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Does Green Finance Development Enhance the Sustainability Performance of China's Energy Companies?

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Abstract: The achievement of China's "dual-carbon" standard has been devoted to the green transformation and the sustainable growth of energy firms, both of which can be financed by the growth of green financing. This study aims to investigate how the development level of green finance influences the sustainable development performance of listed energy companies in China. It seeks to delve into the underlying mechanisms connecting green finance with financing constraints and, subsequently, with sustainability performance, as well as exploring the relationship between green finance and green total factor productivity in relation to sustainability performance. Additionally, this study will provide strategies and recommendations to enhance the sustainable development capabilities of energy enterprises. This study empirically evaluates the four aspects of sustainable development performance: economic, social, environmental, and innovative performance—as well as its mechanism of action using the fixed-effects pattern with two ways and the mediated-effects pattern using unbalanced panel data from Chinese-listed energy firms spanning from 2011 to 2020. The study discovered that (1) energy firms' performance in sustainable development is greatly enhanced by the progression of green finance; (2) the advancement of green finance effectively boosts the sustainable development performance of energy companies by reducing financing constraints and enhancing green total factor productivity; (3) a more distinct relationship is evident between the extent of green financing development and the performance of sustainable development within state-owned enterprises. While green finance development has a stronger role in innovative performance for larger energy firms, it has a noticeable proactive impact on the economic, social, and environmental performance of smaller energy enterprises. Based on the study's findings, this paper presents recommendations for the enhancement of green financing policies and the sustainable enhancement of energy enterprises in China.

Keywords: green finance; sustainable development performance; financing constraints; green total factor productivity

Citation: Guo, L.; Chen, F.; Chen, L. Does Green Finance Development Enhance the Sustainability Performance of China's Energy Companies? *Sustainability* **2024**, *16*, 8052. https://doi.org/10.3390/su16188052

Academic Editor: Paola Demartini

Received: 13 August 2024
Revised: 4 September 2024
Accepted: 12 September 2024
Published: 14 September 2024

1. Introduction

Articulated in the 2022 document titled "Opinions on Enhancing Institutional Mechanisms and Policy Measures for the Promotion of Green and Low-Carbon Energy Transition", the importance of building corresponding institutional mechanisms and comprehensive policy systems, with the aim of ensuring that the energy sector can peak carbon emissions by 2030 and ultimately achieve carbon neutrality by 2060, is emphasized. The key to reaching the "double carbon" purpose lies in the transformation of the energy framework, and energy enterprises are the microscopic main body of the energy system required to change, directly affecting the production and consumption of energy; thus, promoting the clean energy transformation and sustainable development of energy enterprises is a significant method to accomplish the "double carbon" goal. Transitioning to renewable energy and fostering the sustainable development of energy enterprises are critical paths toward achieving China's "dual carbon" goals. To facilitate this green transformation, energy enterprises

require substantial financial resources. Under these circumstances, green finance serves as a crucial element, offering substantial backing for their environmentally friendly efforts. By leveraging green financial instruments, energy enterprises can effectively fund and invest in eligible green projects, actively engage in green innovation, broaden their involvement in the new energy sector, and ultimately pursue sustainable development.

For the past few years, growing concerns have arisen about environmental issues, and there has been a growing interest in sustainability performance in academic research. The performance of sustainable development within enterprises is evaluated through a myriad of indicators that assess the overall effectiveness of businesses in achieving both economic and environmental sustainability objectives [1]. Scholars have primarily concentrated on the economic and environmental dimensions of sustainable development performance, with divergent views on the effect on green finance on these aspects. Some researchers argue that the development of green finance positively influences enterprises' sustainable development performance, promoting a scenario that promotes mutual benefits for both environmental integrity and economic prosperity [2,3]. However, other studies have shown inconsistent results on the impact of green finance on both environmental and economic performance. For instance, Zhang et al. demonstrated that the environmental performance of enterprises significantly improved after receiving financing through green bonds, but this did not directly lead to an enhancement in their economic performance [4]. Conversely, Wu et al. found that green credit directly influences the economic performance of enterprises but did not directly affect their environmental performance [5]. Additionally, certain research has exclusively concentrated on the impact of green finance on either the environmental or economic performance of enterprises. Regarding how green finance impacts businesses, the existing literature primarily explores the policy effects of green finance advancement from the viewpoints of financial support and optimal resource distribution [6]. Although the previous literature has laid the groundwork for this study, there are several significant limitations that need to be acknowledged and addressed. Firstly, there is a lack of empirical research specifically focusing on the sustainable development performance of energy enterprises. Secondly, most studies have primarily examined the economic and environmental aspects of sustainable development, neglecting the comprehensive assessment of sustainability that encompasses the environment, society, and innovation. Consequently, there is a need for more comprehensive and multidimensional analyses of sustainable development performance. Lastly, there is a lack of systematic research exploring the mechanisms through which the development level of green finance affects the sustainable development performance of enterprises. Therefore, investigating the impact of green finance on the sustainable development performance of energy companies, and elucidating the underlying mechanisms, can aid in the development and implementation of effective green finance policies, thereby accelerating the sustainable growth of these corporations.

The marginal contributions of this study are outlined as follows: (1) Focusing on listed energy companies in China, this research adopts a green finance perspective to explore how green finance impacts the sustainability performance of various types of enterprises, given that the effects can differ across different enterprise types. (2) This study measures the green finance level of the cities where these energy enterprises are situated, utilizing seven dimensions: green credit, green investment, green support, green insurance, green bonds, green funds, and green equity. These measurements help construct an overall index of green finance for each city, enabling a comprehensive evaluation of its influence on the sustainable development performance of the energy enterprises. (3) This research elucidates the mechanism through which green finance affects the sustainable development performance of energy enterprises by examining the roles of financing constraints and green total factor productivity.

The remainder of the paper is structured as follows: Section 2 outlines the most recent research related to the variables of interest and formulates the research hypotheses; Section 3 details the measurement of these variables and the development of the theoretical

model; Section 4 presents the findings of empirical research analyses; Section 5 further discusses the mechanism of the mediating effect; and Section 6 provides the conclusions, recommendations, and deficiencies in the study.

2. Literature Review and Hypothesis

2.1. Green Finance and Sustainable Development Performance

Drawing on the principles of sustainable development, this study incorporates the four essential dimensions of "economy, society, environment, and innovation" into the evaluation framework for assessing enterprise sustainable development performance [7]. While enterprises are primarily concerned with their own survival in the context of sustainable growths, previous studies have focused on the economics, particularly financial sustainability [8]. However, for long-term and stable development, enterprises should strive for economic benefits while minimizing adverse effects on the social and ecological environment and actively fulfilling their social responsibilities. In the context of energy enterprises' green transformation, which is crucial for achieving the "dual-carbon" goal, technological innovation serves as a key driver [9]. Thus, the ability to innovate becomes an integral component of enterprise sustainable development. Given these considerations, it is key to conduct an in-depth examination of the key factors that influence the multi-dimensional sustainable development performance of energy enterprises.

Amid numerous developmental challenges, the advancement of green finance offers significant opportunities for energy enterprises, thereby enhancing their sustainable development performance. On the one hand, when corporations leverage green financial instruments for financing, they spread a positive message both to the government and the public regarding their commitment to fulfilling environmental and social responsibilities. This proactive approach not only helps to build a favorable reputation but also boosts the confidence of stakeholders in the company's long-term viability. In addition, green finance establishes an "environmental threshold" for enterprise financing; when the expense of managing pollution surpasses that of implementing sustainable innovation, the financing constraints caused by environmental problems will compel enterprises to increase their research and development in eco-friendly technology [10], which will help to promote the improvement of their economic performance and innovation performance.

Conversely, green finance, functioning as a policy-driven financial service, not only offers the necessary financial assistance to companies involved in environmental governance and green innovation initiatives but also plays a supervisory role in monitoring their green transformation efforts. Green finance usually strictly requires enterprises to provide informative environmental information disclosure so that the enterprises' environmental governance information is more visual. In order for businesses to access more green financial capital support, they must undertake environmental social responsibility [11] and carry out environmental information disclosure demonstrating a strong environmental, social, and governance performance to the community to convey their own positive "bleaching green" signal self "greening". Consequently, the implementation of green finance not only enhances the motivation and proactive engagement of enterprises in addressing pollution issues but also establishes regulatory mechanisms to ensure that funds are allocated towards projects focused on environmental conservation. Consequently, the environmental and social performance of enterprises can be effectively facilitated. Based on these observations, this document introduces the subsequent hypotheses:

H1: *The development of green finance markedly boosts the sustainability quotient of energy conglomerates.*

H1a: *The advancement of green finance markedly improves the economic performance of energy companies.*

H1b: *The advancement of green finance vastly boosts the environmental performance of energy enterprises.*

H1c: *The advancement of green finance greatly facilitates the social performance of energy companies.*

H1d: *The advancement of green finance greatly enhances the innovation performance of energy companies.*

2.2. Green Finance, Financing Limitations, and Sustainable Development Performance

Green finance, as a policy-based financial service, aims to promote industrial upgrading, foster technological innovation, and transform development models. It can influence corporate behavior by alleviating financing constraints [12]. Green finance is significant for alleviating the financial challenges encountered by green energy companies and their related projects [13]. According to Xu et al. [14], it functions as a significant mechanism for these enterprises to settle their financing challenges and foster green innovation. Furthermore, the process of securing green financing is typically accompanied by disclosing environmental information, which helps to decrease information asymmetry between the financial markets and the enterprises. This transparency not only facilitates better access to funding but also aids in diminishing the financial constraints that these companies encounter [15].

Energy companies encounter greater financial limitations due to their special industrial characteristics and project features. Lower financing constraints mean that energy enterprises have more funds to invest in promising sustainable development projects, and these investments bring sustained improvements to the environmental performance and green innovation capacity of energy enterprises, improve their competitiveness [16], and further enhance their economic performance. By offering financial backing for initiatives in sustainable business development, green finance is pivotal in fostering the green and sustainable growth of companies while improving their sense of social responsibility [17]. In this regard, green finance offers substantial financial assistance to energy companies actively involved in green innovation and seeking green transformation. It improves the accessibility and convenience of funding for these enterprises, enabling them to increase their investment in environmental protection initiatives. Such initiatives include researching into the circular economy, promoting green and innovative technologies, and implementing equipment designed for energy conservation and emission reduction. Moreover, green finance helps to expand the production scale of clean and renewable energy sources, thereby enhancing the overall sustainable development performance of energy enterprises. Consequently, this paper formulates the following hypotheses:

H2: *The improvement of green finance enhances the sustainability performance of energy corporations by alleviating financing limitations.*

H2a: *The progress of green finance boosts the economic performance of energy firms by mitigating financing challenges.*

H2b: *The evolution of green finance positively impacts the environmental performance of energy firms by addressing financing limitations.*

H2c: *The evolution of green finance fosters the social performance of energy corporations by reducing barriers to financing.*

H2d: *The growth of green finance enhances the innovation performance of energy firms by alleviating financing constraints.*

2.3. Green Finance, Green Total Factor Productivity, and Sustainable Development Performance

Green finance has functions such as financial support and resource allocation, which can gather the idle funds in society, provide financing services for enterprises and other enterprises in need of funds, and direct financial resources to efficient industries, facilitating the optimal utilization of existing financial resources and promoting effective resource allocation [18]. A notable characteristic and driving force behind enterprises' pursuit of sustainable development is the promotion of green total factor productivity (GTFP). GTFP measures productivity by taking into consideration environmental factors, which integrates the performance of enterprises in various aspects such as resource allocation efficiency, economic performance, and environmental performance [19]. Green financial development can reduce non-pollutant outputs and increase green effects through financial support, resource allocation, financial orientation, and the transmission of signaling effects, thus enhancing the GTFP of enterprises [20]. This paper asserts that the advancement of green finance impacts the sustainable development performance of energy firms through the mechanism of the GTFP. Green finance serves as a source of financial backing and direction for energy enterprises in their pursuit of research and development in energy-saving, emission-reduction technologies and clean energy solutions. This, in turn, enhances the green total factor productivity (GTFP) of these enterprises, driving simultaneous improvement in economic performance, environmental performance, and innovation performance. Furthermore, in the background of the "dual carbon" target policy, energy enterprises face increased social supervision and heightened pressure for undertaking "green transformation", and green finance plays the role of transmitting signals so that energy enterprises will consciously improve green productivity and energy efficiency, increase their GTFP, and endeavor to transmit their GTFP to society. In an effort to convey positive green signals to society, GTFP has been instrumental in enhancing social performance, thereby enhancing the sustainable performance of energy companies. Based on this, this document introduces the subsequent hypotheses:

H3: *The progression of green finance leads to the enhancement of energy companies' sustainability performance through the increase in GTFP.*

H3a: *The advancement of green finance helps in the improvement of energy firms' economic performance through the increase in GTFP.*

H3b: *The advancement of green finance facilitates the enhancement of energy firms' environmental performance through the increase in GTFP.*

H3c: *The progress in green finance promotes the enhancement of energy companies' social performance by increasing their GTFP.*

H3d: *The advancement of green finance contributes to the enhancement of energy firms' innovation performance through the increase in GTFP.*

3. Materials and Methods

3.1. Data Sources

In accordance with the guidelines outlined in the "Guide to Environmental Information Disclosure for Listed Firms", the operations and development of energy enterprises significantly influence a country's energy structure and sustainable development. Therefore, this study adopts data from listed energy enterprises (enterprises whose shares are publicly offered and traded on the Shanghai Stock Exchange and Shenzhen Stock Exchange in China) between 2011 and 2020 as research samples to examine the influence of green finance development on the sustainable development performance of energy enterprises. To safeguard the validity of the research findings, the data are processed through these steps: (1) the elimination of ST and ST* enterprises; (2) the exclusion of enterprises listed

for less than 3 years; (3) the exclusion of firms with substantial missing data. Consequently, a total of 134 enterprises were screened, resulting in 1189 valid observations. To minimize the impact of outliers, the primary continuous variables were adjusted by trimming the top and bottom 1% of values.

The data sources for this study are as follows: (1) The Green Finance Index and related data were gathered from various reliable sources, such as provincial and city statistical yearbooks, environmental bulletins, and a series of statistical publications, including but not confined to the China Financial Yearbook and the China Environmental Statistical Yearbook; (2) Tobin's Q value was from the CSMAR database; (3) environmental protection investment was manually collated from the notes of "Construction in progress" in the annual report of Juchao Information Network; (4) the social responsibility score data were sourced from the Hexun.com Social Responsibility Report Database; (5) the patent application data utilized in this study were collected from two primary sources: China Research Data Service Platform and the intellectual property retrieval system of the State Intellectual Property Office (SIPO); (6) additionally, the necessary data for measuring green total factor productivity (GTFP) were obtained from multiple credible sources, including the China Urban Statistical Yearbook, China Environmental Statistical Yearbook, social responsibility reports of listed companies, annual reports, and other relevant information. It is important to note that all other corporate financial data employed in this study were obtained from the CSMAR and Wind.

3.2. Selection of Variables

(1) Explanatory variable: the level of green financial advancement (referred to as Gfin). The existing literature presents primary methodologies for accessing the development level of green finance. The first approach includes selecting representative single dimensions, for instance, green credit or green bonds, to indicate the degree of green finance development [21]. The second approach involves constructing comprehensive indicators to assess green finance, considering multiple dimensions. For example, Tong et al. advanced a measurement index system for green financial development, encompassing perspectives such as green insurance, green credit, green bonds, and green investment [22]. Considering the current body of literature and the concept of green finance, this study adopts a multi-dimensional evaluation system proposed by Fei et al. [23], which includes seven aspects: green credit, green investment, green support, green insurance, green bonds, green funds, and green equity (see Table 1). The entropy method is utilized to measure the extent of green financial development in Chinese cities between 2011 and 2020.

Table 1. Explanation of the construction of the green finance development level index.

Variables	Level 1 Indicators	Secondary Indicators
Level of development of green finance (Gfin)	Green credit	The proportion of loans for environmental projects
	Green investment	Investment in environmental pollution control as a share of GDP
	Green insurance	The level of promotion for environmental pollution liability insurance
	Green bond	Extent of green bond advancement
	Green support	Percentage of government expenditure on environmental protection
	Green fund	Share of a total market capitalization of green funds
	Green benefits	Green equity development in depth

(2) Explained variable: corporate sustainability performance. Existing studies of sustainable development performance are usually measured by corporate sustainability indicators constructed based on the Higgins sustainable growth model. For example, Chen [24] and Zhang et al. [25] used the entropy weight method to select two dimensions of economic and social–environmental performance to calculate sustainable development

performance. However, the sustainable development indicators constructed by this method focus more on measuring economic sustainability. Therefore, this paper focuses on the practices of Ameer et al. [26], Song et al. [27], and Xu [28], which hone in on the measurement of corporate sustainability performance. It combines the characteristics that science and technology innovation occupies an important position in the sustainable energy development of energy enterprises and subdivides corporate sustainability performance into four sub-dimensions: economic, environmental, social, and innovation. (1) Economic performance (ECO). Economic performance is an overall reflection of an enterprise's profitability and growth capacity. The indicators commonly used to assess the economic performance of enterprises can be categorized into financial value indicators and market value indicators. Financial value indicators primarily rely on DuPont analysis to evaluate enterprise performance, focusing on the current operational performance, including metrics like return on equity, return on assets, and net-profit margin [29]. On the other hand, the valuation in the market indicators encompasses the Tobin's Q value, which represents the ratio of a company's market value to its substitution price. This indicator reflects the prolonged investment value and growth of the enterprise. Therefore, this study follows the approach of Chen et al. [30] and adopts Tobin's Q value as a measure of economic performance for the firms. (2) Environmental performance (EP). Environmental performance is the results achieved by enterprises in resource utilization and environmental protection. Nowadays, the main indicators for measuring environmental performance include rewards received or penalties faced for environmental performance [31] and environmental performance scores [32]. Through comparison, it has been found that rewards or penalties received for environmental problems are mainly given based on specific environmental events, which cannot comprehensively assess the environment of the enterprise as a whole; the environmental performance scoring method is inevitably affected by subjectivity because there is no uniform standard for indicator selection and calculation method. Consequently, this study identifies the ratio of investment allocated to environmental protection to the operating income of energy enterprises as a key indicator for assessing their environmental performance. This indicator can reflect the importance of environmental protection, and a high ratio means that the enterprise is willing to bear more costs for environmental management to improve environmental problems and thus improve sustainability. (3) Social performance (CSR). Social performance pertains to the degree to which a corporation meets its social responsibilities. This paper uses Hexun.com's social responsibility score to measure social performance [33]. Hexun.com's total social responsibility score consists of six parts, including shareholder responsibility and environmental responsibility, and this paper uses the value of the total social responsibility score minus the environmental responsibility score. (4) Innovation performance (EIP). Innovation performance refers to the overall performance of an enterprise's participation in technological innovation. This research employs the number of patent applications submitted by companies as a metric to assess their innovative performance. This metric is chosen due to its capacity to better reflect the actual innovation capabilities of enterprises.

(3) Mediating variable: financing constraints (SA). Given that the KZ index and WW index include a higher number of endogenous variables, which may interfere with the sample regression results, this paper follows the method suggested by Wang et al. [34] and employs the SA index to evaluate the financial limitations faced by corporations. The SA index is calculated using the following formula: $SA = -0.737 \times Size + 0.443 \times Size^2 - 0.04 \times Age$. Here, the absolute value of the SA index is considered, with a higher absolute value indicating more significant financing constraints for the enterprise. Additionally, to evaluate the green total factor productivity (GTFP), this paper adopts the approach of Lee [35] by integrating enterprise environmental pollution into the assessment framework. The non-radial, non-angle SBM-ML index is used to measure the GTFP of the enterprises being analyzed.

(4) Control variables: the sustainability performance of enterprises is affected by various factors. Accordingly, this study incorporates the following control variables, which are

commonly utilized in the current research: enterprise age (Age), leverage ratio (Lev), return on assets (ROA), enterprise growth (GRO), return on invested capital (ROIC), shareholding concentration (TOP10), size of the enterprise (Size), two jobs in one (Dual), percentage of independent directors (Ind), cash flow ratio (Cash), government subsidies (GS), and fixed assets ratio (FAR). Comprehensive definitions and detailed descriptions of the variables within this paper are presented in Table 2.

Table 2. Variable definitions and descriptions.

Variables Type	Variables Name	Description of Variable Definitions
Explanatory variable	Economic performance (ECO)	Firm market value/replacement cost of assets
	Environmental performance (EP)	Environmental investment/operating income
	Social performance (CSR)	Hexun.com corporate social responsibility score
	Innovation performance (EIP)	(Number of current patent applications + 1) logarithmic scale
Explanatory variable	Level of green finance development (Gfin)	Measured by the entropy method from seven indicators, including green credit
Intermediary variable	Financing constraints (SA)	SA index
	Green total factor productivity (GTFP)	SBM-ML index
Control variable	Age of enterprise (Age)	Current year—year of the establishment of the enterprise
	Gearing ratio (Lev)	Total assets/total liabilities
	Return on assets (ROA)	Net profit/total assets at the end of the year
	Growth of the business (GRO)	Current amount of operating income/previous amount of operating income minus one
	Return on invested capital (ROIC)	EBIT/(shareholders' equity + interest-bearing liabilities)
	Shareholding concentration (TOP 10)	Ownership percentage held by the company's top ten shareholders
	Enterprise size (Size)	Total assets taken as a natural logarithm
	Dual	Chairman or Managing Director holding one position on the Board of Directors is assigned a value of 1, otherwise it is assigned a value of 0.
	Percentage of independent directors (Ind)	Number of independent directors/number of directors
	Cash flow ratio (Cash)	Net cash flows from operating activities/income from operations
	Government grants (GS)	(Amount of government grants for the period + 1) rounded to the nearest dollar
	Fixed asset ratio (FAR)	Fixed assets/total assets

3.3. Modeling

This research relies on panel data for its analytical research, and a two-way fixed effects pattern to minimize potential problems such as omitted variable bias in the model design has been applied. Consequently, the following multiple regression linear model is formulated to investigate the previously stated research hypotheses:

$$ECO_{i,t}/EP_{i,t}/CSR_{i,t}/EIP_{i,t} = \alpha_0 + \alpha_1\, Gfin_{i,t} + \alpha_2\, Control_{i,t} + \mu_i + \sigma_t + \varepsilon_{i,t} \quad (1)$$

In Equation (1), the explanatory variables $ECO_{i,t}$, $EP_{i,t}/CSR_{i,t}$, and $EIP_{i,t}$ represent economic, social, and innovation performance separately. The core explanatory variable $Gfin_{i,t}$ represents the index of the green financial development level of cities. The control

variable $Control_{i,t}$ encompasses a set of factors that may impact sustainable development performance. The industry and year fixed effects are denoted as μ_i and σ_t, respectively. The term $\varepsilon_{i,t}$ represents the random disturbance. If hypothesis H1 holds, the ratio α_1 will exhibit a significant positive relationship.

4. Results

4.1. Descriptive Statistics

Table 3 offers a summary of the primary variables' statistical descriptions. Notably, the economic achievement (ECO) demonstrates an average value of 1.451, with a range from 0.798 to 8.321, highlighting the variation in economic performance among enterprises. The environmental performance (EP) demonstrates a mean value of 0.138, ranging from 0.00749 to 0.801, indicating varying degrees of attention to environmental protection by firms. The social performance (SD) displays a standard deviation of 13.53, with a range from −2.67 to 61.91, suggesting significant variation in the pursuit of corporate social responsibility obligations. The innovation performance (EIP) indicates a peak value of 8.309, a baseline minimum value of 0, and an average value of 1.6, reflecting substantial diversity in technological innovation levels among different enterprises. The green finance index (Gfin) spans from 0.0803 to 0.609, highlighting substantial variation in the level of green finance development among various regions. All other control variables fall within reasonable intervals.

Table 3. The descriptive statistics for the primary variables.

Variables	N	Mean	Std. Dev	Min	Max
ECO	1189	1.451	0.973	0.798	8.321
EP	1189	0.138	0.125	0.00749	0.801
CSR	1189	24.14	13.53	−2.670	61.91
EIP	1189	1.600	1.647	0	8.309
Gfin	1189	0.369	0.128	0.0803	0.609
Age	1189	19.31	5.268	7	32
Lev	1189	0.545	0.183	0.0685	0.929
ROA	1189	0.0529	0.0489	−0.154	0.183
GRO	1189	0.681	3.021	−0.778	24.24
ROIC	1189	0.0283	0.0473	−0.194	0.162
TOP10	1189	63.63	16.79	23.57	95.99
Size	1189	23.26	1.553	19.63	28.10
Dual	1189	0.103	0.305	0	1
Ind	1189	36.41	4.139	30.77	50
Cash	1189	0.105	0.0851	0.00519	0.464
GS	1189	16.28	3.032	0	22.11
FAR	1189	0.432	0.197	0.0201	0.860

4.2. Benchmark Regression

Table 4 illustrates the results of the benchmark regression study, which investigates the influence on the green financial development of the sustainable development performance of energy companies. The regression results sans control variables are shown in columns (1) through (4), whereas columns (5) to (8) incorporate these controls. The analysis reveals that the advancement of green finance notably bolsters the economic, environmental, social, and innovative capabilities of energy enterprises, irrespective of the inclusion of control variables. This can be put down to the financial backing supplied by green financial initiatives, which facilitates the sustainable transformation of energy companies. Additionally, it signals to the market about their commitment to environmental protection, instilling trust among shareholders, consumers, and investors. Consequently, energy enterprises are motivated to actively fulfill their social responsibilities, resulting in improved economic performance and market value. Moreover, the advancement of green finance stimulates increased environmental conservation expenditures by energy

enterprises, promoting the execution of renewable energy initiatives and the advancement of research in eco-friendly innovative technologies. This, in turn, reduces carbon emissions and advances the development of green technological innovation, thereby improving ecological efficiency and fostering the sustainable growth of energy companies. These findings confirm Hypothesis 1.

Table 4. Benchmark regression results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ECO	CEP	CSR	EIP	ECO	CEP	CSR	EIP
Gfin	0.250 * (1.69)	0.267 ** (2.99)	10.425 *** (3.27)	2.130 *** (5.31)	0.611 *** (3.85)	0.260 ** (3.18)	4.759 * (1.97)	1.174 ** (3.14)
Age					0.00297 (0.60)	0.00666 (1.06)	0.048 (0.77)	−0.00130 (−0.14)
Lev					−0.404 (−1.06)	−0.0112 (−0.24)	−8.084 ** (−3.28)	−0.922 ** (−3.00)
ROA					0.417 (0.14)	0.0530 (0.17)	81.257 ** (2.61)	−4.575 (−1.21)
GRO					−0.0107 (−1.16)	0.000618 (0.55)	−0.132 (−1.24)	−0.0123 (−1.05)
ROIC					−1.210 (−0.32)	−0.381 (−1.00)	35.62 (1.05)	4.666 (1.17)
TOP10					0.000424 (0.26)	−0.000122 (−0.49)	−0.00875 (−0.35)	0.00594 * (2.06)
Size					−0.238 *** (−5.97)	−0.0365 * (−3.06)	2.255 *** (6.31)	0.308 *** (6.35)
Dual					−0.190 * (−2.27)	−0.0195 * (−2.07)	−2.648 ** (−2.86)	0.0751 (0.61)
Ind					0.00471 (0.80)	−0.00150 (−1.86)	−0.0322 (−0.39)	0.000720 (0.07)
Cash					−0.277 (−0.63)	−0.0835 (−1.57)	6.686 (1.70)	−1.094 * (−2.11)
GS					−0.0680 ** (−3.28)	6.61×10^{-6} (0.00)	0.0522 (0.42)	0.0376 ** (2.81)
FAR					−0.702 *** (−3.62)	−0.110 *** (−3.91)	0.286 (0.14)	0.0177 (0.07)
Constants	1.439 *** (12.58)	0.100 ** (2.93)	27.817 *** (13.88)	1.095 *** (5.79)	8.034 *** (11.65)	1.129 *** (4.08)	−27.72 *** (−3.83)	−6.135 *** (−6.02)
Year Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1189	1189	1189	1189	1189	1189	1189	1189
R^2	0.0624	0.7442	01377	0.1925	0.3990	0.7861	04214	0.3007

Note: The *t*-values are presented in parentheses. Significance levels of *, **, and *** indicate *p*-values below 10 percent, 5 percent, and 1 percent, respectively.

4.3. Robustness Tests

4.3.1. Replacement of Explanatory Variables

Recognizing the potential lag in the effects of green financial advancement on the sustainable advancement performance of energy firms, this study utilizes the one-stage delayed value of the green financial development index (L. Gfin) as a substitute for the current value in the regression analysis. This approach aims to diminish the likelihood of reverse causality present in benchmark regression. The test results demonstrate that, even when utilizing the lagged L. Gfin, green financial development continues to have a substantial positive effect on the sustainable development performance of energy enterprises across all four dimensions: economic, environmental, social, and innovation performance. Notably, all findings attain statistical significance at the 10 percent threshold, further reinforcing the resilience of the conclusions drawn from this analysis.

4.3.2. Deletion of Abnormal Data

Given the interrelation between green finance and the broader financial market, the substantial fluctuations witnessed in China's stock market in 2015 had a profound influence on both the financial market as a whole and individual corporations. To mitigate the

potential interference caused by this impact on the research findings, this research employs the methodology employed by Mahmood et al. [36] and reanalyzes the regression models by excluding the data from 2015. The outcomes indicate that, even after excluding the 2015 data, the advancement in green finance consistently exerts a noteworthy positive impact on the sustainability performance of energy enterprises. Furthermore, the regression coefficients linked to the explanatory variables pertaining to the four dimensions of energy enterprises' sustainable development performance successfully meet the criteria for statistical significance at the 5 percent level. As shown in Table 5, these results further substantiate the robustness of the study's conclusions.

Table 5. Robustness test.

Variables	Replacement Explanatory Variables				Deletion of Anomalous Data			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ECO	CEP	CSR	EIP	ECO	CEP	CSR	EIP
L. Gfin	0.699 ***	0.08 *	5.521 **	0.968 **	0.537 ***	0.298 ***	6.374 ***	1.168 **
	(4.04)	(1.85)	(2.17)	(2.38)	(3.78)	(3.57)	(2.59)	(3.03)
Constants	8.372 ***	0.737 **	−34.067 ***	−5.397 ***	7.461 ***	0.729 **	−26.166 ***	−6.45 ***
	(10.63)	(2.87)	(−4.4)	(−4.82)	(11.93)	(2.09)	(−3.8)	(−6.06)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1034	1034	1034	1034	1073	1073	1073	1073
R^2	0.4183	0.8365	04443	0.2770	0.3947	0.7781	0.4046	0.3055

*, **, and *** indicate *p*-values below 10 percent, 5 percent, and 1 percent, respectively.

4.4. Endogeneity Test

Despite the inclusion of year and industry-specific fixed effects in the foundational regression model, along with the selection of control variables across various dimensions, possible endogeneity concerns stemming from omitted variables may still emerge as the sustainability performance of firms could be influenced by additional factors. To tackle this issue, the current study employs the method described by Gao et al. [37] and utilizes the levels of green financial development lagged by one and two periods as instrumental variables in the model estimation. These lagged values are unlikely to directly influence the explanatory variables and are not correlated with the error term; however, they are closely linked to the present state of green financial development, thereby satisfying the criteria for valid instrumental variables.

The instrumental variables are selected and estimated using the two-stage least squares (2SLS) method. The findings from this estimation can be found in Table 6. Column (1) displays the outcomes of the initial-stage regression, which indicate a significantly positive regression coefficient for the instrumental variable related to green financial development, confirming its validity. Columns (2) to (5) detail the findings from the second-stage regression. Notably, both the K-P Wald rk F statistic and the C-D Wald F statistic are significantly higher than the 10% critical value set by the Stock–Yogo test, suggesting the absence of weak identification problems. Moreover, the K-P rk LM statistic is significant at the 1% level, suggesting that under-identification is not a concern. The Hansen J statistic value is 0.121, which is greater than 0.1 and not statistically significant, thereby confirming that there are no over-identification problems.

Table 6. Regression results of 2SLS.

Variables	(1)	(2)	(3)	(4)	(5)
	Gfin	ECO	CEP	CSR	EIP
L. Gfin	0.505 ***				
	(18.02)				
L2.Gfin	0.514 ***				
	(17.60)				
Gfin		0.749 ***	2.377 *	5.025 *	0.842 **
		(4.13)	(1.90)	(1.95)	(2.00)
Controls	Yes	Yes	Yes	Yes	Yes
Year Fe	Yes	Yes	Yes	Yes	Yes
Industry Fe	Yes	Yes	Yes	Yes	Yes
K-P Wald rk F statistic	7741.92				
	[19.93]				
C-D Wald F statistic	8314.65				
	[19.93]				
K-P rk LM statistic	281.73				
	{0.000}				
Hansen J statistic	0.121				
Obs	883	883	883	883	883
R^2	0.9510	0.4179	0.7180	0.4683	0.3114

Note: Stock–Yogo test 10% critical value in [ ] and *p*-value in { }. *, **, and *** indicate *p*-values below 10 percent, 5 percent, and 1 percent, respectively.

Following the resolution of endogeneity concerns, the analysis reveals that green financial development continues to exert a positive influence on the sustainability performance of energy companies. This discovery is consistent with the findings of the benchmark regression, further reinforcing the robustness of the conclusion regarding Hypothesis 1.

5. Further Analysis

5.1. Mechanism Effects Test

To examine the potential mediating role of financing constraints and comprehensive green factor productivity between green finance development levels and sustainable development performance, this study adopts the methodology proposed by Wen and Ye [38]. Following their approach, a mediating effect model is developed based on Model (1) using a stepwise regression method. This model enables the investigation of the interrelationships among the variables of interest and their potential mediating effects on sustainable development performance.

$$SA_{i,t}/GTFP_{i,t} = \beta_0 + \beta_1\, Gfin_{i,t} + \beta_2\, Control_{i,t} + \mu_i + \sigma_t + \varepsilon_{i,t} \quad (2)$$

$$ECO_{i,t}/EP_{i,t}/CSR_{i,t}/EIP_{i,t} = \gamma_0 + \gamma_1\, Gfin_{i,t} + \gamma_2\, SA_{i,t}/GTFP_{i,t} + \gamma_3\, Control_{i,t} + \mu_i + \sigma_t + \varepsilon_{i,t} \quad (3)$$

In Model (2), the coefficient β_1 indicates the influence of advancements in green finance on both financing constraints and comprehensive green factor productivity within energy corporations. Furthermore, the interaction term ($\beta_1 \times \gamma_2$) in Model (3) captures the mediating role of financing constraints and green total factor productivity. This interaction term highlights how the connection between the advancement of green finance and sustainable performance is influenced by these mediating factors.

5.1.1. Financing Constraint Mechanisms

The impact of green finance on corporate financial constraints is detailed in Table 7, column (1). The regression coefficient for Gfin is −0.148, significant at the 1% threshold. This finding indicates that an increase in green finance development enables energy enterprises to secure financial support at lower costs, thereby alleviating their financing constraints.

Table 7. Tests for the mediating effect of financial constraints.

Variables	(1)	(2)	(3)	(4)	(5)
	SA	**ECO**	**CEP**	**CSR**	**EIP**
Gfin	−0.148 ***	0.248 **	0.241 **	4.614 *	0.824 **
	(−4.25)	(2.08)	(3.01)	(1.67)	(2.24)
SA		−2.636 ***	−0.293 ***	−10.794 ***	−2.360 ***
		(−10.39)	(−3.52)	(−5.58)	(−8.96)
Constants	5.376 ***	22.146 ***	1.711 ***	68.777 ***	6.555 ***
	(33.54)	(13.42)	(5.32)	(10.48)	(4.15)
Controls	Yes	Yes	Yes	Yes	Yes
Year Fe	Yes	Yes	Yes	Yes	Yes
Industry Fe	Yes	Yes	Yes	Yes	Yes
Obs	1189	1189	1189	1189	1189
R^2	0.7653	0.5685	0.8048	0.1822	0.3464

The values in parentheses are *t*-values. *, **, and *** indicate *p*-values below 10 percent, 5 percent, and 1 percent, respectively.

Moreover, the coefficients of regression for SA in columns (2) to (5) are all significantly negative at the 1% threshold, showing a strong inverse association between financing constraints and the economic, environmental, social, and innovation performance of energy enterprises. Specifically, heightened financing constraints impede the enhancement of these firms' sustainable development performance.

In columns (2) through (5), the regression coefficients for Gfin are 0.248, 0.241, 4.614, and 0.824, respectively, with all values showing significant positive effects. This illustrates the direct effect of green financial development regarding the sustainable performance of energy companies. Notably, the total effect coefficient of green financial development is lower compared to that reported in the baseline regression in Table 4. This reduction indicates that financing constraints partially mediate the connection between green finance development and the sustainable performance of energy enterprises, thereby supporting Hypothesis H2.

5.1.2. Green Total Factor Productivity Mechanism

The regression analysis examining the consequences of green finance evolution on GTFP is presented in Table 8, column (1). The researches reveal a regression coefficient of 0.053, indicating that green financial development (Gfin) significantly enhances the GTFP of energy enterprises. This suggests that the advancement of green finance is advantageous for enterprises in bettering resource utilization efficiency and optimizing the allocation of resources within the context of enhanced environmental performance, thereby contributing to improvements in their overall sustainable development performance.

Building on the methodology used by Zhao et al. [39],energy enterprises have been categorized into two groups based on their GTFP, specifically those with higher GTFP levels and those with lower GTFP levels, determined by the median GTFP. Subsequently, regressions of Equations (2) and (3) were conducted for each group, with results displayed in columns (2) to (9) of Table 8.

The coefficients of regression for Gfin reveal that green financial development exerts a pronounced positive effect on the economic performance of both groups. However, this effect is notably stronger in the group with higher GTFP. Additionally, green financial development positively impacts the environmental, social, and innovation performance of this higher GTFP group. This indicates that green financial development serves a pivotal function in fostering the sustainable performance of energy enterprises characterized by higher GTFP.

Table 8. Green total factor productivity mediation effect test.

Variables	Higher GTFP					Lower GTFP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	GTFP	ECO	CEP	CSR	EIP	ECO	CEP	CSR	EIP
Gfin	0.053 **	0.549 ***	0.231 **	11.536 **	2.275 ***	0.578 *	0.147	1.406	0.535
	(2.91)	(3.80)	(2.56)	(2.26)	(4.12)	(1.89)	(1.16)	(0.64)	(1.08)
Constants	0.620 ***	5.090 ***	0.985 **	−45.660	−3.452 **	10.492 ***	1.827 ***	−16.570 **	−9.367 ***
	(13.89)	(10.24)	(3.04)	*** (−3.37)	(−2.45)	(8.28)	(3.60)	(−2.58)	(−5.89)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1162	608	608	608	608	581	581	581	581
R^2	0.3215	0.4153	0.9082	0.4026	0.3091	0.4414	0.8389	0.5127	0.3079

*, **, and *** indicate *p*-values below 10 percent, 5 percent, and 1 percent, respectively.

Thus, the findings confirm that green financial progression enhances the economic, social, environmental, and innovation performance of energy enterprises by improving their GTFP. Hence, GTFP acts as a crucial mechanism through which green financial advancement fosters the sustainable development performance of energy enterprises, thereby substantiating Hypothesis H3.

5.2. Heterogeneity Analysis

5.2.1. Heterogeneity of Enterprise Ownership

Regarding property rights, state-owned enterprises generally benefit from superior access to information and access to funds, particularly when it comes to accessing credit. Meanwhile, non-state-owned enterprises often face difficulties in obtaining support from financial institutions and encounter greater financing constraints due to factors such as ownership discrimination and information asymmetry. In such cases, an increased level of green finance development helps improve corporate information transparency, albeit with varying effects on the sustainable development performance of state-owned enterprises (SOEs) and non-state-owned enterprises.

To examine this dynamic, the study divides the sample into two separate groups based on state-owned and non-state-owned enterprises. The detailed results are presented in Table 9.

Table 9. Heterogeneity test for distinguishing firm ownership.

Variables	State-Owned Business				Non-State Enterprise			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ECO	CEP	CSR	EIP	ECO	CEP	CSR	EIP
Gfin	0.543 ***	0.156 **	5.997 **	0.778 *	−0.125	0.041	5.902	1.060
	(3.21)	(2.00)	(2.08)	(1.79)	(−0.25)	(0.49)	(1.43)	(1.56)
Constants	6.803 ***	0.864 **	−17.389 **	−9.442 **	14.188 ***	0.636 *	−47.894 **	7.057 ***
	(10.09)	(4.59)	(−1.96)	(−8.33)	(6.02)	(1.88)	(−3.20)	(3.82)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	908	908	908	908	281	281	281	281
R^2	0.4006	0.8220	0.4306	0.3791	0.5080	0.3046	0.5360	0.2767

*, **, and *** indicate *p*-values below 10 percent, 5 percent, and 1 percent, respectively.

Columns (1) to (8) in Table 9 reveal that green financial advancement has significantly positive impacts on the economic performance, social performance, environmental perfor-

mance, and innovation performance of state-owned firms. However, for non-state-owned firms, the supportive effect of green financial development is not as pronounced. This disparity can be attributed to the fact that, while pursuing profit maximization, state-owned enterprises also carry greater social responsibilities. Furthermore, compared to non-state-owned enterprises, state-owned enterprises have advantages in human capital structure, access to funding, and innovation and development capabilities. These favorable conditions create a supportive environment for sustainable development performance.

Overall, the findings suggest that green financial development fosters a favorable setting for the sustainability of state-owned enterprises, given their unique characteristics and advantages.

5.2.2. Firm Size Heterogeneity

Given the variations in organizational strategies, structures, and others among energy firms of different sizes, the influence of green financial improvement on their sustainable development performance may differ. To address this issue, this research performs an analysis of heterogeneity by segmenting the sample into two distinct groups: large-scale and small-scale firms, based on the median of the logarithm of firms' total assets. The regression results, presented in Table 10, shed light on this analysis.

Table 10. Heterogeneity test to distinguish firm size.

Variables	Small-Scale Enterprises				Large-Scale Enterprises			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ECO	CEP	CSR	EIP	ECO	CEP	CSR	EIP
Gfin	0.672 **	0.341 **	5.997 **	0.457 (0.92)	−0.121	0.004	5.513	1.273 **
	(2.21)	(2.20)	(2.08)		(−0.71)	(0.18)	(1.59)	(2.31)
Constants	19.156 ***	1.333 **	−17.389 **	4.214 **	14.188 ***	0.699 ***	−33.694 **	−12.985 ***
	(10.48)	(3.04)	(−1.96)	(3.01)	(6.02)	(9.31)	(−2.61)	(−6.46)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	594	594	594	594	595	595	595	595
R^2	0.5529	0.7877	0.4306	0.2011	0.2689	0.4714	0.4859	0.3858

, and * indicate *p*-values below 5 percent, and 1 percent, respectively.

Columns (1) to (8) of Table 10 demonstrate that green financial progression exerts a markedly beneficial effect on the economic, environmental, and social performance of small-scale energy firms. Conversely, it exerts a substantial beneficial influence on the innovation performance of large-scale energy firms. This discrepancy can be attributed to several factors. Small-scale firms, being more lightweight and agile, are able to make more precise and tailored choices regarding sustainable development options that align with their specific needs. On the other hand, larger firms enjoy advantages in terms of accessing innovation resources and obtaining financial support, which enhances their ability to excel in innovation performance.

In summary, the findings highlight the differential effects of green financial advancement on the sustainable development performance of energy enterprises based on their size. Small-scale firms benefit in terms of economic, environmental, and social performance, while large-scale firms excel in innovation performance, leveraging their resources and capabilities.

6. Conclusions

6.1. Conclusion of the Study

This study empirically examines the influence of green finance evolution on the sustainable development performance of 134 listed energy firms in China, utilizing unbalanced panel data from 2011 to 2020. Additionally, it investigates the intermediary functions of

financing limitations and green total factor productivity within this relationship. The results unveil several significant revelations:

(1) The advancement of green finance substantially enhances the sustainable development performance of energy enterprises across four aspects: economic, environmental, social, and innovation.
(2) The progression of green finance augments the efficacy of sustainable development in these four areas by mitigating financing constraints and boosting green total factor productivity.
(3) For state-owned enterprises (SOEs), the positive influence of green finance development on economic, social, environmental, and innovation performance is particularly marked. In contrast, for non-state-owned enterprises (non-SOEs), the positive effects on sustainable development performance are less apparent.

Furthermore, the results indicate that small-scale energy enterprises experience a more pronounced positive impact from green finance development regarding their economic, environmental, and social performance. Conversely, larger energy enterprises demonstrate a stronger effect in terms of innovation performance.

6.2. Research Recommendations

Drawing upon these findings, the study suggests the following recommendations:

(1) Strengthen the establishment of a comprehensive green financial system and boost funding for sustainable finance. The results of this research underscore the substantial beneficial effects of green finance on the sustainable advancement performance of energy firms in China. This underscores the need to prioritize green finance as an effective tool for optimizing the country's energy structure and promoting the green transformation of energy enterprises in line with the "double carbon" goal. Accordingly, it is advisable for China to allocate more financial resources towards green finance and introduce supportive policies to motivate financial entities to offer diverse and targeted green financial products. This will enable the channeling of financial resources into the development of the green industry. Enhance the financial regulatory mechanism and improve the information disclosure system. It is crucial to strengthen the regulatory oversight of green finance and ensure the transparency of information. This will encourage financial institutions to leverage their professional expertise to address the resource mismatch resulting from information asymmetry. By doing so, the potential barriers created by limited access to information can be mitigated, promoting a more effective allocation of financial resources towards sustainable development initiatives. This will also foster innovation in green financial products and services. As such, encouraging the advancement of innovative green financial tools such as green credit, insurance, and bonds is essential. These tools can contribute to building up a comprehensive financial support system that facilitates the green technological innovation of energy enterprises. By providing targeted financial support, these instruments can address specific challenges faced by energy firms in their pursuit of sustainable development. By adopting these recommendations, China could further strengthen the significance of green finance in driving the sustainable development performance of its energy enterprises. This will aid in the country's efforts in achieving its environmental and climate goals.
(2) Another crucial aspect to consider is the diversification of green capital financing channels and the increase in dedicated financial backing for the green transformation of energy companies. Previous research has demonstrated that the improvement of green finance contributes to the improvement of energy enterprises' sustainable development performance through the mitigation of financing constraints and the augmentation of green total factor productivity. In light of these findings, it is crucial for the government to strengthen financial support for the green transition of energy enterprises, thus providing essential backing for their environmentally friendly endeavors. To achieve this, the government should establish a supportive mechanism for

green financial products and explore various avenues for green capital financing. This entails fostering the symbiotic relationship between green credit and other financial instruments, for instance, green bonds, green insurance, and transformation funds. By doing so, the government can effectively address the issue of project funding shortages, optimize resource allocation, and mitigate the risks associated with short-term financing for long-term investments. By opening up diversified green capital financing channels and increasing financial support dedicated to the green transformation of energy enterprises, the government can provide the necessary resources and assistance to facilitate their transition towards more sustainable practices. This will not only benefit the enterprises themselves but also contribute to the broader goals of environmental protection and sustainable development. Specifically, for energy enterprises that have undergone smooth transformation and are actively developing renewable energy sources, green financial instruments will be fully utilized to provide these enterprises with a convenient financing channel. For traditional energy enterprises, such as coal and oil, that have difficulties in transitioning and have environmental information that is difficult to quantify, the Government should adopt more policy-based environmental regulatory instruments, such as increasing environmental protection subsidies to encourage enterprises to shut down some factories that are seriously polluting the environment, so as to force energy enterprises to undergo green transition, thereby enhancing the sustainable development performance of the enterprises.

(3) Energy enterprises with different property rights and sizes should combine their own characteristics to improve their overall sustainable development performance. Based on the results of the previous studies, firstly, SOEs should be more active in fulfilling their social responsibilities and improving their profitability while responding to the national green policy. At the same time, they can develop more green products through green technological innovation and pay attention to the environmental performance of the enterprise in order to continue to play a positive role in sustainable development performance. While pursuing profitability goals, non-state-owned enterprises should fully leverage the opportunities for green financial development to develop green and clean innovation products, send positive social signals, and build a good corporate image, so as to further enhance sustainable development performance. Secondly, while ensuring their own survival, smaller enterprises need to amplify their investment in R&D and innovation to create competitive advantages and strive to increase their market share. Larger enterprises, although with a more complete system, should use green finance to develop a broader market in future development and obtain higher benefits while also focusing on protecting the environment and minimizing the harm to the social environment.

6.3. Research Shortcomings and Prospects

This paper may have the following research deficiencies:

(1) In the sample selection, this paper considers the availability of data. Only selected Shenzhen and Shanghai-A-share-listed energy enterprise data are used as a research sample, with many of the unlisted enterprises not being included in the scope of the study. Unlisted enterprises, in comparison to the listed enterprises, have financing channels that are narrower, and the impact of green finance to them will be different from the impact of the listed enterprises; therefore, the sample has been perfected from this aspect.

(2) The accuracy of some data needs to be further improved. There are some limitations in the selection of the explanatory variables in this paper, i.e., the indicators of green finance, although scholars at this stage are mostly sure that this indicator can represent the level of development of green finance, but it also has its shortcomings, and future research can be more precise in measuring the green finance development index of each enterprise.

(3) In this study, while examining the relationship between green finance and sustainable development performance, certain key limitations may have been overlooked. In the transmission process from green finance to the sustainable development performance of enterprises, future research could further investigate the various impact pathways.

Author Contributions: Conceptualization, L.G.; Methodology, L.G.; Software, F.C.; Writing—original draft, F.C.; Writing—review & editing, L.C.; Supervision, L.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Natural Science Foundation of China under Grant No. 71473194, "Theoretical and Applied Research on Multi-stage Investment Management of Coal Resources under Uncertain Environment".

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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