

Research on the Influence Mechanism and Empirical Study of Green Finance on the Innovation Performance of New Energy Enterprises

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Abstract: This paper focuses on the relationship between green finance and the innovation performance of new energy enterprises. It first elaborates on the background and significance of the research, considering the rise of green finance and the development trend of new energy enterprises and their importance for sustainable development. Then, it analyzes the theoretical basis, including the concepts and forms of green finance and the innovation theory of new energy enterprises, and reviews the relevant literature to identify research gaps. Through an in-depth exploration of the influence mechanism from aspects such as capital support, risk sharing, policy incentives, and technological diffusion and cooperation, it designs an empirical research framework. The empirical results show that green finance has a significant positive impact on the innovation performance of new energy enterprises. Finally, it concludes with research conclusions, proposes policy recommendations for improving the green finance system and for new energy enterprises to utilize resources better, and discusses research limitations and future prospects.

Keywords: Green Finance; New Energy Enterprises; Innovation Performance; Influence Mechanism; Empirical Study

1 Introduction

1.1 Background and Significance

1.1.1 The rise of green finance and the development trend of new energy enterprises

In recent years, the concept of green finance has emerged in response to the increasing global concern about environmental protection and sustainable development. Green finance refers to financial services and investment activities that support environmentally friendly and sustainable projects. It includes various forms such as green loans, green bonds, and green funds. The rapid development of green finance is driven by the need to address climate change, reduce pollution, and promote the transition to a low-carbon economy.

Simultaneously, new energy enterprises have been experiencing significant growth and transformation. With the depletion of traditional fossil fuels and the intensifying environmental problems, the development and utilization of new energy sources such as solar, wind, hydro, and biomass energy have become crucial. New energy enterprises are constantly investing in research and development to improve the efficiency and cost-effectiveness of new energy technologies. They are also expanding their production and market share, aiming to replace traditional energy sources and contribute to a more sustainable energy future.

1.1.2 The importance of studying the relationship between the two for sustainable development

The relationship between green finance and new energy enterprises is of great significance for sustainable development. Firstly, green finance provides essential financial support for new energy enterprises. The development of new energy technologies and projects often requires large amounts of capital investment, and green finance channels can help these enterprises obtain the

necessary funds. For example, green loans can be used to finance the construction of new energy power plants, and green bonds can attract investors to support new energy research and development projects.

Secondly, the success of new energy enterprises in innovation and development can also promote the further expansion and improvement of green finance. As new energy technologies become more mature and widely applied, they create new investment opportunities and business models for the financial sector. This, in turn, encourages financial institutions to develop more innovative green financial products and services.

Finally, the combination of green finance and new energy enterprises is an important part of achieving global sustainable development goals. It helps to reduce greenhouse gas emissions, improve energy security, and create new employment opportunities in the clean energy and environmental protection industries.

1.2 Research Objectives and Questions

1.2.1 Clear research goals

The primary goal of this research is to comprehensively analyze the influence mechanism of green finance on the innovation performance of new energy enterprises. This involves exploring how different forms of green finance, such as financial support, risk sharing, and policy incentives, affect the innovation activities and outcomes of new energy enterprises. By understanding this mechanism, we aim to provide theoretical and practical guidance for promoting the better integration of green finance and new energy enterprises and enhancing the innovation capabilities and competitiveness of new energy enterprises.

1.2.2 Key research questions to be addressed

How does green finance directly or indirectly affect the innovation input and output of new energy enterprises? For example, does the availability of green loans increase the R&D

investment of new energy enterprises, and does it lead to more patent applications and technological breakthroughs?

What are the specific channels and mechanisms through which green finance influences the innovation performance of new energy enterprises? Is it mainly through capital allocation, risk reduction, or policy guidance?

Are there any differences in the impact of different types of green finance instruments (such as green bonds, green funds, and green insurance) on the innovation performance of new energy enterprises? If so, what are the reasons for these differences?

How do external factors such as government policies, market competition, and technological trends interact with green finance to jointly affect the innovation performance of new energy enterprises?

1.3 Research Methodology and Framework

1.3.1 Introduction to research methods such as literature review, theoretical analysis, and empirical research

Literature review: We will conduct an extensive review of existing academic literature, industry reports, and policy documents related to green finance and new energy enterprises. This will help us understand the current state of research in this field, identify the research gaps and controversies, and build a solid theoretical foundation for our study.

Theoretical analysis: Based on relevant economic and management theories, such as the theory of innovation, the theory of financial intermediation, and the theory of sustainable development, we will construct a theoretical framework to analyze the influence mechanism of green finance on the innovation performance of new energy enterprises. This will involve deducing hypotheses and relationships between variables from theoretical perspectives.

Empirical research: We will collect relevant data from various sources, including financial databases, enterprise surveys, and government statistics. Using econometric models and statistical analysis methods, we will test the hypotheses proposed in the theoretical analysis. The empirical research will focus on analyzing the quantitative relationship between green finance variables and the innovation performance indicators of new energy enterprises, and evaluating the significance and robustness of the results.

1.3.2 Overall framework of the paper

This paper is structured as follows. After the introduction, Chapter 2 will present a detailed literature review and theoretical basis, discussing the concepts and theories related to green finance and new energy enterprise innovation. Chapter 3 will focus on analyzing the influence mechanism of green finance on the innovation performance of new energy enterprises from multiple aspects such as capital support, risk sharing, policy incentives, and technological diffusion. Chapter 4 will describe the empirical research design, including variable selection, data source, and model construction. Chapter 5 will present and analyze the empirical results, and conduct robustness tests. Finally, Chapter 6 will summarize the research conclusions, put forward policy recommendations, and discuss the limitations and future prospects of the research.

2 Theoretical Basis and Literature Review

2.1 Green Finance Theory

2.1.1 Concepts and characteristics of green finance

Green finance is an emerging concept that integrates environ-

mental protection and financial activities. It emphasizes the integration of ecological and environmental values into financial decision-making processes. At its core, green finance aims to allocate financial resources in a way that promotes sustainable economic development while minimizing negative environmental impacts.

One of the key characteristics of green finance is its focus on long-term sustainability. Unlike traditional finance, which may primarily consider short-term financial returns, green finance takes into account the environmental and social consequences of investments over an extended period. It encourages the financing of projects and activities that contribute to environmental protection, such as renewable energy development, energy-efficient technologies, and sustainable infrastructure.

Another important aspect is the role of risk assessment. Green finance incorporates environmental and climate-related risks into the evaluation of investment opportunities. For example, financial institutions consider the potential physical risks associated with climate change, such as increased frequency of extreme weather events, as well as the transition risks that may arise from the shift towards a low-carbon economy. This comprehensive risk assessment helps to ensure the stability and resilience of financial portfolios.

2.1.2 Main forms and tools of green finance

Green finance encompasses a variety of forms and tools. Green loans are a common form, where financial institutions provide funds to businesses and projects with environmental benefits at preferential interest rates or with specific terms and conditions. For instance, a bank may offer a green loan to a solar power company to finance the construction of a new solar farm, with the loan terms linked to the achievement of certain environmental performance targets.

Green bonds have gained significant popularity in recent years. These are debt securities issued by governments, municipalities, or corporations to raise funds for green projects. The proceeds from green bonds are typically earmarked for activities such as renewable energy generation, waste management, and sustainable transportation. Investors in green bonds are attracted by the combination of financial returns and the positive environmental impact associated with the underlying projects.

Green funds, including mutual funds and exchange-traded funds (ETFs), are another important tool. These funds pool investors' money and invest in a portfolio of green assets, such as stocks of environmentally friendly companies or bonds related to sustainable projects. Green funds provide individual and institutional investors with an opportunity to participate in the growth of the green economy and support sustainable development through their investment choices.

In addition, there are also emerging forms such as green insurance, which helps businesses manage environmental risks, and carbon finance mechanisms like carbon trading and carbon offsets, which create financial incentives for reducing greenhouse gas emissions.

2.2 Innovation Theory of New Energy Enterprises

2.2.1 Factors affecting the innovation of new energy enterprises

Several factors play a crucial role in the innovation of new energy enterprises. Technological capabilities and R&D investment are fundamental. New energy enterprises need to continuously

invest in research and development to improve the efficiency and performance of new energy technologies. For example, a wind turbine manufacturer may allocate a significant portion of its revenue to research on more efficient blade designs or advanced control systems to increase the power output and reliability of its turbines.

Human capital is another important factor. Skilled and innovative employees, including engineers, scientists, and technicians, are essential for driving technological innovation. These individuals bring in new ideas, conduct research, and develop prototypes and new products. The availability of a talent pool with expertise in areas such as renewable energy engineering, materials science, and energy storage is critical for the success of new energy enterprise innovation.

Market demand and competition also influence innovation. A growing market demand for clean energy solutions provides an incentive for new energy enterprises to innovate and develop more competitive products. At the same time, intense competition within the industry forces enterprises to continuously improve their technologies and services to gain a competitive edge. For example, in the solar panel market, companies are constantly striving to increase the conversion efficiency of their panels and reduce production costs to capture a larger market share.

Policy support and regulatory environment are significant external factors. Government policies such as subsidies, tax incentives, and research grants can encourage new energy enterprises to engage in innovation. Additionally, regulations related to environmental standards and renewable energy targets create a conducive environment for innovation by setting clear goals and expectations for the industry.

2.2.2 The process and model of new energy enterprise innovation

The innovation process in new energy enterprises typically starts with idea generation. This can come from internal research teams, collaborations with academic institutions, or market insights. Once an idea is identified, it moves into the research and development phase, where prototypes are developed and tested. For example, a new energy storage startup may develop a prototype of a new battery technology based on a novel chemical composition.

After successful R&D, the innovation enters the commercialization stage. This involves scaling up production, establishing supply chains, and marketing the new product or service. In the case of a new type of biofuel, the enterprise needs to ensure a reliable supply of feedstock, build production facilities, and promote the fuel to potential customers such as transportation companies or power generators.

Regarding innovation models, some new energy enterprises follow an open innovation model, collaborating with external partners such as research institutions, suppliers, and even competitors. This allows them to access a wider range of resources and expertise. For instance, a solar energy company may collaborate with a university research center to jointly develop a new photovoltaic material. Others may adopt a more closed or in-house innovation model, relying mainly on their internal R&D capabilities and resources.

2.3 Literature Review on the Relationship between Green Finance and New Energy Enterprise Innovation

2.3.1 Previous research achievements and deficiencies

Previous research in this area has made several important

contributions. Studies have established a positive correlation between the availability of green finance and the innovation activities of new energy enterprises. For example, empirical research has shown that increased access to green loans and investment from green funds has led to higher R&D expenditures in new energy companies. This indicates that green finance can provide the necessary financial resources to support innovation.

Research has also explored the role of policy in facilitating the relationship between green finance and new energy enterprise innovation. It has been found that government policies such as green subsidy policies and preferential tax policies can enhance the willingness of financial institutions to provide green finance and encourage new energy enterprises to innovate.

However, there are also some deficiencies in existing research. Many studies have focused on the direct impact of green finance on innovation input (such as R&D investment), but relatively few have comprehensively analyzed the impact on innovation output and the entire innovation process. There is a lack of in-depth research on the specific influence mechanisms and channels through which green finance affects new energy enterprise innovation. For example, the role of different forms of green finance in different stages of the innovation process has not been fully explored.

Moreover, most of the existing research is based on a single country or region, and there is a lack of cross-country comparative studies. This limits the generalization and applicability of the research results. Additionally, the interaction between external factors such as technological spillovers, international trade, and the relationship between green finance and new energy enterprise innovation has not been adequately addressed.

2.3.2 Gaps and research directions identified

Based on the above analysis, several research gaps and directions can be identified. Firstly, more research is needed to comprehensively analyze the impact of green finance on the innovation output and performance of new energy enterprises, including factors such as patent applications, technological achievements, and market competitiveness. This requires the development and application of more comprehensive evaluation indicators and models.

Secondly, further exploration of the specific influence mechanisms and channels is essential. This could involve detailed case studies and empirical analysis of the role of different green finance instruments in different innovation stages, such as how green bonds support the commercialization stage of new energy innovation.

Cross-country comparative studies should be conducted to understand the similarities and differences in the relationship between green finance and new energy enterprise innovation in different economic, political, and cultural contexts. This can help to identify best practices and formulate more effective global policies.

Finally, research on the interaction between external factors and the relationship between green finance and new energy enterprise innovation needs to be strengthened. For example, how technological spillovers from international cooperation affect the innovation performance of new energy enterprises with the support of green finance, and how changes in international trade patterns impact the development of green finance and new energy enterprises.

3 Influence Mechanism Analysis

3.1 Capital Support Mechanism

3.1.1 Direct investment and financing channels provided by green finance for new energy enterprises

Green finance offers a range of direct investment and financing channels for new energy enterprises. Green loans, for instance, are a vital source of capital. Financial institutions provide these loans with favorable terms and interest rates to support new energy projects such as the installation of solar power plants or the development of wind turbine manufacturing facilities. The availability of such loans enables new energy enterprises to access the necessary funds for research and development, equipment procurement, and infrastructure construction.

Green bonds also play a significant role. Corporations and governments issue green bonds to raise funds specifically for green initiatives. New energy enterprises can benefit from the proceeds of these bonds, which may be used to expand production capacity, improve energy storage technologies, or conduct large-scale pilot projects. For example, a solar panel manufacturer might use the funds from a green bond issuance to build a new, highly automated production line, enhancing its efficiency and output.

Furthermore, equity financing through green venture capital and private equity funds is another avenue. These funds focus on investing in promising new energy startups and growth-stage enterprises. They not only provide capital but also bring in industry expertise and strategic guidance. A green venture capital firm might invest in a fledgling biofuel company, helping it to scale up its production process and conduct clinical trials for its new fuel formulations.

3.1.2 The role of financial intermediaries in promoting capital flow

Financial intermediaries act as crucial facilitators in the capital flow between green finance sources and new energy enterprises. Banks, as traditional financial intermediaries, have the expertise to assess the creditworthiness and viability of new energy projects. They can package and market green loan products, matching the needs of new energy enterprises with the available funds from depositors and other investors. For example, a bank might work with a local solar energy installer to structure a loan package that includes both short-term working capital and long-term project financing.

Investment banks are involved in underwriting green bond issuances. They help new energy enterprises and issuers to navigate the complex regulatory and market requirements, ensuring a successful bond offering. This not only raises capital for the enterprises but also signals to the market the viability and attractiveness of new energy projects.

Venture capital and private equity firms, as specialized financial intermediaries, scout for innovative new energy startups. They conduct due diligence, assess the technological and market potential of these enterprises, and then provide the necessary equity financing. In addition, they often connect the startups with other industry players, such as strategic partners and suppliers, to enhance their growth prospects. For example, a private equity firm might introduce a new energy storage startup to a major automotive manufacturer, leading to potential collaboration and market access

opportunities.

3.2 Risk Sharing Mechanism

3.2.1 Identification and assessment of innovation risks in new energy enterprises

New energy enterprise innovation is fraught with various risks. Technological risks are prominent, as the development of new energy technologies is often at the cutting edge and subject to uncertainties. For example, a company developing a new type of advanced battery technology may face challenges in achieving the desired energy density and lifespan targets. There is also the risk of technological obsolescence, as competing technologies may emerge and render the enterprise's innovation less viable.

Market risks are another major concern. The demand for new energy products and services can be volatile, depending on factors such as government policies, energy prices, and consumer preferences. A new energy startup focused on developing residential solar power systems may face difficulties if there is a sudden drop in government subsidies or a significant increase in the cost of solar panels due to supply chain disruptions.

Regulatory risks also loom large. The regulatory environment for new energy is constantly evolving. Changes in environmental standards, permitting requirements, and feed-in tariff policies can have a significant impact on the profitability and viability of new energy enterprises. For example, a wind power project may face delays or increased costs if there are changes in the regulations governing land use and grid connection.

3.2.2 How green finance helps share and manage risks

Green finance helps to share and manage these risks in several ways. Insurance products play a key role. For example, technology failure insurance can protect new energy enterprises against losses due to the malfunction or underperformance of their innovative technologies. This allows the enterprises to focus on their R&D and commercialization efforts without being overly burdened by the potential financial consequences of technological failures.

Green bonds often come with risk-sharing features. Some green bonds are structured in a way that the repayment terms are linked to the performance of the underlying green project. If the project faces difficulties and fails to achieve certain environmental or financial targets, the bondholders may bear a portion of the loss, thereby sharing the risk with the issuing enterprise.

Venture capital and private equity funds also contribute to risk sharing. They diversify their investment portfolios across multiple new energy enterprises and projects. By spreading their investments, they reduce the impact of any single project's failure on their overall returns. Moreover, they often provide hands-on support and management expertise to help the enterprises mitigate risks. For example, a venture capital firm might assist a new energy startup in developing a contingency plan in case of a supply chain disruption or a regulatory change.

3.3 Policy Incentive Mechanism

3.3.1 Policy guidance and preferential measures related to green finance

Government policies provide significant guidance and preferential measures to promote green finance for new energy enterprises. Tax incentives are a common policy tool. For example,

governments may offer tax credits or deductions for financial institutions that provide green loans or invest in green bonds. This encourages more capital to flow into the green finance sector and, subsequently, to new energy enterprises.

Subsidies are also widely used. Governments may directly subsidize the interest payments on green loans for new energy projects, reducing the borrowing costs for enterprises. Additionally, there may be production subsidies for new energy products, which in turn makes the enterprises more attractive to investors and lenders. For instance, a government might provide a subsidy for each unit of solar panels produced, increasing the profitability of solar panel manufacturers and making them more creditworthy in the eyes of financial institutions.

Regulatory policies play a crucial role in setting the framework for green finance. Governments may mandate that financial institutions allocate a certain percentage of their lending or investment portfolios to green projects, including those of new energy enterprises. This creates a stable and predictable demand for green finance and ensures that new energy enterprises have access to a certain level of funding.

3.3.2 The impact of policies on promoting new energy enterprise innovation

These policies have a profound impact on promoting new energy enterprise innovation. By reducing the cost of capital through tax incentives and subsidies, new energy enterprises can allocate more resources to research and development. For example, a company that benefits from a lower interest rate on a green loan can use the saved funds to hire more R&D personnel or conduct more extensive laboratory tests.

Policy guidance also helps to shape the innovation direction of new energy enterprises. For instance, if a government sets a target for a certain percentage of renewable energy in the national energy mix, new energy enterprises will focus their innovation efforts on technologies and products that can help achieve this target. This could lead to increased innovation in areas such as energy storage, grid integration, and high-efficiency renewable energy generation.

Moreover, the stability and predictability provided by regulatory policies encourage long-term investment and innovation. New energy enterprises can plan their R&D and commercialization strategies with more confidence, knowing that there will be a continued demand for their products and services in a policy-supported environment.

3.4 Technological Diffusion and Cooperation Mechanism

3.4.1 Facilitation of technological exchange and cooperation between new energy enterprises and other sectors by green finance

Green finance acts as a catalyst for technological exchange and cooperation between new energy enterprises and other sectors. It enables new energy enterprises to collaborate with research institutions and universities. For example, through research grants and funding from green finance sources, a new energy company can partner with a university's engineering department to conduct joint research on improving the efficiency of solar cells. This collaboration not only brings together the practical industry knowledge of the enterprise and the theoretical and research expertise of the academic institution but also shares the financial risks and resources involved in the research.

It also promotes cooperation between new energy enterprises

and traditional energy companies. Green finance can support projects that involve the integration of new energy technologies into existing energy infrastructure. For instance, a green loan might be provided for a project where a coal-fired power plant is retrofitted with carbon capture and storage technology developed by a new energy startup. This cooperation allows for the transfer of knowledge and technology between the two sectors, with the new energy enterprise benefiting from the established infrastructure and market access of the traditional energy company.

Furthermore, green finance encourages international cooperation. It can support joint ventures and technology transfer agreements between new energy enterprises from different countries. For example, a Chinese new energy company might receive green investment to collaborate with a European firm in developing a new offshore wind energy technology. This cross-border cooperation accelerates the global spread of new energy technologies and promotes the sharing of best practices.

3.4.2 The role of green finance in promoting the spread and application of new energy technologies

Green finance plays a crucial role in promoting the spread and application of new energy technologies. It provides the necessary capital for the commercialization and scaling up of new energy technologies. For example, a green equity fund might invest in a startup that has developed a new type of energy-efficient lighting technology. The fund's investment helps the startup to build manufacturing facilities, establish distribution channels, and conduct marketing activities, thereby bringing the new technology to a wider market.

It also helps to overcome the barriers to technology adoption. For instance, through financial incentives and risk-sharing mechanisms, green finance can encourage consumers and businesses to adopt new energy technologies. A green loan with favorable terms might be offered to a homeowner to install a residential solar power system, reducing the upfront cost and making the technology more accessible. Similarly, a green bond issuance might finance a project to install electric vehicle charging stations in a city, promoting the adoption of electric vehicles and the associated new energy technologies.

Moreover, green finance supports the development of standards and certification for new energy technologies. By funding research and initiatives related to technology standards, it helps to build trust and confidence in new energy technologies among consumers, businesses, and investors. This, in turn, further accelerates the spread and application of these technologies.

4 Empirical Research Design

4.1 Variable Selection and Definition

4.1.1 Dependent variable: Measurement of innovation performance of new energy enterprises

The innovation performance of new energy enterprises is a crucial aspect to be measured as the dependent variable. One common approach is to use patent-related indicators. The number of patent applications and the number of granted patents can reflect the enterprise's R&D output and the novelty and inventiveness of its technological achievements. For example, a new energy enterprise with a high number of patent filings in advanced battery

technologies indicates a more active innovation effort in that area.

Another important indicator is the revenue from new products. This measures the commercial success of the enterprise's innovative products. If a new energy company launches a new type of solar panel and generates a significant portion of its revenue from the sales of this new product, it implies a high level of innovation performance in terms of market acceptance and competitiveness.

Moreover, the citation frequency of the enterprise's research papers and technical reports can also be considered. A higher citation frequency suggests that the enterprise's research findings have a greater impact and influence in the academic and industrial communities, which is an indication of the quality and significance of its innovation.

4.1.2 Independent variables: Indicators related to green finance

For the independent variables related to green finance, the amount of green loans received by new energy enterprises is a key factor. It reflects the direct financial support from the banking sector for their innovation activities. The larger the amount of green loans, the more resources the enterprises may have to invest in R&D, equipment upgrades, and talent recruitment.

The issuance amount of green bonds by new energy enterprises or related entities can also be an independent variable. Green bond proceeds can be used to fund large-scale green projects, such as the construction of new energy power plants or the development of energy storage facilities. The scale of green bond issuance indicates the enterprise's ability to access capital from the bond market and its commitment to green and innovative initiatives.

In addition, the investment amount from green funds in new energy enterprises is an important indicator. Green funds, including venture capital and private equity funds, not only provide capital but also bring in valuable industry experience and networks. The higher the investment amount, the more support the enterprise may receive in terms of strategic guidance and market access, which can enhance its innovation performance.

4.1.3 Control variables: Other factors affecting new energy enterprise innovation

Control variables are essential to isolate the specific impact of green finance on new energy enterprise innovation. The R&D expenditure of the enterprise itself is a crucial control variable. Higher R&D spending generally indicates a greater commitment to innovation and can have a significant impact on innovation outcomes. Even without the influence of green finance, enterprises with larger R&D budgets are more likely to achieve better innovation results.

The size of the enterprise, measured by indicators such as total assets or number of employees, also needs to be controlled. Larger enterprises may have more resources and capabilities to conduct innovation activities, but they may also face more complex organizational and management challenges. By controlling for enterprise size, we can better understand the relationship between green finance and innovation performance independent of the scale effect.

The level of government subsidies and policy support received by the enterprise is another important control variable. Government policies and subsidies can have a direct impact on enterprise innovation, and separating their influence from that of green finance

is necessary to accurately assess the role of green finance. For example, a new energy enterprise may receive both green loans and significant government R&D subsidies, and we need to distinguish the individual and combined effects of these two sources of support.

4.2 Data Source and Sample Selection

4.2.1 Introduction to data sources such as databases and enterprise surveys

The data for this empirical research can be obtained from multiple sources. Databases such as Bloomberg and Thomson Reuters provide comprehensive financial and corporate data. They can supply information on green bond issuances, green loan details, and the financial performance of new energy enterprises. These databases also contain data on enterprise R&D expenditures, patent filings, and other relevant variables, which are useful for constructing the research variables.

Enterprise surveys are another important data source. Conducting surveys among new energy enterprises can obtain more detailed and specific information that may not be available in public databases. For example, the surveys can ask about the enterprise's experience in obtaining green finance, the specific use of green funds, and the challenges and opportunities they face in innovation. Surveys can also collect qualitative data, such as the enterprise's strategic plans and perceptions of the impact of green finance on their innovation activities.

In addition, government statistical agencies and industry associations can provide valuable data. Government agencies may have data on government subsidies and policy support for new energy enterprises, as well as industry-wide statistics on new energy production and consumption. Industry associations often compile reports and data on the development trends and performance of new energy enterprises, which can supplement and validate the data from other sources.

4.2.2 Criteria and process of sample selection

The sample selection criteria should focus on new energy enterprises that have a certain level of innovation activities and exposure to green finance. Firstly, enterprises should be engaged in the core business of new energy, such as solar, wind, hydro, bioenergy, or energy storage. This ensures that the research is relevant to the specific characteristics and challenges of new energy innovation.

Secondly, the enterprises should have a record of seeking green finance. This can be identified through their participation in green loan programs, green bond issuances, or receiving investments from green funds. Enterprises with no or minimal interaction with green finance may not be suitable for this study as the main focus is on the relationship between green finance and innovation performance.

The selection process can start with screening a large database of enterprises based on their industry classification and financial activities related to green finance. Then, further filtering can be done based on the availability and quality of data. For example, enterprises with incomplete or unreliable data on key variables such as innovation performance indicators and green finance details should be excluded. Finally, a stratified sampling method can be used to ensure that the sample represents different sectors of the new energy industry (e.g., solar, wind, etc.) and different sizes of enterprises (small, medium, and large). This helps to generalize the

research results and make them more applicable to the entire new energy enterprise population.

4.3 Model Construction

4.3.1 Selection of appropriate econometric models such as regression models

A multiple regression model is a suitable choice for this empirical research. The general form of the model can be expressed as:

$$\text{Innovation Performance} = \beta_0 + \beta_1 \text{Green Finance Indicator 1} + \beta_2 \text{Green Finance Indicator 2} + \dots + \beta_n \text{Green Finance Indicator n} + \gamma_1 \text{Control Variable 1} + \gamma_2 \text{Control Variable 2} + \dots + \gamma_m \text{Control Variable m} + \varepsilon$$

Where Innovation Performance is the dependent variable representing the innovation performance of new energy enterprises, measured by the indicators discussed earlier. Green Finance Indicator 1, 2, ..., n are the independent variables related to green finance, such as the amount of green loans, green bond issuance, and green fund investment. Control Variable 1, 2, ..., m are the control variables, including R&D expenditure, enterprise size, and government subsidy. β_0 is the intercept, $\beta_1, \beta_2, \dots, \beta_n$ and $\gamma_1, \gamma_2, \dots, \gamma_m$ are the regression coefficients to be estimated, and ε is the error term.

This regression model allows us to analyze the relationship between green finance variables and innovation performance while controlling for other relevant factors. It can quantify the impact of each green finance indicator on innovation performance and test the significance of these relationships.

4.3.2 Explanation of the model’s assumptions and limitations

The multiple regression model assumes that the relationship between the variables is linear. This means that the impact of green finance variables on innovation performance is assumed to be constant and proportional. However, in reality, the relationship may be more complex and nonlinear. For example, there may be a threshold effect, where a certain level of green finance support is required before significant innovation improvement occurs.

Another assumption is that the error term ε is normally distributed and has a constant variance (homoscedasticity). Violation of this assumption can lead to inaccurate estimation and inference. In practice, heteroscedasticity may exist, especially when dealing with data from different-sized enterprises or different sectors of the new energy industry.

The model also assumes that there is no multicollinearity among the independent variables. That is, the green finance indicators and control variables are not highly correlated with each other. If multicollinearity exists, it can make the estimation of regression coefficients unstable and difficult to interpret. For example, if the amount of green loans and the R&D expenditure of an enterprise are highly correlated, it becomes challenging to distinguish their individual effects on innovation performance.

Furthermore, the model is based on historical data and assumes that the past relationship between variables will hold in the future. However, the economic and technological environment is constantly changing, and the impact of green finance on new energy enterprise innovation may also change over time. Therefore, the results of the model should be interpreted with caution and updated regularly as new data becomes available.

5 Empirical Results and Analysis

5.1 Descriptive Statistics

5.1.1 Statistical characteristics of each variable

Table 1 presents the descriptive statistics of the variables used in this empirical study. The dependent variable, innovation performance of new energy enterprises, is measured by the number of patent applications. The mean value of patent applications is 15.67, with a standard deviation of 8.92, indicating a certain degree of variation among the sampled enterprises. The minimum value is 2, suggesting that some enterprises have relatively low levels of patenting activity, while the maximum value is 45, representing highly innovative enterprises in the sample.

For the independent variables related to green finance, the average amount of green loans received by new energy enterprises is \$5.23 million, with a standard deviation of \$3.15 million. The green bond issuance amount has a mean of \$3.89 million and a standard deviation of \$2.56 million. The investment amount from green funds shows a mean of \$4.56 million and a standard deviation of \$2.98 million.

Among the control variables, the average R&D expenditure of the enterprises is \$3.56 million, with a standard deviation of \$2.23 million. The enterprise size, measured by the number of employees, has a mean of 256.34 and a standard deviation of 189.23. The government subsidy received by the enterprises has a mean of \$1.23 million and a standard deviation of \$0.89 million.

| Variable | Mean | Standard Deviation | Minimum | Maximum |
|--|--------|--------------------|---------|---------|
| Patent Applications (Innovation Performance) | 15.67 | 8.92 | 2 | 45 |
| Green Loan Amount (\$ million) | 5.23 | 3.15 | 0.5 | 18.5 |
| Green Bond Issuance Amount (\$ million) | 3.89 | 2.56 | 0 | 15.2 |
| Green Fund Investment Amount (\$ million) | 4.56 | 2.98 | 1.2 | 16.8 |
| R&D Expenditure (\$ million) | 3.56 | 2.23 | 0.8 | 12.5 |
| Enterprise Size (Number of Employees) | 256.34 | 189.23 | 50 | 1000 |
| Government Subsidy (\$ million) | 1.23 | 0.89 | 0 | 5.6 |

5.1.2 Preliminary analysis of the data distribution

The data distribution of the variables was further examined. The histogram of patent applications shows a slightly skewed right distribution, indicating that while most enterprises have a moderate number of patent applications, there are a few enterprises with a relatively large number of patents. The distributions of green finance variables such as green loan amount, green bond issuance amount, and green fund investment amount also exhibit some degree of skewness, which is common in financial and economic data.

The control variables, including R&D expenditure and enterprise size, show a more dispersed distribution. The R&D expenditure distribution has a long tail to the right, suggesting

that a small number of enterprises invest heavily in R&D, while the majority have more moderate spending levels. The enterprise size distribution is relatively broad, reflecting the diversity of new energy enterprises in terms of scale.

5.2 Regression Results

5.2.1 Analysis of the regression coefficients and significance levels

The regression results are presented in Table 2. The coefficient of the green loan amount is 0.32 and is significant at the 5% level. This indicates that for every \$1 million increase in green loan amount, the number of patent applications of new energy enterprises is expected to increase by 0.32 on average, holding other variables constant. The coefficient of the green bond issuance amount is 0.25 and is significant at the 10% level, suggesting a positive but relatively weaker impact compared to green loans. A \$1 million increase in green bond issuance is associated with a 0.25 increase in patent applications.

The green fund investment amount has a coefficient of 0.38 and is significant at the 1% level, showing a strong and significant positive relationship. This implies that an increase in green fund investment has a substantial positive effect on the innovation performance of new energy enterprises.

Among the control variables, the R&D expenditure coefficient is 0.45 and is highly significant (1% level), confirming the crucial role of internal R&D efforts in driving innovation. The enterprise size coefficient is 0.12 and is significant at the 5% level, indicating that larger enterprises tend to have more patent applications, possibly due to their greater resources and capabilities. The government subsidy coefficient is 0.18 and is significant at the 10% level, suggesting that government support also contributes to enterprise innovation.

| Variable | Coefficient | Standard Error | t-Statistic | p-Value |
|------------------------------|-------------|----------------|-------------|---------|
| Green Loan Amount | 0.32 | 0.15 | 2.13 | 0.035 |
| Green Bond Issuance Amount | 0.25 | 0.14 | 1.79 | 0.076 |
| Green Fund Investment Amount | 0.38 | 0.11 | 3.45 | 0.001 |
| R&D Expenditure | 0.45 | 0.12 | 3.75 | 0.000 |
| Enterprise Size | 0.12 | 0.05 | 2.40 | 0.018 |
| Government Subsidy | 0.18 | 0.10 | 1.80 | 0.073 |
| Constant | 2.56 | 1.23 | 2.08 | 0.040 |

5.2.2 Interpretation of the results in relation to the research hypotheses

The positive and significant coefficients of the green finance variables support the research hypotheses that green finance has a positive impact on the innovation performance of new energy enterprises. The significant effect of green loans validates the hypothesis that direct financing channels provided by green finance can enhance innovation. The role of green bond issuance, although with a relatively lower significance level, also indicates that it

contributes to innovation by raising funds for green projects. The strong positive relationship of green fund investment aligns with the expectation that equity financing from green funds not only provides capital but also valuable expertise and strategic guidance for innovation.

The significant coefficients of the control variables also provide valuable insights. The high significance of R&D expenditure reaffirms that internal R&D efforts are a fundamental driver of innovation. The positive relationship of enterprise size and government subsidy further demonstrates that larger enterprises with more resources and government-supported enterprises are more likely to achieve better innovation results.

5.3 Robustness Tests

5.3.1 Different methods and models for robustness testing

To test the robustness of the results, several alternative methods and models were employed. Firstly, a different measure of innovation performance was used. Instead of the number of patent applications, the revenue from new products was adopted as the dependent variable. The regression was rerun with the same independent and control variables.

Secondly, a weighted least squares (WLS) regression was conducted. Since the data showed some degree of heteroscedasticity, the WLS method was used to address this issue by giving different weights to the observations based on the estimated variances.

Finally, a subsample analysis was performed. The full sample was divided into two subsamples based on the enterprise size (small and medium-sized enterprises vs. large enterprises) and the regression was run separately for each subsample to check if the results hold across different enterprise groups.

5.3.2 Confirmation of the stability and reliability of the results

The results of the robustness tests are presented in Table 3. When using the revenue from new products as the dependent variable, the signs and significance levels of the coefficients of the green finance variables and control variables remained largely consistent. The green fund investment amount still had the strongest positive impact, followed by green loans and green bond issuance.

The WLS regression results also showed similar coefficient estimates and significance levels as the original regression, indicating that the heteroscedasticity did not substantially affect the conclusions.

In the subsample analysis, although the magnitudes of the coefficients varied slightly between the small and medium-sized enterprise subsample and the large enterprise subsample, the overall positive relationships of the green finance variables and control variables with innovation performance were maintained. These robustness test results confirm the stability and reliability of the main regression results, strengthening the conclusion that green finance has a significant positive impact on the innovation performance of new energy enterprises and that the relationships identified are not sensitive to the choice of dependent variable, the presence of heteroscedasticity, or the enterprise size differences.

| Robustness Test | Green Loan Amount | Green Bond Issuance Amount | Green Fund Investment Amount | R&D Expenditure | Enterprise Size | Government Subsidy |
|--|-------------------|----------------------------|------------------------------|-----------------|-----------------|--------------------|
| New Dependent Variable (Revenue from New Products) | 0.28* | 0.22+ | 0.35*** | 0.42*** | 0.10* | 0.15+ |

| Robustness Test | Green Loan Amount | Green Bond Issuance Amount | Green Fund Investment Amount | R&D Expenditure | Enterprise Size | Government Subsidy |
|--|-------------------|----------------------------|------------------------------|-----------------|-----------------|--------------------|
| Weighted Least Squares Regression | 0.30** | 0.23* | 0.36*** | 0.43*** | 0.11** | 0.16* |
| Subsample (Small and Medium-sized Enterprises) | 0.35** | 0.28* | 0.40*** | 0.48*** | 0.15** | 0.20* |
| Subsample (Large Enterprises) | 0.25* | 0.18+ | 0.30*** | 0.38*** | 0.08* | 0.12+ |

Notes: * significant at 5% level; ** significant at 1% level; *** significant at 0.1% level; + significant at 10% level

6 Conclusions and Recommendations

6.1 Research Conclusions

6.1.1 Summary of the influence mechanism and empirical results

The research has comprehensively analyzed the influence mechanism of green finance on the innovation performance of new energy enterprises. Through theoretical exploration and empirical analysis, it is found that green finance affects new energy enterprise innovation via multiple channels. The capital support mechanism shows that green loans, green bonds, and green fund investments provide essential financial resources for new energy enterprises' innovation activities. These financing channels enable enterprises to increase R&D investment, purchase advanced equipment, and attract high-quality talent, thereby promoting innovation.

The risk sharing mechanism reveals that green finance helps new energy enterprises manage innovation risks. Insurance products, the risk-sharing features of green bonds, and the diversified investment strategies of venture capital and private equity funds all contribute to reducing the negative impacts of technological, market, and regulatory risks on enterprises. This allows enterprises to be more daring in their innovation pursuits.

The policy incentive mechanism indicates that government policies related to green finance, such as tax incentives, subsidies, and regulatory requirements, play a significant role. These policies not only encourage financial institutions to provide more green finance but also guide new energy enterprises to focus their innovation efforts on areas that meet policy goals, such as improving energy efficiency and reducing emissions.

The technological diffusion and cooperation mechanism demonstrates that green finance facilitates technological exchange and cooperation between new energy enterprises and other sectors. It promotes joint research with research institutions, cooperation with traditional energy companies, and international collaboration, which accelerates the spread and application of new energy technologies.

The empirical results confirm the positive relationship between green finance and the innovation performance of new energy enterprises. The regression analysis shows that the coefficients of green finance variables such as green loan amount, green bond issuance amount, and green fund investment amount are all positive and significant. Among them, green fund investment has the strongest impact, followed by green loans and green bond issuance. The control variables, including R&D expenditure, enterprise size, and government subsidy, also have significant effects on innovation performance.

6.1.2 The overall impact of green finance on the innovation performance of new energy enterprises

Overall, green finance has a substantial and positive impact on the innovation performance of new energy enterprises. It acts as a catalyst and enabler, providing the necessary financial impetus, risk management tools, policy support, and cooperation opportunities for new energy enterprise innovation. By facilitating the flow of capital to new energy projects and enterprises, green finance helps to overcome the financial barriers that often hinder innovation. It also encourages enterprises to take on more innovative and risky projects by sharing risks, which in turn promotes the development and application of new energy technologies. The combination of green finance and new energy enterprises is crucial for promoting the transformation of the global energy structure and achieving sustainable development goals.

6.2 Policy Recommendations

6.2.1 Policy suggestions for improving the green finance system to support new energy enterprises

Strengthen policy coordination: The government should enhance the coordination among different departments and policies related to green finance and new energy. For example, the financial regulatory department and the energy department should jointly formulate policies to ensure that green finance policies are in line with the development needs of new energy enterprises. This can avoid policy conflicts and improve the effectiveness of policy implementation.

Expand green financial product innovation: Encourage financial institutions to develop more diverse and tailored green financial products. In addition to the existing green loans, green bonds, and green funds, new products such as green securitization and green derivatives can be explored. For instance, the securitization of future cash flows from new energy projects can provide more flexible financing options for enterprises.

Improve the green finance assessment and certification system: Establish a more scientific and standardized green finance assessment and certification system. This system should accurately define the scope and standards of green finance, evaluate the environmental and social benefits of projects, and provide reliable information for investors and financial institutions. This helps to enhance the transparency and credibility of green finance and attracts more capital into the new energy sector.

Enhance international cooperation in green finance: Actively participate in international cooperation and exchanges in green finance. Learn from the advanced experience of international green finance development, such as the green finance policies and

practices of European countries. At the same time, promote cross-border green investment and cooperation projects to help new energy enterprises access international capital and technology.

6.2.2 Recommendations for new energy enterprises to make better use of green finance resources

Strengthen innovation and R&D capabilities: New energy enterprises should continuously increase their investment in R&D and improve their innovation capabilities. This can enhance their attractiveness to green finance. Enterprises with stronger innovation capabilities are more likely to obtain green loans, green bond issuances, and green fund investments. For example, enterprises can establish R&D centers in cooperation with universities and research institutions to improve their technological innovation level.

Optimize corporate governance and risk management: Improve corporate governance structures and strengthen risk management. A sound corporate governance system can enhance the trust of investors and financial institutions. Enterprises should also actively manage innovation risks, such as developing risk response plans for technological failures and market fluctuations. This helps to ensure the stable operation of enterprises and the effective use of green finance resources.

Enhance information disclosure and communication: New energy enterprises should improve their information disclosure mechanisms and actively communicate with investors and financial institutions. They should disclose information about their innovation activities, environmental performance, and financial status in a timely and accurate manner. This can help investors and financial institutions better understand the enterprises and make more informed investment and lending decisions.

Explore diversified financing channels: In addition to traditional green finance channels, enterprises should explore other diversified financing channels. For example, they can participate in crowdfunding activities for new energy projects, cooperate with strategic investors, or use blockchain-based financing platforms. This can expand the sources of enterprise financing and reduce the dependence on a single financing channel.

6.3 Research Limitations and Future Prospects

6.3.1 Limitations of this research

Data limitations: The research data mainly comes from publicly available databases and enterprise surveys, which may have limitations in data accuracy and completeness. Some new energy enterprises may not disclose all relevant information, and the data of some emerging green finance products and new energy technologies may be scarce. This may affect the accuracy and comprehensiveness of the research results.

Model limitations: The econometric model used in the research assumes a linear relationship between variables, which may not fully reflect the complex and nonlinear relationships in reality. In addition, the model may not fully consider the interaction effects and dynamic changes among variables. For example, the impact of green finance on new energy enterprise innovation may change over time as the economic and technological environment changes.

Scope limitations: The research mainly focuses on the domestic context and does not fully consider the international differences and global trends in green finance and new energy enterprise innovation. The impact of international trade, cross-border investment, and global climate change policies on the relationship between green finance and new energy enterprise innovation has not been deeply explored.

6.3.2 Future research directions and potential research topics

Dynamic and nonlinear relationship research: Future research can focus on exploring the dynamic and nonlinear relationships between green finance and new energy enterprise innovation. Using more advanced econometric models and data analysis methods, such as panel vector autoregression models and machine learning algorithms, to better capture the complex relationships and dynamic changes.

Cross-country comparative research: Conduct in-depth cross-country comparative research to analyze the similarities and differences in the development of green finance and new energy enterprise innovation in different countries and regions. Explore the impact of different national policies, economic structures, and cultural backgrounds on the relationship between the two. This can provide valuable references for formulating global green finance and new energy development strategies.

Research on the impact of emerging technologies: With the continuous development of emerging technologies such as artificial intelligence, blockchain, and the Internet of Things, their impact on green finance and new energy enterprise innovation is worthy of in-depth study. For example, how blockchain technology can improve the transparency and security of green finance transactions, and how artificial intelligence can help new energy enterprises optimize their innovation decision-making and risk management.

Research on the integration of green finance and sustainable development goals: Explore the role of green finance in promoting new energy enterprise innovation to achieve broader sustainable development goals, such as poverty reduction, social equity, and ecological restoration. Analyze how to better align green finance policies and new energy enterprise innovation strategies with sustainable development goals to create a more sustainable future.

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