Can Companies Make Green Innovation a Reality by Means of Corporate Environmental Responsibility? The Mediating Role of Environmental Subsidies

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ABSTRACT

This paper analyses how Chinese listed companies have channelled their environmental responsibility through government resources by observing corporate behaviour between 2015 and 2020. Results indicate that corporate environmental responsibility does not directly enhance corporate green innovation (CGI) and that government environmental subsidies (ES) are required to positively incentivise CGI capabilities. Increased corporate investment in environmental protection and improved governance are positive for CGI, unlike environmental management system certification. This paper provides novel ideas for future research on how Chinese listed companies may convert their environmental responsibility into green innovation through government ES. This may benefit future research on sustainable development.

Keywords: Corporate Green Innovation, Environmental Subsidies, Corporate Environmental Responsibility, Sustainability Development, Corporate Governance
JEL Classifications: F63, F64, H23

1. INTRODUCTION

Although China's economic development has been enormously successful over the past few decades, extensive development has also caused serious environmental problems (Bai et al., 2019). The contradiction between the current economic development mode and environmental pollution is becoming increasingly serious. Environmental pollution and the waste of resources prevent sustainable economic development and seriously threaten the health and life of residents. Therefore, China must promote the process of sustainable development (Hao et al., 2021). The growing and pressing pollution problem has made both the government and businesses aware of the importance of environmental sustainability and economic development

(Hu et al., 2021). In response, the Chinese government introduced environmental protection and green ecology bills in 2007 and 2015. Companies, as polluters, have begun taking environmental responsibility more seriously (Li and Wang, 2021). In addition, stakeholders and government departments have increased their attention to corporate environmental responsibility (CER) through development and implementation of new legislation (Shao et al., 2020). The China new Environmental Protection Law came into force in 2015, which represents global environmental legislation, especially in emerging markets (Liu et al., 2021).

The new Environmental Protection Law highlights the principles of 'public participation' and 'liability for damage' (Liu et al., 2021). Zhang et al. (2015) has a corresponding interpretation of this

law. Article 58 of the new law provides that social organisations with a good reputation for engaging in environmental protection and public interest activities may file environmental public interest litigation against polluting enterprises that engage in illegal and destructive environmental practices. In addition, the new law clearly states that the government is responsible for the environmental quality in its own administrative area, which increases governmental departments' influence on environmental regulation and governance. This can force local governments to adopt policies such as providing environmental subsidies (ES) to local enterprises to motivate then to engage in environmental protection activities, thus improving the quality of the local environment. Moreover, under Article 55, highly polluting enterprises are required to disclose specific environmental information to the community, which significantly increases the disclosure of environmental information by polluters. Wang et al. (2020) argued that introducing an information disclosure mechanism under public supervision strengthens corporate environmental information disclosure, while the Environmental Protection Law emphasises corporate information disclosure. In addition, the law directly increases the cost of environmental violations by increasing the associated penalties, thus 'reverse-compelling' heavily polluting enterprises to undertake green innovation activities. Apart from governmental interventions such as Environmental Protection Law, green innovation is widely regarded as an effective tool for addressing the dilemma of economic growth and environmental pollution (Pan et al., 2020). Firms are more likely to engage in green innovation when faced with greater regulatory pressure from the government and normative pressure from social organisations (Berrone et al., 2013).

Governments urge firms to reduce pollutant emissions and energy consumption by doing things such as increasing penalties or shutting down businesses. To avoid major penalties, companies choose to comply with the law and adopt various environmental protection measures, such as reducing energy consumption and curbing environmental pollution through green innovation (Liu et al., 2021). In the face of serious environmental challenges, the Chinese government has encouraged companies to develop and adopt environmentally relevant innovations (Ren et al., 2021), such as the Chinese Ministry of Ecology and Environment's subsidies for energy savings and emissions reduction, environmental technological upgrading, as well as special projects for environmental protection as part of China's 12th Five-Year Plan. ES are market-based incentives designed to stimulate green innovation by enterprises. Based on this background, this paper explores the links between environmental responsibility, corporate green innovation (CGI) and ES among listed companies in China.

The research objectives of this study are as follows:
(1) To examine the effect of the CER on CGI of Chinese listed companies;
(2) To assess the relationship between CER and ES; and
(3) To evaluate the mediating effects of ES on the relationship between CER and CGI.

The remainder of this paper is organised as follows. The next section reviews the CER literature and establishes links to the associated domains of CER and CGI. This review sets the scene for the introduction of the conceptual framework underpinning the research design section, where details of the methodology are presented. The findings follow with the focus on establishing the cluster analysis and then linking this to the sample characteristics. The findings are discussed and linked to relevant literature before concluding with some comments on limitations and future research.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Corporate Environmental Responsibility (CER)

There is no unified answer to the interpretation of CER; many scholars agree that CER is motivated by the common goals of protecting the environment and achieving sustainable development. The research on measuring CER is diverse, including various methods such as the indicator evaluation measurement method, the input-output method and the modelling measurement method (Han and Cao, 2021). Scholars who use indicator evaluation as a measurement method argue that the environmental responsibility of companies for environmental pollution can be evaluated using evaluation indicators (Shvarts et al., 2016). The quality of environmental management as well as corporate environmental impact disclosure was used in a study by Shvarts et al. (2016) to measure the environmental responsibility ratings of Russian oil and gas companies. Due to the rapid development of the Chinese economy, the input-output method has been adapted to the requirements of measuring and applying CER by many Chinese scholars to study CER in China (Han and Cao, 2021). Based on the system of environmental–economic accounting, Wu and Han (2020) analysed input-output models for energy-intensive and high-emissions industries in China to assess the environmental governance costs. Chen et al. (2022) used CER performance based on the CER scores reported by Hexun, which also includes the certification of environmental management systems (Haldar, 2013) and environmental protection investment scores. Therefore, this study will use three dimensions—corporate environmental system management, corporate environmental investment and corporate environmental governance—to measure the CER of companies.

2.2. Corporate Green Innovation (CGI)

The aim of CGI is to produce advanced technologies and production methods that help reduce the company's environmental impact (Ziegler and Rennings, 2004). Green innovation differs from general innovation in that externalities include knowledge spillover, whereas green innovation involves both knowledge spillover and environmental externalities (Ren et al., 2021). Institutional theory suggests that organisations comply with social behaviour to ensure their legitimacy and survival (Deephouse, 1996). In particular, the new law holds government officials accountable for environmental protection, with the government urging businesses to reduce pollutant emissions and energy consumption, and those causing serious pollution to face severe penalties such as phase-out or closure (Yee et al., 2016). To avoid penalties, companies choose to comply with the law and diversify

their environmental practices, for example by reducing energy consumption and curbing environmental pollution through green innovation (Liu et al., 2021). This paper considers corporate green knowledge spillover (i.e. green research and development (R&D) spillover) at the firm level. Past research has found that environmental regulation from government and environmental awareness in society can significantly increase the number of green innovation patents by firms (Fang et al., 2021; Shao et al., 2020). Thus, both external drivers and knowledge spillover are closely linked to green innovation.

2.3. Corporate Environmental Responsibility (CER) and Corporate Green Innovation (CGI)

Past literature has explored the relationship between CER and CGI, and research by Liao et al., 2020 suggests that the adoption of CER by firms can contribute to CGI. Proactive environmental protection strategy and management should be integrated with corporate innovation to make environmental sustainability efforts a realistic activity (Wijethilake et al., 2018). Song and Yu (2018) found that managers usually take responsibility for the environment only comply with laws and regulations and view CER as a burden, while proactive environmental strategies foster green innovation in firms. Environmental degradation has prompted governments, consumers and the public to pay more attention to environmental protection and sustainable development, and CGI can alleviate stakeholder pressure for green products and services (Li et al., 2020). Resource base theory, Hart (1995) suggests that environmental strategies and green innovation explain the relationship between environmental resources and competitive advantage. Green innovation is usually technological innovation related to environmental protection and improvement (Hao et al., 2021), and thus CER is necessarily linked to CGI. Based on the discussion above, the hypothesis is developed:

H_1: CER is significantly correlated with CGI.

2.4. Environmental Subsidies (ES)

ES in China are centrally administered and locally implemented for distribution. Provincial governments encourage enterprises to apply for these ES and then forward their applications to the central government (e.g. the Ministry of Ecology and Environment and the Ministry of Finance) for assessment. The finances are jointly managed by the Ministry of Finance, which is responsible for budgeting and managing the funds, and the Ministry of Ecology and Environment, which is responsible for evaluating and monitoring the funded environmental innovation projects (Ren et al., 2021). In the current institutional situation, local governments hold a large amount of power over the allocation of resources. Government intervention in the form of ES is expected to be effective in allocating resources and promoting environmental activities by local companies (Kang and Park 2012). At the same time, as micro-entities of economic operation, the environmental responsibility performance of enterprises is directly related to local environmental quality, which inevitably affects the government's evaluation of them and thus the allocation of government subsidies (Klette et al., 2000; Ren et al., 2021). Due to China's unique political and social system, corporate environmental behaviour may have more varied consequences than in other countries (Jakuboski, 2014). As China's environmental

management is based mainly on a territorial governance model in which local governments are responsible for local ecological issues, according to the resource-based view, government ES can directly provide firms with the resources required for green innovation (Kang and Park, 2012; Ren et al., 2021), which further strengthens their relationship.

2.5. Corporate Environmental Responsibility (CER) and Environmental Subsidies (ES)

Resource dependence theory (RDT) holds that organisations need to obtain key resources from the external environment to survive, and the importance of resources determines the degree of organisation's dependence on the external environment (Reitz et al., 1979; Chand and Tarei, 2021). As an important scarce resource, government subsidies have a significant impact on the operation of listed companies. Generally, firms actively undertake social responsibility and cooperate with the government to achieve policy goals, which may enable them to obtain resources and achieve better developmental prospects (Su and He, 2010). Government subsidies are a precious resource transferred freely from the government to microeconomic subjects. The stakeholders of companies will judge the competitive strength of the firm by considering the number of government ES obtained by the company because they believe that government authorities have more valuable information than they do (Xia et al., 2021). Based on this analysis, with environmental issues receiving increasing attention in all walks of life, the fulfilment of environmental responsibility by companies not only protects the local environment, but also improves their reputation. It is important to establish and maintain a good relationship with the government for the development of the company. Thus, this paper assumes that fulfilling one's environmental responsibility enhances the ability of enterprises to obtain government resources.

H_2: CER is positively related to ES.

2.6. The Mediating Role of Environmental Subsidies (ES)

An increasing number of scholars are currently focusing on the study of CER (Chen et al., 2020) and examining the importance of the relationship between ES and CGI (Li and Wang, 2021). The drivers of CGI include both internal and external components; government regulation is usually seen as an external driver (Cao and Chen, 2019). Ai et al. (2020) suggested that government regulations and environmental awareness have a significant impact on CGI. The Chinese government's ES has a significant relationship with firms' environmental management innovation (Shao et al., 2020). It has been argued that firms' participation in policy-oriented activities (e.g. making charitable donations, participating in poverty alleviation activities, etc.) may enable them to be recognised by the government, which may improve their own financing environment and access to subsidies (Hao et al., 2020). Recent empirical analysis has established that there is a positive impact between enterprise green innovation and green subsidies and that enterprises can transform government green subsidies into financial performance through green innovation (Hu et al., 2021). In addition, Li et al. (2021) argued that CER promotes enterprises to obtain government subsidies only in the short term between enterprises' environmental responsibility and enterprises' obtaining government subsidies. Previous studies have

focused mostly on the relationship between ES and traditional innovation and have not distinguished between green and non-green innovation. Therefore, this paper assumes that companies convert government resources into internal resources and that companies' environmental responsibility may influence green innovation through ES. Therefore, this paper proposes the third hypothesis as follows:

H_3: ES mediates the relationship between CER and CGI.

In other words, this paper uses a mediating model in which firms take on environmental responsibility and thus receive ES through the mediating effect of green innovation. The research framework, which relates all the research variables and shows the hypotheses, is illustrated in Figure 1.

3. RESEARCH DESIGN

3.1. Sample
This paper uses a sample of listed companies from China, spanning the period from 2015 to 2020, when the new Environmental Protection Law was implemented. The China Securities Market and Accounting Research (CSMAR) database provides the necessary access to the corporate social responsibility (CSR) reports and annual reports of listed companies. It is widely used in business and environmental management literature as it is the largest research database that can provide relatively accurate and comprehensive data for listed companies in China. Of these, data on CGI can be obtained from CSR reports, and corporate accounting data on *ES,* firm age and corporate leverage abstract from company annual reports. Finally, a total of 4,577 observations from 797 sample companies after excluding special treatment (ST), the financial sector and data missing parts.

3.2. Independent Variable (CER)
To provide a more comprehensive assessment of CER, the paper relies on past literature (e.g. Li et al., 2020; Hao et al., 2021) and combine with the CSR reports from HeXun. This paper adopts a CER scoring system. The Guidelines on Social Responsibility of Listed Companies issued in 2006 explicitly require listed companies to periodically assess their CSR performance in accordance with the guidelines, combining the environmental governance scores, environmental management system scores and environmental investment scores disclosed by listed companies,

this study adopts a comprehensive measure of CER assessment assignments.

3.3. Dependent Variable (CGI)
Typically, innovation performance is measured through R&D inputs and patent applications, which represent innovation inputs and outputs, respectively (Xia et al., 2021). However, given the difficulty of distinguishing between a firm's traditional R&D investment and their green R&D investment, this study uses green patent applications as a proxy for a firm's green innovation, a measurement that is in line with many recent studies such as Bai et al. (2019), Yuan et al. (2021) and Xu et al. (2021). These studies assessed the green innovation performance of firms by analysing green patent applications.

3.4. Mediating Variable (ES)
ES is seen as a special type of financial incentive aiming at protecting environmental and natural resources (Xie et al., 2016). ES is government funding to help companies develop green activities and achieve sustainability. Generally, ES includes government green R&D support, policy funds and discount loans to encourage green development of enterprises (Xie et al., 2019). In this paper, ES is measured as the sum of the amounts received by listed companies for each of the financial subsidies and other incentives related to environmental protection.

3.5. Control Variables
Previous studies have shown that some firm-specific factors may influence firms' environmental responsibility strategies (e.g. Xie et al., 2019; Hu et al., 2021). Therefore, the following three variables are used as control variables in this paper, Firm age, Firm Leverage and the environmental awareness of the chief operating officer (CEO). This paper considers the impact of these variables on the CER of listed companies and CGI.

3.6. Model Construction
Based on MacKinnon, Coxe and Baraldi's (2012) approach to identify the mediating role, this study examines the mediating role of environmental subsidy between CER and CGI. A simple mediation model with an independent variable CER, a mediator ES and a dependent variable CGI provides information to study mediation by estimating three regression equations. Thus, this study first establishes Model 1 to detect the relationship between CER and CGI. The coefficient a_1 represents the effect of ES on CGI; a_0 is the intercept, and e_1 is the residual variance.
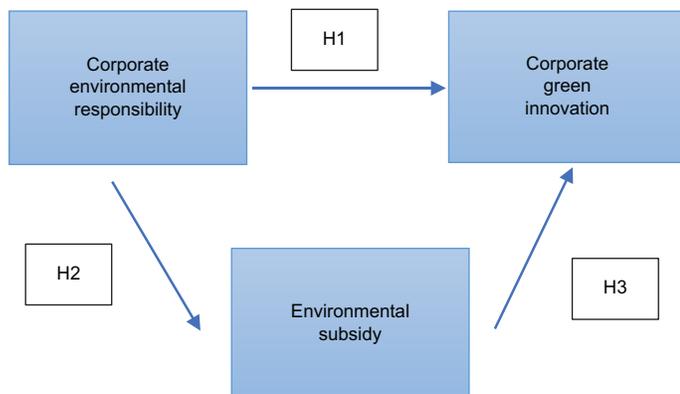
Model 1: $CGI = a_0 + a_1 * CER + CEO + Lev + Age + e_1$ (1)

Model 2 examines the influence of CER on ES.

Model 2: $ES = b_0 + b_1 * CER + CEO + Lev + Age + e_2$ (2)

Model 3 investigates the mediating role of ES on the relationship between CER and CGI.

Model 3: $CGI = m_0 + m_1 * CER + m_2 * ES + CEO + Lev + Age + e_3$ (3)

Figure 1: Research framework

This study analyses the mediating effect through the following four steps. Step 1 checks the coefficient a1. If coefficient a1 is not significant, the analysis of mediating effects is stopped. If it is significant, proceed to the second step; Step 2 examines coefficients b1 and m2; if they are significant, move to the third step; Step 3 examines coefficient m1. There is a mediating effect present when coefficient m1 is significant. Step 4, the final step, checks for the significance of at least one of the two coefficients. If neither coefficient (b_1 and m_2) is significant, the Sobel test is performed. If the Sobel test result is significant, the mediation effect is significant.

4. EMPIRICAL RESULTS

Table 1 presents descriptive statistics, including CER, CGI and government grants received by companies, with the lowest value of CER being 0 and the highest value being 17, with a mean value of 0.453, probably due to the fact that the Environmental Protection Act has only been in force for 6 years and many listed companies did not pay much attention to environmental strategies and information disclosure until then.

The correlation matrix for the dependent and independent variables is presented in Table 2. The correlation matrix shows correlation between CER index and its explanatory variables, as well as the correlations among other variables. This will help in checking the statistical relationship between the dependent and independent variables and whether there is any potential sign of collinearity. It can be decided that multicollinearity does not appear to be a concern in explaining the results from variance inflation factor results, which were tested separately.

Table 3 shows the regression results for the constructed models. Model 1 was used to test the first hypothesis that states that CER has statistical significance related to CGI. It is worth noting that the coefficient between CER and enterprise green innovation is −0.802. The assumption of environmental responsibility by listed CER will not contribute to an increase in the number of corporate green patents during the period 2015 to 2020. In addition,

the results of Model 2 reveal that CER promotes obtain the ES, with a positive and significant coefficient, which is consistent with the previously discussed motivations for CER. Then, the results of Model 3 are of greater interest, it can be seen from the table that b_1*m_2 is less than 0, m_1 is greater than 0 and a_1 is less than 0, which means the indirect effects seriously offset direct effects. Therefore, the results showing that CGI is significantly correlated with CER in the model and that the correlation coefficient is positive, implying that CER can be translated into green innovation capacity through ES.

Based on the results of regression analysis, this paper conducts further analysis by splitting the CER measure into three different subsamples—environmental management system scores, environmental investment scores and environmental governance scores, which are used to analyse the results from different levels of CER performance. These three dimensions are represented in Table 4 by *CER1*, *CER2* and *CER3*, respectively. The results of the empirical model in Table 4 indicate that correlation coefficient of ES is both significant and positive for firms' green innovation. Although the results for the impact of environmental management systems on green innovation are not significant for listed companies in China, it is nonetheless positive for companies to increase their green innovation capacity in terms of environmental investment and management.

The Environmental Protection Act reflects the wishes of the central government in China, but its implementation relies heavily on local governments, which must usually make trade-offs between economic development and environmental protection. In practice, ES does have influence in the process of realising corporate responsibility for the environment and green innovation (Liu et al., 2021). This paper analyses a total of 4,577 observations regarding Chinese listed firms during the 2015–2020 period and uses the approach of MacKinnon et al. (2012) to explore how ES is a mediating variable on the relationship between CER and green innovation. The results of this paper determine that CER does not positively stimulate CGI but rather acts as a mediator for the effect of CGI through ES, which fills this research gap in the field. In addition, further findings show that companies should pay more attention to investing in environmental protection and increasing the level of corporate environmental governance than management system certification. In fact, the findings are not contradictory to previous studies and that provides new evidence to investigate how reality CER can further bring green innovation. Environmental strategy is, thus, a hot topic. Many firms consider sustainable development strategies in the context of a circular economy (Hu et al., 2021). According to the empirical results over the past

Table 1: Descriptive statistics

Variable	Obs.	Mean	SD	Min	Max
CGI	4577	6.862	19.11	0	139
ES	4577	4807721	1.49e+07	5000	1.11e+08
CER	4577	0.453	2.490	0	17
Lev	4577	0.418	0.205	0.061	0.905
FirmAge	4577	2.939	0.230	2.080	3.555
CEO	4577	0.102	0.565	0	4

Table 2: Correlation matrix

	CGI	ES	CER	LEV	FIRMAGE	CEO
CGI	1.000					
ES	0.138***	1.000				
CER	0.046***	0.056***	1.000			
LEv	0.201***	0.160***	0.050***	1.000		
firmage	−0.014	0.079***	−0.015	0.176***	1.000	
ceo	0.046***	0.041*	0.972***	0.058***	−0.019	1.000

*Statistical significance at 10%. **Statistical significance at 5%. ***Statistical significance at 1%

Table 3: Model regression results

Dependent variable	Model (1) CGI	Model (2) ES	Model (3) CGI
CER	−0.802	511150.9	1.33e−07
	(0.006)	(0.045)	(0.000)
ES			−0.870
			(0.003)
LEv	18.496	1.12e+07	17.002
	(0.000)	(0.000)	(0.000)
firmage	−3.874	3036181	−4.280
	(0.000)	(0.000)	(0.000)
ceo	4.119	−1456683	4.313
	(0.002)	(0.205)	(0.001)
intercpet	10.385	−9405947	11.640
	(0.000)	(0.000)	(0.000)
Obvs	4577	4577	4577
adj.r²	0.0497	0.0305	0.0625

The P values appear in parentheses

Table 4: Additional analysis

CGI	CER1	CER2	CER3
CER (subsamples)	−1.422941	1.906	0.657
	(0.092)	(0.012)	(0.005)
ES	1.32e−07	1.33e−07	1.32e−07
	(0.000)	(0.000)	(0.000)
LEv	17.233	17.035	17.012
	(0.000)	(0.000)	(0.000)
firmage	−4.341	−4.300	−4.342
	(0.000)	(0.000)	(0.000)
ceo	−1.059	4.683	3.773
	(0.282)	(0.005)	(0.002)
intercpet	11.676	11.679	11.804
Obvs	4577	4577	4577
adj.r²	0.061	0.062	0.062

P values appear in parentheses

5 years, environmental strategy cannot directly promote the green innovation of firms. This may be because environmental strategy is usually long term, so short-term strategy can be transformed into enterprises' green innovation capability through governmental assistance. These results also enrich the existing empirical evidence on the drivers of innovation for companies, which are increasingly aware of and working towards environmental responsibility considering the increasing environmental pollution and protection situation.

5. CONCLUSION

As research into corporate environmental strategy and social responsibility intensifies, awareness of CER is being further understood and studied. As environmental issues have become more serious, attitudes towards environmental protection have become more important, resulting in stricter disclosure and regulation of relevant information by companies. Furthermore, there is still a research gap in exploring the internal transformation mechanisms of CER and innovation, although there are many research findings on CSR and corporate innovation. This paper analyses how CER is converted into CGI resources through external government funding. And using listed companies during the period 2015–2020 as sample to examines the relationship between CER as measured by corporate ES and CGI outcomes as measured by corporate green patents and explores the mediating role of government environmental subsidies received by firms.

The empirical results of this paper find that CER does not directly enhance CGI and that government environmental subsidies play a positive mediating role. Therefore, government involvement is essential in the implementation of CER for green innovation promotion by Chinese listed companies. As a government department it is more important to incentivise firms to take on environmental responsibility and thus promote green innovation among local companies. In fact, the time frame of this study is only in the last six years since the environmental protection laws were implemented, whereas green strategies and CSR are usually long-term strategies. Therefore, future researchers can analyse this further by comparing the long and short term. At the same time, as the government, as a stakeholder, provides some external conditions to help local companies, this paper suggests that future research could be conducted in the context of regional factors.

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