treat_i$ means the policy variable, and $Controls_{i,t}$ means control variables. $Year_t$ means year fixed effects, Id_i means individual fixed effects, $\varepsilon_{i,t}$ means the disturbance term. If Energy Internet can promote high energy-consuming enterprises to enhance their ESG performance, the coefficient β_1 in model 1 would be significantly positive.

3.2. Variables definition

3.2.1. Explained variables

According to the existing literature, we can mostly use two means to obtain ESG performance. First, some scholars independently construct proxies of corporate environment, social responsibility and corporate governance to calculate corporate ESG performance. For example, Li and Wu use firm-level negative ESG events for measurement. Second, some scholars select ESG rating data established by third-party institutions [[39–43]]. Compared with the former, it is more objective and comprehensive to measure by institutional ESG rating data. There are currently ESG rating databases in China such as Bloomberg, SynTao Green Finance, and Sino-Securities Index. In comparison to other ESG rating databases, the Bloomberg database has been updated longer, and the indicator system is more complete and widely used by scholars. Therefore, the paper chooses the ESG rating data from the Bloomberg database to assess corporate ESG performance.

3.2.2. Explanatory variables

This paper adopts the dummy variable Time to determine whether Energy Internet has been implemented. If the time is 2017 and

Table 1
Variable definitions.

Variable Level	Variable Name	Variable Definition	Variable Measurement
Corporate financial indicators	Ltime	the listed year(s)	the listed years
	Size	Size of enterprise	Ln(Total assets)
	ROE	Net Return on Assets	Net profit/Net assets
	LEV	Gearing ratio	Debt/Total assets
	Growth	Growing capacity	Tobin's Q value
Corporate governance structure	Top1	Concentration of shareholding	the shareholding ratio of the biggest shareholder
	Board	Size of Board of Directors	Ln(Number of board directors)
	Ind_r	Board independence	Number of independent directors/Number of board directors
	Wage	Management remuneration	Top three management remuneration/Total assets
	Dual	The combination of two roles into one	Assign a value of 1 if the Chairman and General Manager positions are held by the same individual, and 0 otherwise.
Regional factors	Gdp	Regional economic level	Ln(Gross regional product)
	Industry	Economic structure	Gross regional product of the secondary sector/Gross regional product
	Rtax	Resource tax	Amount of regional resource taxes/Gross regional product
	Gtech	Science business finance	Science business finance expenditure/Gross regional product

later then Time = 1, or else Time = 0. This paper adopts the dummy variable Treat to indicate whether it is a policy pilot area. If the registered location of the company is in 53 pilot cities, then Treat = 1, or else Treat = 0. The vector product of two dummy variables obtains the policy variable, which is denoted by Time × Treat.

3.2.3. Control variables

As per the research conducted by Wang and Hu, Mu et al. and Lu et al. [[44–46]], this paper defines a range of control variables Controls, from three perspectives: corporate financial indicators, governance structure and regional factors. Meanwhile, this paper deflates the variables Size and Gdp based on China's inflation rates in each year, using 2011 as the base period. Table 1 shows these control variables.

3.3. Sample and data

The initial sample of this paper is drawn from high energy-consuming enterprises listed in China's Shanghai and Shenzhen A-shares between 2011 and 2020. Referring to previous scholarly studies on energy-intensive industries [47,48]], and considering the sample size, this paper selects mining (B), manufacturing (C), and electricity, heat, gas and water production and supply (D) as high energy-consuming industries. Based on this, the initial sample is processed according to the following steps: (1) Excluding samples with ST and ST* in the current year; (2) Excluding samples which have appeared on the market for 1 year or less; (3) Exclude samples with asset liability ratio higher than 100 %. After processing, a total of 6060 observations from 726 sample companies can be gained.

The corporate data in this article were gained from CSMAR and Wind databases. Data for mainland Chinese cities were gained by compiling the *China Statistical Yearbook*. This paper employs STATA 16.0 to process data.

4. Empirical analysis

4.1. Descriptive statistics

Table 2 demonstrates the descriptive statistics of primary variables. Specifically, the average ESG score is 21.396, indicating a generally poor overall ESG performance of high energy-consuming enterprises in China. Meanwhile, the minimum value stands at 1.24 and the maximum one stands at 64.115, with a standard deviation as high as 7.243, revealing a broad and highly dispersed spectrum of ESG performance among the sampled companies. Table 2 displays additional results from the descriptive statistics.

4.2. Baseline regression

4.2.1. Regression results

The outcomes of the baseline regression aredisplayed in Table 3. As shown in column (1), after factoring in fixed effects, the coefficient of DID stands at 1.099 and is significant at the 0.05 level. As shown in column (2), after further controlling for the control variables, the coefficient of DID stands at 1.183 and is significant at the 0.01 level. Therefore, Energy Internet can markedly enhance corporate ESG performance of high energy-consuming companies. On average, high energy-consuming companies in the pilot cities improved their ESG performance scores by approximately 1.183 points compared to companies in cities that did not implement the Energy Internet.

4.2.2. Dynamic effects test

One of the important and key prerequisites for the difference-in-difference model is to be in accord with Parallel Trend Assumption, i.e., the outcome variable has identical trend in the experimental and control groups in the absence of policy intervention. Therefore, based on Event Study Approach introduced by Jacobson et al. [[49]], this paper adopts an empirical approach to demonstrate the dynamic effects of Energy Internet and builds the model as follows:

$$ESG_{i,t} = \beta_0 + \sum_{t=2011}^{2020} \beta_t Year_t \times Treat_i + \beta Controls_{i,t} + Year_t + Id_i + \varepsilon_{i,t} \quad (2)$$

Fig. 1 charts the estimated results of the regression coefficients at 90 % confidence intervals using 2011 as the base period. First, in 2011–2016 confidence intervals all contain 0 values and none of regression coefficients are of significance, indicating no significant difference between the experimental and control groups prior to the implementation of the pilot policy, satisfying Parallel Trend Assumption. Second, in 2017 and thereafter, the confidence intervals are above the zero value and the regression coefficients begin to be of significance, indicating that Energy Internet's policy effects are beginning to emerge. In addition to this, the regression coefficient appears to increase and then decrease in 2017–2020. The reason for this may be that the pilot cities have developed a demonstration effect and favorable influence on neighboring cities in the process of infrastructure development for Energy Internet. Neighboring cities have achieved similar results to the policy implementation by learning from and imitating it.

4.3. Robustness test

4.3.1. Placebo test

To test whether Energy Internet policy effect is influenced by unobservable factors, this paper performs a placebo test using a

Table 2
Descriptive statistics.

Variable	Obs	Mean	Std.Dev.	Min	Max
ESG	6060	21.396	7.243	1.24	64.115
Ltime	6060	12.974	6.452	1	28
Size	6060	22.907	1.307	19.467	28.432
ROE	6060	0.084	0.196	−2.816	8.715
LEV	6060	0.457	0.191	0.008	0.995
Growth	6060	1.997	1.465	0.701	27.338
Top1	6060	0.375	0.16	0.03	0.9
Board	6060	2.292	0.181	1.386	2.944
Ind_r	6060	0.374	0.057	0.182	0.8
Dual	6060	0.977	1.123	0	18.34
Wage	6060	0.2	0.4	0	1
Gdp	6060	8.59	1.143	4.117	10.344
Industry	6060	0.363	0.175	0	0.893
Rtax	6060	0.138	0.289	0	2.25
Gtech	6060	0.596	0.348	0.136	1.405

Table 3
Baseline regression.

	(1)	(2)
	ESG	ESG
DID	1.099**	1.183***
	(0.427)	(0.421)
Ltime		0.465***
		(0.160)
Size		1.756***
		(0.363)
ROE		−0.275
		(0.262)
LEV		−2.094*
		(1.112)
Growth		0.125
		(0.092)
Top1		1.956
		(1.470)
Board		−0.177
		(1.042)
Ind_r		−0.642
		(2.913)
Wage		0.090
		(0.343)
Dual		0.217**
		(0.093)
Gdp		−0.901
		(0.593)
Industry		0.760
		(0.634)
Rtax		−1.107**
		(0.476)
Gtech		0.062
		(0.819)
_cons	21.186***	−17.101*
	(0.085)	(9.809)
Year FE	Yes	Yes
Id FE	Yes	Yes
Obs	6060	6060
R^2	0.778	0.785

Note: Standard errors robust to clustering at the firm level are reported in parentheses, ***, **, and * denoting significance at the 0.01, 0.05, and 0.1 levels, respectively. The same for the subsequent tables.

counterfactual approach with artificially random assignment of pilot cities [[50]]. Specifically, the experimental group is set up by randomly selecting 53 cities, while the other cities serve as the control group. Based on an assumption, the experimental group has implemented Energy Internet, but the control group has not implemented it. In this paper, 500 random samples were conducted and the baseline regression was executed following the DID model.

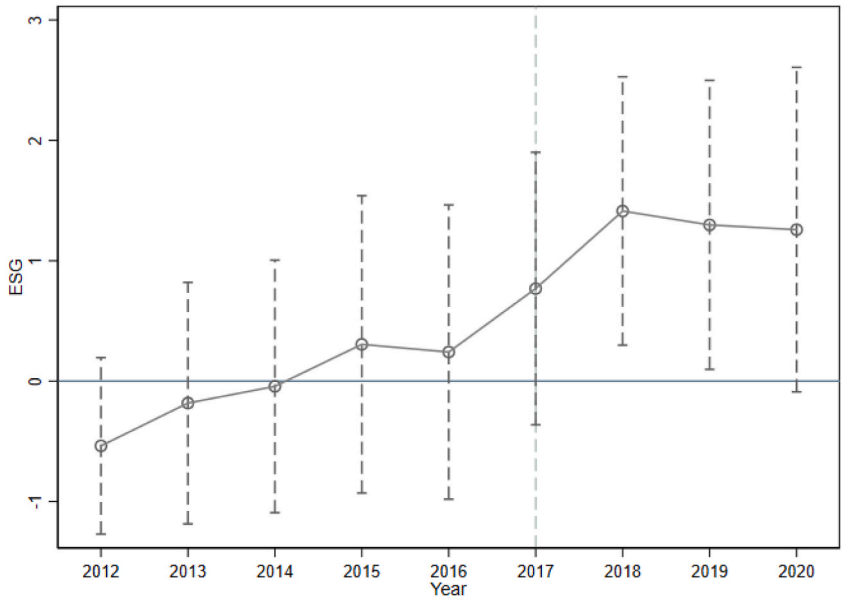

Fig. 1. Dynamic effects test.

Fig. 2 reports the regression coefficient values for 500 random samples. The horizontal dashed line denotes the 0.05 significance level, and the vertical dashed line denotes true regression coefficients (as demonstrated in columns 2 of Table 3). Fig. 2 shows the regression coefficients are predominantly clustered around 0 and the *P*-value is greater than 0.05, which indicates they are insignificant at 95 % confidence interval. In addition, the true regression coefficients of 1.183 in this paper were outliers in the placebo test. Thus, there are almost no unobservable variables that influence the conclusions.

4.3.2. Replacement of variable measures

To ensure the stability of ESG measures, this paper replaces Bloomberg ESG rating data with Sino-Securities Index ESG rating data to minimize the potential variation under different evaluation systems. The regression result after replacing the measure is displayed in column (1) of Table 4. The coefficient of DID is positive at a significance level of 0.05, which is the same as the main regression result. Therefore, replacing the variable measures does not change the policy effects and the conclusions are robust.

4.3.3. Excluding municipalities

In China, there is a big difference between municipalities directly under the central government and prefecture-level cities in terms of economic development, policy implementation, and awareness of energy conservation. To further demonstrate the robustness of the findings, this section excludes all municipalities[2] from the original sample and performs the baseline regression again. The regression result after excluding municipalities is displayed in column (2) of Table 4. The DID coefficient is prominently positive, which is identical to the main regression result. Therefore, the exclusion of municipalities directly under the central government does not change the policy effect and the conclusion is robust.

4.3.4. Reduction of industry scope

To ensure the robustness of the division of high energy-consuming industries, this section adjusts the classification of high energy-consuming companies to manufacturing companies. The regression result after the reduction of industries is displayed in column (3) of Table 4. The coefficient of DID is positive at a significance level of 0.05, consistent with the main regression result. Therefore, reducing the scope of the industry will not change the policy effect and the conclusion is robust.

4.3.5. Hysteresis effect

To further tackle endogeneity concerns, this paper re-tests the DID and all control variables with a one-period lag. The regression result for the lagged period is displayed in column (4) of Table 4. The coefficient of DID is positive at a significance level of 0.05, consistent with the main regression result. Therefore, the hysteresis effect does not change the policy effect and the conclusion is robust.

[2] Municipalities include Beijing, Tianjin, Shanghai, Chongqing.

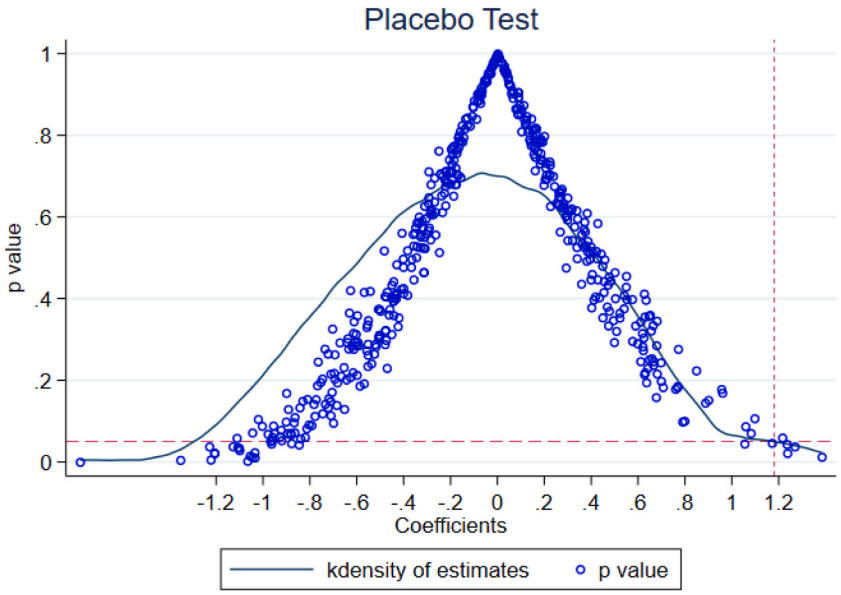

Fig. 2. Placebo test.

Table 4
Robustness tests.

	(1)	(2)	(3)	(4)	(5)
DID	0.075**	1.180**	1.031**	1.047**	1.181***
	(0.031)	(0.552)	(0.452)	(0.405)	(0.412)
Envtax					0.552
					(0.399)
Genv					0.425
					(0.334)
_cons	−2.615**	−19.112*	−22.623**	−13.345	−16.940*
	(1.073)	(10.640)	(9.704)	(8.827)	(10.050)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Id FE	Yes	Yes	Yes	Yes	Yes
Obs	8946	4861	5188	5362	6060
R^2	0.633	0.752	0.781	0.805	0.785

4.3.6. Controlling the impact of other policies

Around 2017, China introduced many other policies, especially regarding environmental protection. Existing research suggests that China's environmental policies also have an impact on corporate ESG [51,52]. For example, in 2016 China introduced the *Environmental Protection Tax Law*, which stipulates that it is only from 2018 that environmental protection taxes can be levied on corporate polluting behavior. In this paper, regions where the environmental tax rate standard is higher than the previous sewage fee standard are used as the experimental group because their tax burden standard is increased. At the same time, other regions are used as a control group. The policy shock point is 2018, as this is the year the environmental protection tax becomes official. Envtax is set based on a difference-in-difference model and employed as a control variable to evaluate the influence of environmental taxes on ESG.

Besides, to better control the influence and interference of other environmental policies on this study, the ratio of regional financial expenditures on environmental protection to GDP has been included as a control variable. This variable serves to gauge the degree of regional attention and support to environmental protection.

The regression results, after accounting for the impact of other policies, are demonstrated in column (5) of Table 4, revealing a positive coefficient of DID significant at the 0.01 level., which is identical to the main regression result. Therefore, other policies does not change the policy effect and the conclusion is robust.

5. Further discussion

5.1. Mechanistic tests

5.1.1. Government subsidies

This paper collects government subsidies received by the firm in the notes to the financial statements, in which subsidies related to environmental protection and energy conservation of the firm are selected and divided by the total assets to standardize them.

As displayed in the column (1) of Table 5, the coefficient of DID stands at 0.264 and of significance at the 0.05 level. Therefore, the implementation of Energy Internet has enabled enterprises in the pilot areas to obtain more government subsidies for energy conservation and environmental protection.

5.1.2. Absorb employment

If the number of employees in a business is growing, it indicates the business is continuously absorbing talent for employment. Based on the findings of Bu et al. this paper utilizes the number of employees in a firm to represent the level of employment absorption, while taking the natural logarithm of it [[53]].

As demonstrated in the column (2) of Table 5, the coefficient of DID stands at 0.054 and is of significance at the 0.1 level. Therefore, the implementation of Energy Internet policy has enabled enterprises in the pilot areas to absorb more talents for employment and expand the scale of employees.

5.1.3. Information communication

With reference to the research findings of Wu and Zeng, this paper adopts the "information communication" scoring item in the internal control index constructed by DIB database to assess the information environment of enterprises and reflect the information transparency of enterprises in internal governance [[54]].

As displayed in the column (3) of Table 5, the coefficient of DID stands at 0.145 and is of significance at the 0.01 level. Therefore, the implementation of Energy Internet policy has enabled companies in the pilot areas to improve the information environment within them.

As shown in column (4) of Table 5, Subsidy and Information are both significantly positive, and Staff is not significant, which suggests that increasing environmental protection and energy-saving subsidies, absorbing employment, and optimizing information communication can further motivate companies to enhance ESG score. Meanwhile, the coefficient of DID is 1.154, showing a decrease compared to the baseline regression (displayed in column (2) in Table 3), suggesting that increasing environmental protection and energy-saving subsidies, absorbing employment, and optimizing information communication play a mediating role in Energy Internet's impact on promoting companies to improve ESG score.

5.2. Heterogeneity analysis

5.2.1. Science business finance

This paper argues the policy effects are more significant in the sample with higher financial expenditures on local science undertakings. Firstly, from the government level, the financial expenditure on scientific undertakings is an important origin of funding for the construction of local scientific infrastructure. The higher the financial expenditure on scientific undertakings, the stronger the support for Energy Internet in the area, which means more robust supporting facilities. Secondly, from the enterprise level, increasing financial expenditure is beneficial for enterprises to obtain relevant talent, capital and technology subsidies. The higher the local science business financial expenditure on scientific undertakings, the better it can meet the resource needs of enterprises for

Table 5
Mechanism test.

	(1)	(2)	(3)	(4)
	Subsidy	Staff	Information	ESG
DID	0.264**	0.054*	0.145***	1.154***
	(0.125)	(0.028)	(0.052)	(0.423)
Subsidy				0.048**
				(0.023)
Staff				−0.040
				(0.335)
Information				0.128*
				(0.071)
_cons	11.493**	−7.823***	−0.921	−17.851*
	(4.662)	(1.104)	(1.920)	(9.924)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Id FE	Yes	Yes	Yes	Yes
Obs	6060	6060	6060	6060
R^2	0.515	0.958	0.480	0.785

management change and technological innovation, and better promote the growing of Energy Internet for enterprise level.

This paper chooses the ratio of fiscal expenditure on science and business to GDP in the provinces where the enterprises are located to measure, and take the median as the criterion, and those above the median as the sample with higher expenditure and vice versa as the sample with lower expenditure. As displayed in Table 6, the coefficient of DID is of significance in the sample with higher financial expenditures on local science undertakings and insignificant in the lower sample.

5.2.2. Nature of property right

This paper argues the policy effect is more significant for state-owned enterprises. First, in addition to their responsibility for economic development, state-owned enterprises need to take into account more social responsibilities, such as environmental protection, social employment and welfare. As a result, there is a more urgent need for state-owned enterprises to motivate their ESG performance. Secondly, the research and development of intelligent technology needs the support of capital, technology and human capital. Compared to non-state-owned enterprises, state-owned enterprises have a more straightforward path to get sustainability from local resources, which means their R&D on Energy Internet is less risky and more productive.

In this paper, the regression is conducted separately for the state-owned enterprises group and the non-state-owned enterprises group. Then the resulting regression outcome is displayed in Table 6. The coefficient of DID is of significance in state-owned enterprises but insignificant in non-state-owned enterprises.

5.3. Extensibility analysis

The study indicates the possibility of enterprises participating in impression management through the disclosure of ESG information [[55]]. Therefore, ESG ratings may not be a true representation. For this reason, this paper explores positively and negatively in an expansive manner, respectively.

5.3.1. Green technology innovation

On the positive side, this paper selects the degree of corporate green technology innovation as an indicator that specifically reflects corporate ESG performance. This is because enterprise green technology innovation contains both environmental protection and technological innovation. From the point of view of environment, it can truly improve corporate environmental performance. From the point of view of technological innovation, it is embedded in its impact on changes in production relations and on the strategic decisions of enterprises, so it can affect the social performance of firms and the performance of corporate governance.

With reference to the research result of Cormier and Magnan, in this paper, the ratio of the number of green patent applications to the number of all patent applications is selected to assess the green technology innovation level of enterprises [[56]]. As demonstrated in column (1) of Table 7, the coefficient of DID is significantly positive, indicating Energy Internet markedly contributes to the level of green technology innovation of enterprises in the pilot region.

5.3.2. Real earnings management

On the negative side, this paper selects real earnings management as an indicator to reflect whether a company has impression management motivation. Zhang et al. argue that if a company's true earnings management declines significantly, the company may be able to maintain a positive corporate image by increasing ESG disclosure [[57]]. Conversely, this paper argues that if the true earnings management of a company does not significantly decrease, there is no motivation for the company to use ESG information disclosure for impression management.

As demonstrated in column (2) of Table 7, the coefficient of DID is positive but not significant, suggesting that Energy Internet did not cause a significant decline in companies' true earnings management and that firms do not have incentives to engage in impression management.

6. Conclusions and implications

Energy Internet can achieve the integration of "four streams" of energy flow, information flow, value flow and carbon emission

Table 6
Heterogeneity analysis.

	(1)Science business finance		(2)Nature of property right	
	Lower	Higher	non-state-owned	state-owned
DID	0.713	2.045***	0.605	1.656***
	(0.646)	(0.586)	(0.618)	(0.616)
_cons	−25.370*	9.996	−51.683***	4.512
	(14.559)	(24.309)	(15.243)	(13.264)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Id FE	Yes	Yes	Yes	Yes
Obs	2860	3143	2897	3139
R^2	0.759	0.827	0.787	0.783

Table 7
Extensibility analysis.

	(1)	(2)
	Green	REM
DID	0.019**	0.008
	(0.009)	(0.012)
Controls	Yes	Yes
Year FE	Yes	Yes
Id FE	Yes	Yes
Obs	18560	21125
R^2	0.475	0.528

flow, which is crucial to promote energy digitalization and smart transformation. In this paper, I use the 2016 Energy Internet Demonstration Project as a quasi-natural experiment to study its microscopic policy effects using a difference-in-difference model. First, the baseline regression illustrates that Energy Internet can markedly enhance ESG performance of high energy-consuming companies. Second, mechanism tests show that Energy Internet can facilitate high energy-consuming enterprises to enhance their ESG performance through three mechanisms: increasing government subsidies for enterprises in energy conservation and environmental protection, absorbing talent employment and improving the information environment within the enterprises. Finally, heterogeneity analysis finds that the policy effects of Energy Internet are more pronounced in regions with higher science business financial expenditures on local science undertakings and among state-owned enterprises.

In response to the aforementioned findings, this paper makes three recommendations. First, we should continue to accelerate the growing process of Energy Internet and gradually expand the scope of pilot projects. On the basis of summarizing the effectiveness and experience of the pilot project, promote the promotion of the excellent demonstration project model. What's more, the difficulties of the current stage of Energy Internet construction will be analyzed in depth to provide strong support for the next stage of sustainable promotion. Second, enterprises should increase training for middle and senior managers to effectively promote the application of Energy Internet at the enterprise level. In particular, enterprises need to focus on cultivating management's thinking concepts on Energy Internet application, innovation and development, increasing investment in Energy Internet research and development, and deeply increasing relevant government subsidies, talent and technology support. Finally, local governments need to develop the Energy Internet according to local conditions and enterprises. Local governments should increase financial expenditures on scientific undertakings to support the construction of supporting infrastructure, the introduction of talent and technology subsidies. Moreover, local governments need to increase their support for non-state enterprises to reduce their costs and risks in carrying out Energy Internet and to stimulate their innovative energy.

This paper also has some shortcomings. First, there may be other potential mechanisms for the Energy Internet to facilitate energy-intensive firms to enhance their ESG performance that need to be further explored. In addition, regarding the heterogeneity analysis, this study just takes into account the regional and firm levels, and future studies may also consider industry-related characteristics, etc.

Data availability statement

Data could be obtained upon request. Please contact the corresponding author via email at halinazhang@163.com.

CRediT authorship contribution statement

Zihe Zhang: Writing – review & editing, Writing – original draft, Validation, Software, Data curation, Conceptualization.

Declaration of competing interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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