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# Exploring the Sustainable Development Path of a Green Financial System in the Context of Carbon Neutrality and Carbon Peaking: Evidence from China

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**Abstract:** In the 75th session of the United Nations General Assembly, the Chinese government first proposed the goal of carbon neutrality and carbon peaking. Since then, China's economy and society have undergone a comprehensive green and sustainable development upgrade and transformation. The development of green finance can provide financial support for the achievement of the dual carbon goals and mitigate the impact of climate change, and more importantly can contribute to the sustainable development of the national economy and society. In this study, we innovatively draw on the quality function deployment theory in marketing to logically formulate the research idea of this paper. The greatest advantage of this approach is that it enhances the readability of this paper and enriches the research logic system of this paper. On this basis, we also applied the G1-entropy value method from fuzzy mathematical theory for quantitative research. In fact, it should be noted that the G1 method we propose in this study is actually an improved subjective assessment method, in which we introduce expert ratings to improve the reliability of the subjective assessment results. As we all know, financial system architecture and research is a common academic topic, but unlike the classical research on the development quality of financial systems, we innovatively addressed the actual national conditions in China and fully integrated green elements in the construction of the index system from the perspective of green finance and sustainability. Finally, we calculated the index weights through G1-entropy quantification, and qualitatively propose countermeasures for the development quality of China's green finance for key index factors. In conclusion, we sort the contributions of this paper into the following three aspects: (1) we innovatively combined the quality function deployment theory and built the quantitative analysis process architecture in this paper, which enhanced the readability of this paper; (2) we realized the use of quantitative research for qualitative analysis and proposed the G1-entropy value method, which made up for the defects of the subjective and objective methods in the traditional evaluation methods; and (3) we realized the organic combination of quantitative and qualitative analysis, and proposed relevant countermeasure suggestions based on the quantitative index calculation results, which provided relevant countermeasure suggestions for promoting the sustainable and high-quality development of green finance in China.

**Keywords:** economic quality evaluation; dual-carbon context; G1-entropy value method; green financial system; quality function deployment theory



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## 1. Introduction

Green finance is the core driving force of the financial system to help sustainable economic and social development and the achievement of the dual-carbon goal. In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development in its seventieth session to promote the direction of sustainable development in the world, after which China issued the China Country Program for Implementing the 2030 Agenda for Sustainable Development, which planned a comprehensive deployment of the work to be implemented. In September 2015, the Central Committee of the Communist Party of

China (CPC) and the State Council issued the General Plan for the Reform of the Ecological Civilization System, which for the first time explicitly proposed to "establish China's green financial system", and "green finance" was included in this plan for the first time. In August 2016, the People's Bank of China and seven other departments jointly issued the Guiding Opinions on Building a Green Financial System, which established the top-level structure for the construction of China's green financial system, clarified the important role of the securities market in supporting green investment, and put forward a series of incentives to support and encourage green investment and financing. In 2020, the Sixth Plenary Session of the 19th CPC Central Committee included carbon peak and carbon neutral targets in the 14th Five-Year Plan for the first time, aiming to achieve carbon peak by 2030 and carbon neutrality by 2060. It is clear that we should promote green development, circular development and low-carbon development and adhere to the civilized development path of production development, affluent living and good ecology.

According to Data from China Statistical Yearbook, China Research Data Service Platform and other relevant databases, the green finance index of China's provinces and regions is currently rising year by year, with Beijing having the largest increase, from 0.19 in 2001 to 0.84 in 2020; green credit in the market accounts for 90% of green financing. By the end of 2021, the total balance of green loans in China was CNY 15.9 trillion, 12.7% higher than the end of 2020; in addition, funds invested in carbon emission reduction and other green loan projects accounted for 67% of the green loan balance, taking into account the four major state-owned banks, Bank of China, Agricultural Bank of China, Industrial and Commercial Bank of China and China Construction Bank. We used the following Figure 1 to show the table of green credit of the four major banks during 2015–2021: green bonds, green funds, green insurance, carbon finance, etc. Accounting for only 10% of green financing, green bonds currently have a stock size of CNY 1.16 trillion and the number of issues is about 560, with a year-on-year growth of more than 100%. Green insurance mainly contributes to the development of low-carbon agriculture, with the amount of green insurance close to CNY 45 trillion in the past three years.

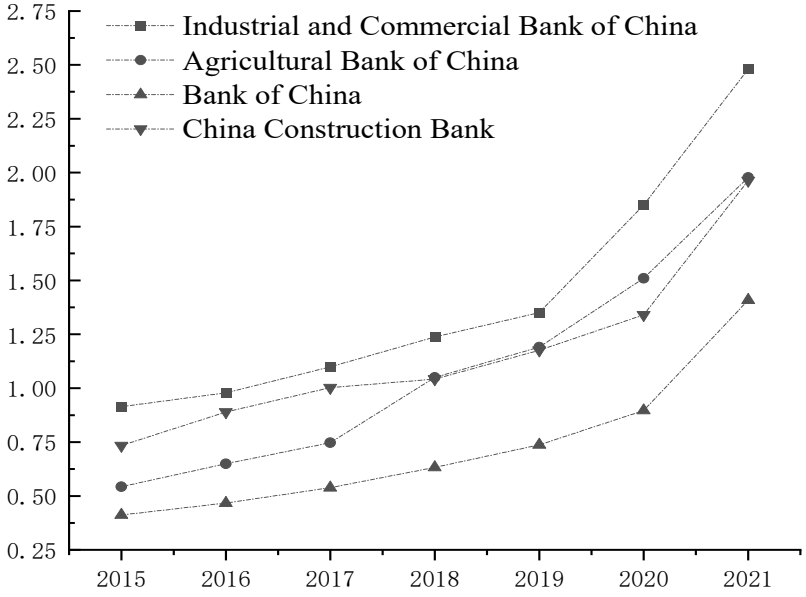


**Figure 1.** Green credit balance of China's four largest state-owned banks (unit: trillion yuan).

Green finance is now a global issue. Clarence Tolliver et al. found that because of the growing demand for sustainable economic development, the amount of green innovation and finance in Asia is already increasing [1]. Japan has been a global leader in green patents since the mid-1980s, while South Korea and China have largely increased their patents related to pollution reduction and they believe this has been driven in large part

by government policy [1]. Jia QX argues that limited efforts have been made in Russia to decarbonize the economy [2]. Meanwhile, renewable energy generation and low-carbon transportation are two of the largest and most established areas of green investment in the United States [2]. Ge SB et al. examined the use of green energy to reduce $CO_2$ emissions and how new materials can help green agriculture is also an interesting research area [3,4].

The rest of this paper is organized as follows: Section 2 is a literature review, in which we provide a detailed review of the literature related to green finance, carbon neutrality, carbon peaking and green finance quality assessment; Section 3 is the basic theory, in which we introduce the quality function deployment theory; Section 4 is an overall qualitative analysis of the current situation of the development of China's green financial system; Section 5 is a method used to assess the development of green financial systems based on quality function deployment theory; Section 6 is a quality assessment of building a green financial system in China as a practical case to verify the scientific rationality of the proposed method; Section 7 is a path and countermeasures to improve the quality of a green financial system in China for quantitative analysis results; and Section 8 is a conclusion.

## 2. Literature Review

We focus on the quality assessment problem of green finance development in China in this study, aiming to build a comprehensive financial quality assessment system, propose a quality assessment method based on QFD and G1-entropy method, and argue the feasibility and scientific rationality of the research method with China as the actual analysis object. We drew the literature review into a schematic diagram, as shown in Figure 2.

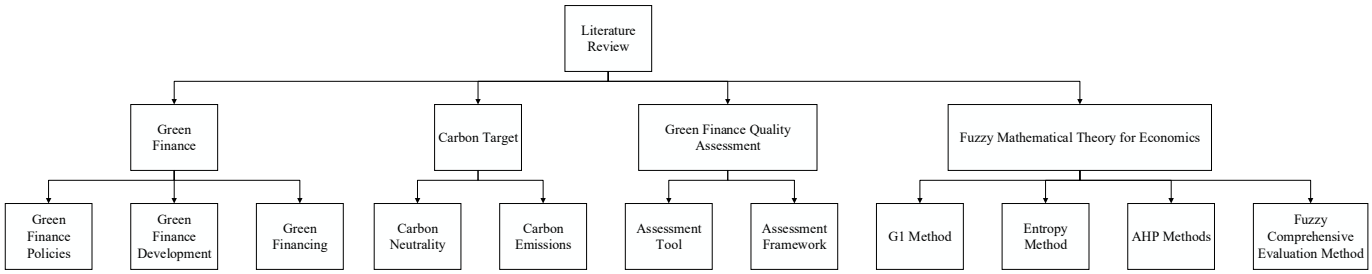


**Figure 2.** Schematic diagram of literature review.

In terms of green-finance-related research, there is a rich collection of international research literature available, mainly focusing on financial policies and empirical financial case studies. For example, Zhang, DY used bibliometric analysis to summarize the current situation and development trend of green finance [5]. Lee, JW explored the role of green finance in achieving sustainable development goals through the case of China and summarized the latest trends of green finance, the main challenges to development, development policy recommendations, and how the public and private sectors can promote green finance [6]. The study by Jin, Y et al. reflects the interactive effects of green finance policies and policies to support the economies of less developed regions, and they argue that banks still dominate credit allocation in the Chinese financial market [7]. Their study summarizes the current status of green finance development in qualitative terms, which provides a basis for us to understand the current status of green finance development, and provides theoretical support for us to evaluate the quality of green finance development by combining qualitative and quantitative analysis methods. The study by Lee, C and C. Lee extends and refines the comprehensive indicators of green financial development and comes up with the estimation that green financial development significantly increases the level of green productivity, and this study also finds that implementing green financial policies can further enhance the impact of green financial development [8]. We endorse this study, and interestingly they are similar to our research idea, in which we will study the overall quality indicators of green finance so as to construct a comprehensive evaluation mechanism and countermeasure suggestions, and their study can provide ideas for us to

build an indicator system. In addition, existing scholars have summarized the methods and roles of green finance. The study of Ozili, PK proposed the link between digital finance, green finance and social finance, showing that digital finance is an enabler and channel for efficient green finance and social finance [9]. Zhang, DY et al. assessed the relationship between public research, development expenditure, green economic growth and energy efficiency [10]. The study found that the fluctuations in green economic growth indicators are due to the non-seriousness of government policies and they also found that public green finance promotes green economic growth. Their study provides multiple perspectives on our understanding of green financing. Green financing includes many aspects, and the current research in academia mainly focuses on green credit. There is a lack of research on green bonds, green funds, and green insurance, which will be included in our study to enrich the existing research in the index system for assessing the quality of green financial development. Among the studies on green credit are Liu, XH et al., who studied green credit policy, property rights and debt financing and proved that a green credit policy system has a guiding effect on credit resource allocation [11]. Song, ML et al. showed that green credit has a significant role in promoting efficient energy use and green credit has a positive impact on efficient energy use in China [12]. Their study provides assistance for our study of green credit policy. Xu, XK and Li, JS showed that both green credit policy and green credit development reduced the cost of debt financing for green firms, and the effect of green credit policy on the cost and maturity of corporate debt financing occurred partly through the development of green credit [13]. A study by Hu, GQ et al. examined the impact of green credit policies on green innovation in heavily polluting firms [14]. The findings suggest that green credit policies can stimulate green innovation in emerging economies by imposing credit constraints that lead to green transformation. The above studies on green credit show that green credit can have a positive impact on green resource allocation, green firms, and provide evidence for our study on the importance of green credit. The study by Nguyen, TTH et al. found low or negative correlations between green bonds and stocks and commodities, and their decentralization benefits were significant [15]. Although the direction of their study deviated somewhat from ours, it is a good topic to explore the link between green bonds and financial markets. This study also provides us with assistance in understanding green bonds. In addition, many scholars have given countermeasure suggestions for the development of green finance. Yu, CH et al. suggested through their study that the government should increase support for private enterprises to invest in green projects, financial institutions and private enterprises could disclose more information about green credit and green projects, and the CBRC should design a comprehensive evaluation mechanism for green performance [16]. Chen, Z et al. proposed a policy recommendation for the green development and governance of Chinese agricultural policy recommendations for coordinated development and governance [17]. Naqvi, B et al. suggested that immediate legislative, governance and regulatory interventions are necessary to promote a sustainable financial system [18]. We appreciate their study, and interestingly, they also point out the need to construct a system of indicators related to green financial development, providing strong evidence for the need of our study. Finally, the research in this section focuses on green finance policy formulation as well as empirical analysis, with most of the studies adopting a qualitative approach to provide targeted policy recommendations for green finance quality development. Although this study also focuses on green finance policies, the difference is that we will explore the key issues of the quality assessment system of green finance development through interdisciplinary theoretical integration to quantitatively analyze.

The adoption of the Paris Agreement marks the formation of a common goal for countries around the world to transition to green and low-carbon in order to combat climate change. Under the requirement of a carbon neutral target, there is a huge gap in the funds paid by countries around the world for this purpose, and green financial privacy is given higher expectations and more responsibilities. In terms of the research related to the double-carbon target and green finance, the current research in academia mainly

focuses on carbon emission and carbon trading analysis. In terms of carbon emissions, Li, JY and Li, SS showed that both energy investment and economic growth are the main reasons for the increase in $CO_2$ emissions at the provincial level in China, and that regional economic growth suppresses the increase in carbon emissions in neighboring provinces through an indirect effect [19]. Hailemariam, A found a nonlinear relationship between economic growth and $CO_2$ emissions, and the results suggest that policies aimed at reducing the highest income inequality can reduce carbon emissions and improve environmental quality [20]. Li, GC and Wei, WX showed that there is a significant nonlinear relationship between carbon emissions and financial development, openness, innovation, and economic growth, and they found that carbon emissions attenuate the contribution of financial development and innovation to economic growth and the impact of carbon emissions on economic growth varies by region [21]. While A and Eadson, W studied decarbonization as a form of spatial economic restructuring and its potential impact on reinforcing and/or countering existing patterns of spatial development imbalances, providing a new critical perspective on the low-carbon transition [22]. We praise their research results, which very well reveal the interaction mechanisms between carbon emissions and economic development, and we will build on their work to refine the structural system of relevant carbon emission indicators that affect green finance. The study of Chen, X and Lin, BQ examined the policy effectiveness of carbon trading in two stages and clarified the role of carbon-trading mechanisms in promoting energy saving and emission reduction [23]. Gao, YN et al. argue that the ETS helps pilot regions and industries to reduce emissions, while they also argue that the ETS encourages the outsourcing of emissions from pilot regions to non-pilot regions and exacerbates the imbalance of emissions transfer between regions [24]. Although their study deviates from our perspective, we find it interesting that their study quantitatively analyzes the role of carbon trading, which can provide a reference for us to construct a comprehensive indicator system from combining qualitative and quantitative methods. They also give policy recommendations from the carbon trading perspective, which can also support our subsequent policy recommendations on the quality of green financial development in response to the quantitative analysis results. The study of Pereda, PC et al. concluded that the adoption of a carbon tax would have a negative impact on GDP, wages and employment in the short term, but would reduce emissions and generate new government revenues, especially in the case of tax increases [25]. Their study provides a policy recommendation for carbon emission governance, which can provide us with subsequent policy recommendations. Yang, CX et al. found that energy restructuring can help achieve the 2030 carbon intensity target in both the steady- and medium-growth scenarios [26]. Their study can also provide us with ideas for giving policy recommendations. In general, the studies in this section focus on the relationship between carbon emissions and economic growth and the formulation of policies related to dual carbon, and most of the studies adopt a single perspective to provide targeted policy recommendations for dual carbon targets. Although this study also focuses on the green finance issue under the dual carbon target, the difference is that in our study, we will consider green finance as a whole to provide countermeasure suggestions for achieving the dual carbon target.

A sound green financial system and the promotion of ecological civilization are important tasks for the Chinese government to achieve sustainable economic development, as well as a necessary path for countries around the world to achieve carbon neutrality and carbon peaking. In addition, whether green finance can truly contribute to the promotion of sustainable economic development is inseparable from quantitative and effective assessment tools. We have compiled the current research on green finance quality assessment by scholars, and it can be seen that the existing research directions are very rich. The research literature is currently focused on global and national green financial development quality assessment and corporate green development quality assessment analysis. In terms of global green financial development quality assessment, Melnyk, T et al. developed a complete methodology to revise the System of Environmental-Economic Accounting

(SEEA) established by the UN methodology by comparing existing methods with statistical assessment of the state of the green economy and green growth potential [27]. The study of Shkola, V et al. was based on green projects, environmentally damaging projects, environmentally neutral projects and mixed projects and calculated a sustainability index, resilience index, and risk (including country risk) to improve the accuracy of the assessment [28]. The current indicators for macro green financial development quality assessment are mostly focused on environmental protection and damage factors, while the highlights of the research specifically on green financial indicator systems are less obvious, and we will focus our research on this issue. In terms of practical country cases for assessing the quality of green finance development, Adjei-Bamfo, P et al. proposed a novel evaluation framework for environmentally sustainable human resource management in the context of developing economies and local government organizations [29]. The study of Wasan, P et al. explored the barriers and strategies for promoting green finance development in India. Policy barriers, economic barriers, and knowledge barriers were found to be the three major barriers to green finance adoption, and an environmental policy and risk assessment framework was identified [30]. Their study used quantitative analysis to identify country-specific barriers to green finance development and give policy recommendations; unlike them, we will add qualitative analysis factors to construct a system of indicators to assess the quality of green financial system development. The study of Lv, CC et al. uncovered the construction of a policy-oriented and market-based green finance development index system and used the entropy–weight method to calculate the green finance development index and to reveal the evolutionary trends and root causes of the green finance development gap in China [31]. Interestingly, we also used China as a case study, and their study can inform our own. In terms of quality assessment of corporate green development, Chygryn, O et al. examined stakeholders' evaluation of green competitiveness effects in five dimensions: consumer satisfaction with green goods, green product production efficiency, green product quality and cleaner production, institutional cooperation, and community impact [32]. Han, MN et al. showed that analyst coverage can significantly improve firms' green innovation performance and encourage managers to promote green investments with a long-term perspective [33]. The study of Sellitto, MA proposed a model based on three constructs: green strategy, green innovation, and green operations, organized in 16 categorical indicators, prioritized using hierarchical analysis, and evaluated by three practitioners from each focal company for indicator completion [34]. Similar to their study, we also ranked the indicators in terms of importance. Their study can provide a reference for us to construct the indicator system, but in terms of methodology we improved the traditional hierarchical analysis method and proposed to apply the G1 method for subjective assignment. In terms of quality assessment in the context of green supply chain management, although deviating from our study, we consider it an interesting research topic. Thanki, S and Thakkar, J proposed a fuzzy decision test and evaluation laboratory method incorporating an analytical network process for assessing lean and green performance of supply chains [35]. Khan, SAR and Yu, Z provided an experimental assessment of the impact of in-house environmental management and green information systems on green supply chain practices, providing a policy framework for manufacturers, regulators, and legislators [36]. Notably, their study also illustrates the necessity and importance of government green policies for green development and provides a theoretical basis for our study. This part of the study mainly deals with the aspect of green financial system evaluation indicators by domestic and foreign scholars, who use energy, environmental protection, and risk as part of evaluating the green financial system, and our present study will further expand the evaluation indicators of green financial quality in China to provide a deeper methodological support for similar international academic studies.

Fuzzy mathematical theory is often applied in the research of decision evaluation problems in the field of economic management such as enterprise financial evaluation, fuzzy decision-making, economic quality assessment, economic development, etc. The main methods in fuzzy mathematical theory include intuitionistic fuzzy set theory, hooked

fuzzy set theory, hesitant fuzzy set theory, entropy method, cumulative prospect theory, fuzzy comprehensive evaluation method, G1 method, etc. The study of Zhang, BF and Wang, YF transformed the internal development of green finance into three subsystems through the PSR model and calculated the evaluation scores through the entropy–weight method. They also constructed an evaluation system for the development of green finance [37]. The study of Sun, XS established a complete evaluation system of ecological environment quality, compared it with the current situation and development of a circular economy, and compared it with foreign models of circular economy development [38]. He considered it necessary to apply the entropy value method to conduct a comprehensive analysis and evaluation of regional economic development. This study was more objective and used only the entropy method, while our study further optimized the entropy method and proposed a method combining the subjective and objective assignment methods. Fan, M combined the entropy method with the hierarchical analysis method to construct a comprehensive economic development evaluation index system [39]. Their research method is similar to ours; we used the combination of the entropy method and the G1 method, and our method was improved on the basis of the hierarchical analysis method. He, XW combined expert evaluation, the objective weighting method and the entropy evaluation method to jointly determine the index weights, and then constructed a comprehensive index of regional ecological capital operation to empirically analyze regional ecological capital operation [40]. Their research is similar to our research idea, but our research focuses on green finance. Xu, XY and Zeng, ZJ used computer technology to combine with regional economic development to establish an economic development evaluation model to evaluate and analyze regional economy [41]. They chose the entropy–weight–TOPSIS model as a comprehensive evaluation model for regional economy, and used the entropy–weight method to determine the weights of each indicator, and then used the TOPSIS method for comprehensive evaluation. All the above five studies used the entropy method to construct the evaluation system, which indicates that the entropy method is a popular method for constructing evaluation indexes in academia, and our study also used the entropy method for objective weighting, and they provided methodological references for our study. In terms of intuitionistic fuzzy set theory, the study of Percin, S proposed for the first time a group decision model based on integrated hierarchical analysis and complex proportional assessment methods in an interval-valued intuitionistic fuzzy set setting for dealing with uncertainties affecting decision makers' decisions [42]. For the fuzzy comprehensive evaluation method, Li, H and Wang, B established an entropy-weighted fuzzy comprehensive evaluation model based on the comprehensive consideration of entropy-weighted theory and fuzzy mathematical theory, used entropy-optimal theory to determine the weights of each index, and finally conducted a fuzzy comprehensive evaluation of the relevant indexes [43]. Their research can provide a reference for improving environmental economic efficiency. Their study combined centering analysis and quantitative analysis, which is similar to our research idea and can provide a reference for our research focusing on green finance. The study of Liao, CN et al. combined qualitative and quantitative criteria and proposed new integrated fuzzy techniques, including fuzzy hierarchical analysis, the fuzzy additive ratio evaluation method and the multi-segment objective planning method to solve the green supplier selection problem [44]. Ouyang, ZY proposed a fuzzy correlation method for economic phenomena and used the method to study the correlation between economic phenomena [45]. He also used fuzzy methods to analyze the relationship between economic phenomena and fuzzy correlations, and used fuzzy two-way decision making methods for economic management and decision making. All of the above four studies used the fuzzy comprehensive evaluation method to explore the fields of economy and management, and these studies can help us to construct the evaluation index system. For the G1 method, Huang, XH et al. proposed an improved G1 method based on gray correlation to establish a coordination degree model based on bull's-eye distance [46]. Their study provides a reference for evaluating the coordinated development of economic, social, and ecological systems in China. Wang, Y and Wang, HF used gray system theory to

analyze the main factors of regional economic development imbalance and proposed the comparative advantage of regional development through empirical tests [47]. Although our study did not use gray system theory, it is an interesting and widely used approach in economics research. We will also use the G1 method and link it to the entropy method in this study to delve into the core issues of the quality assessment of China's green financial system. This part of the study reviews the fuzzy evaluation theories and applications used in existing studies and discusses the advantages of our adoption of the G1-entropy method.

In summary, the international studies that have focused on green finance and the quality assessment of green financial development are currently relatively abundant, and the relevant assessment ideas and logical theories used can provide very good ideas for reference and reference for this study, and what can be further seen is that the quality assessment problem in the development of green financial quality cannot be ignored. However, few studies have focused on social status, and in-depth analysis of quality assessment methods have not yet formed a perfect set of technical methods applicable to the quality assessment of green financial system construction. Therefore, based on the existing research literature and the current research status, we aim in this study to address the urgent quality assessment problem in the development of green finance, firstly by setting out the quality function deployment theory as the research idea of this paper, then using the more classical fuzzy mathematical theory of G1-entropy value method for quantitative analysis, constructing the quality assessment index structure of a green financial system for the actual status quo in China, and quantitatively calculating the weight size of the indicators, so as to give countermeasure suggestions applicable to the construction and development of China's green financial system. Thus, we have achieved a deep combination of theory and practical application in this study, and made further contributions to enriching similar academic research topics internationally.

## 3. Methodology

### *3.1. Quality Function Deployment (QFD)*

The concept of QFD (Quality Function Deployment) was first put forward by Yoji Akao, a Japanese researcher on product quality risk management. There are many types of QFD translation in international academic research. The representative translations generally recognized by Chinese scholars are: quality function deployment theory, quality function deployment, quality function deployment and house of quality. Although the concept of QFD comes from the field of product quality management, QFD has been widely used in many disciplines and social applications, such as system risk assessment, engineering quality management, enterprise strategic management, infrastructure design and so on. By tracing back to the initial start and development research process of QFD, the main core idea of QFD is to analyze customer needs, focus on customer demand objectives, study the correlation between needs and realization ways and the competitive relationship between needs, and finally output the evaluation results of customer demand importance through quality evaluation theory and technology. This method actually builds a "house" in the evaluation system of system management science, and realizes the specific customized demand scenario inside the "house". The specific structure of the house is shown in Figure 3 below. In short, the quality function deployment theory is based on the "customer demand (or customer problem)-implementation method (or technical means)-relationship matrix between demand and approach-quantifiable evaluation and analysis method". Its core idea is demand splitting and importance ranking. The specific operation process is to input customer demand purpose and information elements through targeted construction of the house of quality structure model. Then, the quantifiable method is used to output the demand results and realize the ranking analysis of the importance of demand factors, so as to transform the actual needs of customers into specific production plans that can be implemented.

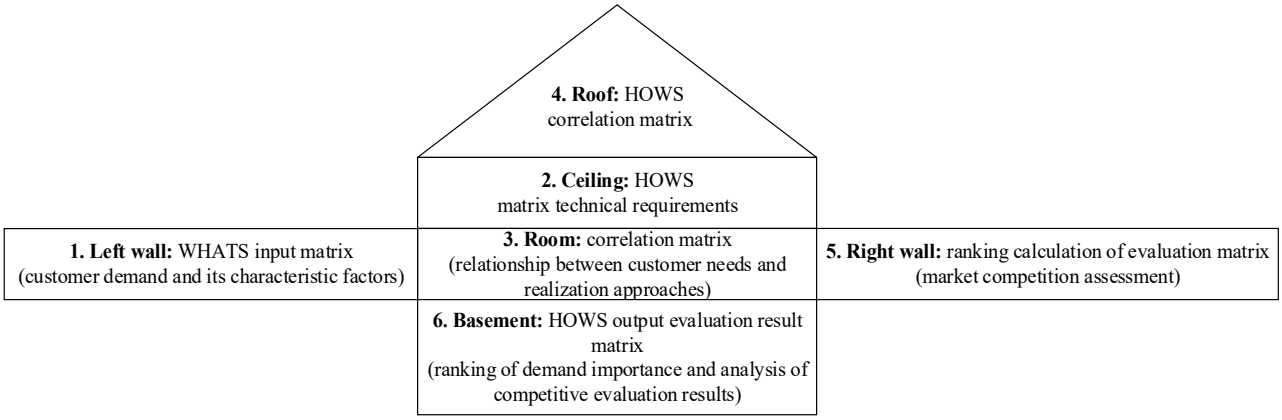


**Figure 3.** General formal framework of house of quality.

1. Left wall: represents the input matrix, representing customer needs and characteristic elements, which can generally be obtained through social investigation.
2. Ceiling: represents the HOWS matrix, which indicates how to proceed according to the technical requirements, that is, the quantifiable technical methods and measures obtained from the demand transformation.
3. Room: represents the correlation matrix, describing the relationship between customer needs and the technical ways to realize this demand.
4. Roof: represents the HOWS correlation matrix, which represents the analysis of the correlation between requirements and technology.
5. Right wall: represents the results of the evaluation matrix, which refers to competitive or feasibility analysis and comparison, and evaluates the market competitiveness from the perspective of customer needs.
6. Basement: represents how to output the evaluation result matrix, which represents the application of quantifiable technical methods to realize customer needs and the ranking results of the importance relationship between customer demand factors.

Although the concept of QFD originated in the field of product quality management, QFD is now widely used in many studies and applications in the field of economics. Obviously, QFD is not a quantitative calculation method, but an idea for logically analyzing the correlation between customer needs and product characteristics. For the application of QFD in economic management, Li, W et al. used the quality function theory for financial innovation prioritization, and their study concluded that an effectively designed financial innovation product could help solve the financing problem of renewable energy investors [48]. Cui, HY et al. analyzed the green supply chain management innovation strategy through multidimensional analysis by drawing on the quality function unfolding theory, and they study suggested that energy companies should have an effective customer relationship management [49]. The study of Abdel-Basset, M et al. analyzed the sustainability assessment of supply chains from economic, environmental, and social perspectives based on the QFD approach [50]. Aouag, H et al. studied the application of fuzzy quality function deployment theory in enhancing economic and environmental benefits [51]. It can be seen that the QFD method application has certain value significance in all aspects of economics research and application, and QFD as a system analysis method shows its advances and frontiers, so we used QFD in this study to logicalize our quantitative technical framework for quality assessment of green financial system development.

## 4. Analysis of the Current Situation of the Development of China's Green Financial System

In order to explore the development quality and specific status of China's green financial system, we will analyze the development status of China's green financial system from the perspective of green financial forms and systems, specifically including green credit, green bonds, green funds, green insurance, carbon finance, etc., and provide an in-depth analysis of the development status of China's green financial system.

(1) Green Credit

According to the data of the People's Bank of China, as of FY2021, the total balance of green loans in domestic and foreign currencies in China was CNY 15.9 trillion, an increase of 33% year-on-year, ranking the first in the world in terms of stock size. This is an increase of CNY 8.8 trillion from the total balance of green loans in 2017, an increase of nearly 124%. The main directions of green credit investment are infrastructure, green transportation, environmental protection, water resources treatment, wind power projects, ecological environment, clean energy and other green industries. The 2021 loan balances for infrastructure green upgrade industry, clean energy industry and energy conservation and environmental protection industry were CNY 7.4, 4.21 and 1.94 trillion, up 28.3%, 31.7% and 46.7% year-on-year, respectively. Figure 4 below shows the percentage of green credit scale of major financial institutions in China in 2021.

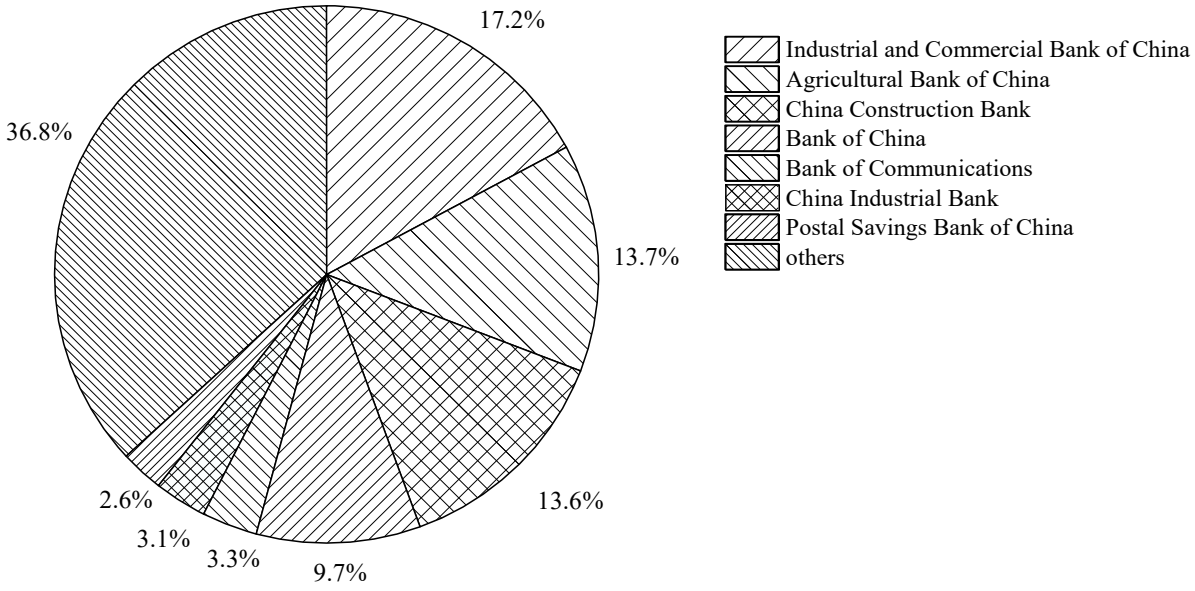


**Figure 4.** Green credit scale share of major financial institutions in China in 2021.

(2) Green Bonds

According to data from the People's Bank of China, green bond issuance in China exceeded RMB 600 billion in FY 2021, up 180% year-over-year, with a balance of RMB 1.1 trillion. By the end of 2021, China's cumulative green bond issuance was close to RMB 1.3 trillion, second only to the U.S. at USD 305.5 billion. The issuance volume ranking jumped from the fourth place in the world in 2020 to the second place in 2021. Clean energy is the key area of support for China's general green bonds, accounting for 39.40% of the new general green bond issuances in China, with the fundraising projects mainly used to support new energy generation and heating equipment manufacturing, project construction and operation, such as photovoltaic, wind and biomass energy. Figure 5 below shows the scale of green bond issuance and stock scale in China from 2017–2021.

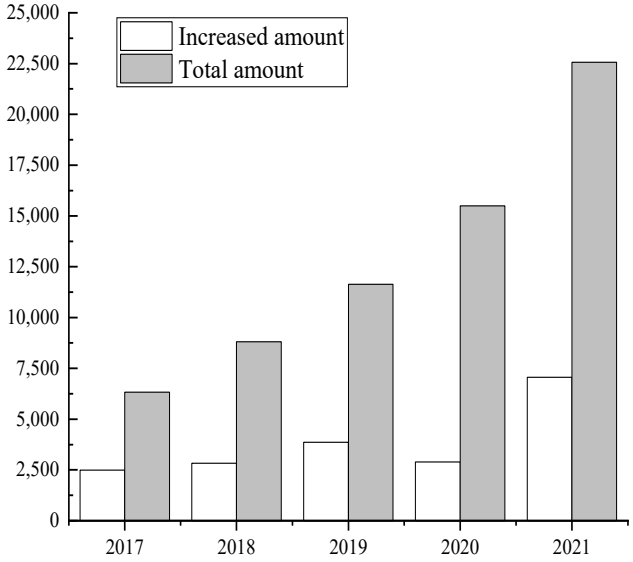


**Figure 5.** China's green bond issuance and stock size, 2017–2021 (Unit: RMB billion).

(3) Green funds

According to the data of China Securities Investment Fund Association, as of the end of the third quarter of 2021, the number of public and private funds in the direction of green, sustainable and ESG was close to 1000, with a combined scale of more than CNY 790 billion; an increase of 36% over the scale at the end of 2020. Among them, there were more than 190 public funds, with a management scale of more than CNY 410 billion, and 800 private funds, with a management scale of CNY 370 billion, 90% of which were equity venture capital funds. Divided by green fund investment areas, the number of newly established and filed green funds invested in ecological and environmental protection in 2020 was 38, accounting for 30%; 86 were invested in low-carbon and energy-saving areas, accounting for 68%; and 2 were invested in circular economy areas, accounting for 2%. Figure 6 below shows the number of new green funds and their growth rate from 2015 to 2020.

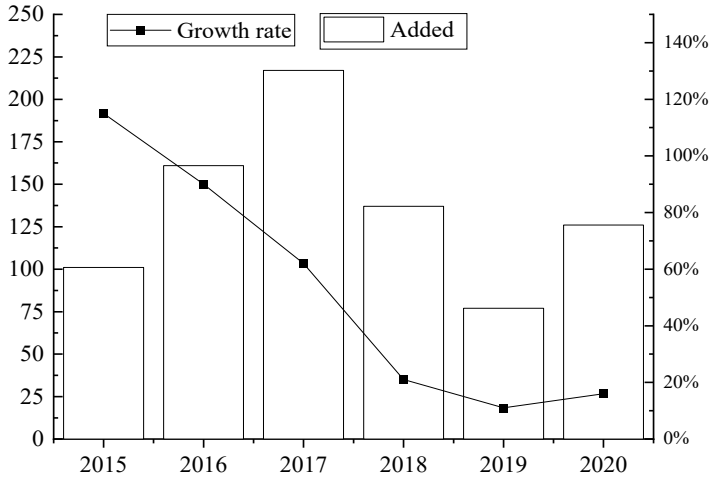


**Figure 6.** Number and growth rate of new green funds from 2015 to 2020.

(4) Green Insurance

According to data from the China Insurance Association, the amount of green insurance coverage and payouts in China continued to grow between 2018 and 2020. the amount of green insurance coverage in China reached CNY 18.33 trillion in 2020, up 24.9% year-on-year, and the amount of green insurance payouts was CNY 21.357 billion, up 11.6%

year-on-year. From 2018 to 2020, the insurance industry provided a total of green insurance as follows: the insured amount was CNY 45.03 trillion, and the payout was CNY 53.377 billion. Table 1 below shows the main statistics of green insurance from 2018–2020.

**Table 1.** Green insurance key statistics table 2018–2020 (in billions).

| Years | Green Insurance Coverage | Green Insurance Payout | Green Investment Balance |
|---|---|---|---|
| 2018 | 120,284.96 | 128.79 | 3945 |
| 2019 | 146,766.99 | 191.41 | 4236 |
| 2020 | 183,263.62 | 213.57 | 5615 |

(5) Carbon Finance

According to data from the Chinese Ministry of Ecology and Environment, by the end of 2021, China's carbon emissions trading had nine pilot regions, including Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong, Shenzhen, Sichuan and Fujian, and the pilot regions had carried out innovative practices such as carbon bonds, carbon funds, green structured deposits, over-the-counter swaps of carbon allowances, carbon borrowing transactions and carbon quota forwards. The national carbon emission trading market has been active since 16 July 2021, and as of 15 July 2022, the cumulative volume of carbon emission allowances traded reached 194 million tons, with a cumulative turnover of CNY 8.492 billion. Figure 7 below shows the turnover and trading volume of China's carbon trading market from 2014–2021.

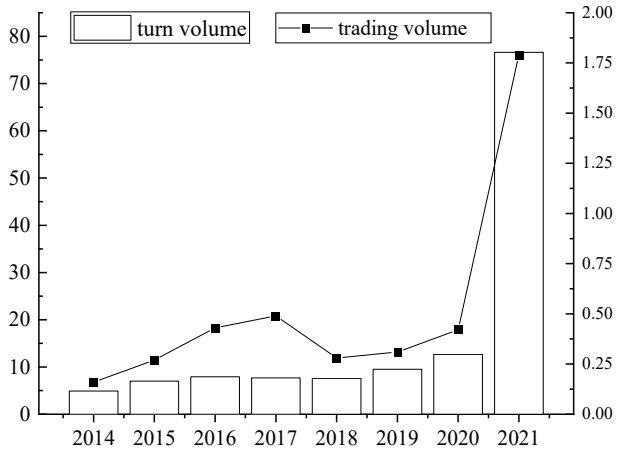


**Figure 7.** China's carbon trading market turnover (CNY billion) and trading volume (million tons), 2014–2021.

From the above, we can see that China's green finance is developing fast, and green credit, green bonds, green funds, green insurance and carbon finance are all important elements indispensable for building China's green financial system. Specifically, (1) green credit is the earliest green financial product in China and has a relatively mature operation model. It mainly relies on the four state-owned banks, whose share is close to 50%. (2) China's green credit and green bond markets are now at an advanced level of development in the world. (3) Green funds have been affected by the strengthening of regulatory policies on asset management of financial institutions in 2018, and their growth has slowed down. (4) Chinese insurance asset management institutions have promoted China's green economy by supporting investments in green and low-carbon projects with the funds they own. (5) Currently, China's carbon finance is in the initial development stage, and although the market volume is small and the transaction amount is low, the launch of the national carbon emission trading market will bring opportunities for the carbon finance market to develop by leaps and bounds.

## 5. A Method for Assessing the Development of Green Financial System Based on Quality Function Deployment Theory

### *5.1. Quality House Structure Design for Green Financial Development Assessment*

We designed the QFD-based quality house structure for green finance development assessment based on the schematic diagram of the quality house design in Section 3.1, as shown in Figure 8 below.

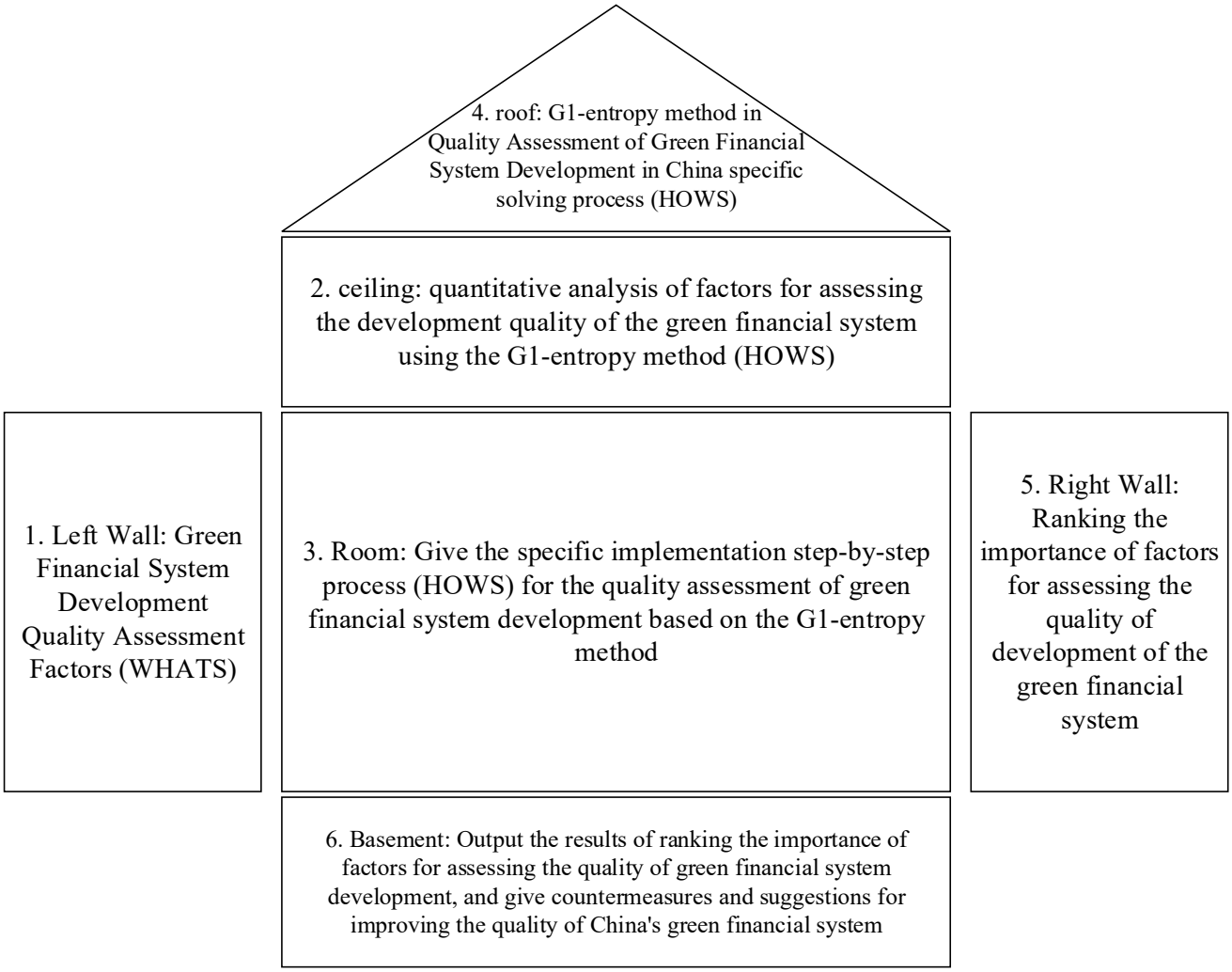


**Figure 8.** Green financial system development quality house structure diagram.

### *5.2. General Process of Assessing the Quality of Green Financial System Development*

We designed a general process for assessing the development quality of the green financial system based on the green financial development assessment quality house in Section 5.1, as shown in Figure 9 below.

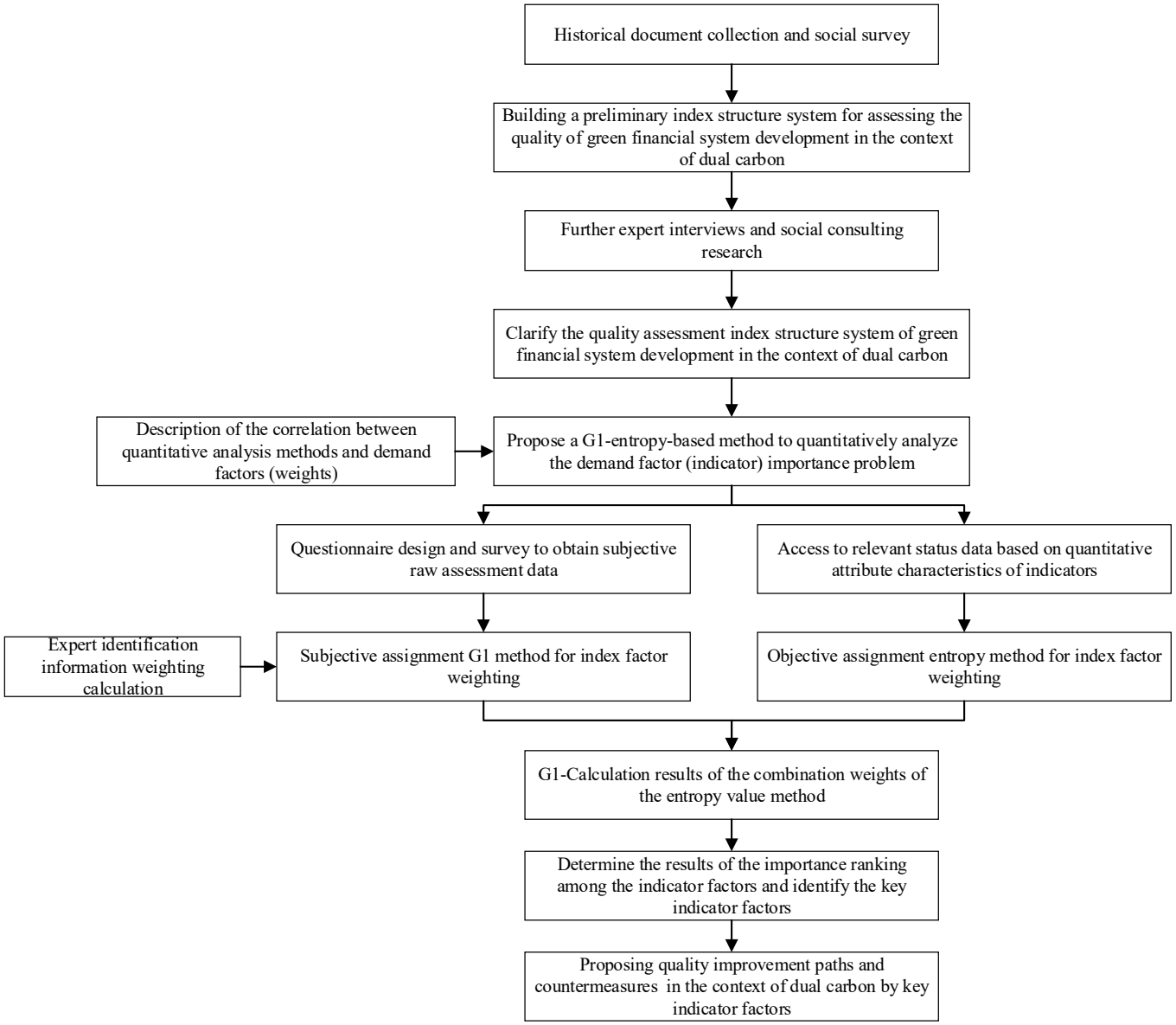


**Figure 9.** Schematic diagram of the general process of assessing the quality of green financial system development.

## 6. Case Study: Research Survey Evidence from China

### *6.1. Green Financial System Development Quality Index System Construction*

(1) Principles of index system construction

This study focuses on the quality assessment of the development of green financial system in the context of double carbon, and there is no perfect indicator assessment system for green finance issues. Therefore, we considered in this study that the green financial system includes government support, social awareness, and environmental resources in addition to green finance, so we combined the principles of scientificity, systematicity, and data availability to construct this paper's green financial system construction quality assessment index system from four dimensions: government support, social awareness, environmental resources, and green finance.

(2) Ideas of index system construction

This study focuses on the quality assessment of the development of green financial system in the context of double carbon, and according to the above-mentioned principles of

index system construction, the index system is constructed from four dimensions: government support, social awareness, environmental resources, and green finance. Among them, government support includes government financial supervision, financial environmental protection, and green investment. Social consciousness includes green energy consumption and green technology innovation. Environmental resources include forest resources, water resources, and carbon emissions. Green finance includes green credit, green bonds, green funds, green insurance, and carbon finance.

(3) Content of the construction of index system

We took the quality assessment of China's green financial system as the primary indicator, government support, social awareness, environmental resources, and green finance as the secondary indicators, and 13 indicators such as government financial supervision, financial and environmental protection, and green investment as the tertiary indicators, to construct the structure of the quality assessment indicator system for the construction of China's green financial system, as shown in Table 2 below.

**Table 2.** Green financial system construction quality assessment index system structure table.

| First-Level Indicators (Target Level) | Secondary Indicators (Guideline Layer) | Tertiary Indicators (Programmatic Level) | Orientation | Quantitative Meaning of the Three Levels of Indicators |
|---|---|---|---|---|
| Quality Assessment of China's Green Financial System $A_1$ | Government Support $B_{11}$ | Government Financial Regulation $C_{111}$ | + | Fiscal and financial supervision expenditure (unit: CNY billion) |
| | | Financial Environmental Protection $C_{112}$ | + | Fiscal environmental protection = environmental protection expenditure/fiscal expenditure |
| | | Green Investment $C_{113}$ | + | Green investment = investment in environmental pollution control/GDP |
| | Social Consciousness $B_{12}$ | Green Energy Consumption $C_{121}$ | + | Nuclear power, hydropower, wind power, solar power as a percentage of total energy consumption (unit: %) |
| | | Green Technology Innovation $C_{122}$ | + | Number of Green Patent Applications in China |
| | Environmental Resources $B_{13}$ | Forest Resources $C_{131}$ | + | Forest area to land area (unit: %) |
| | | Water Resources $C_{132}$ | + | Total water resources (unit: trillion cubic meters) |
| | | Carbon Emissions $C_{133}$ | − | Carbon dioxide emissions (unit: thousand tons) |
| | Green Finance $B_{14}$ | Green Credit $C_{141}$ | + | Green Credit Balance (Unit: CNY trillion) |
| | | Green Bonds $C_{142}$ | + | New green bond issuance (unit: CNY billion) |
| | | Green Fund $C_{143}$ | + | The number of new green funds (unit: a) |
| | | Green Insurance $C_{144}$ | + | Green Insurance = Agricultural Insurance Revenue/Total Agricultural Output |
| | | Carbon Finance $C_{145}$ | + | China's carbon trading market turnover (unit: CNY billion) |

Based on the above Table 3, we further constructed a schematic diagram of the hierarchy of the index system, as shown in Figure 10 below.

**Table 3.** Expert scoring weight table.

| Factors | Weight $r_i$ | Level | Score $s$ |
|---|---|---|---|
| Working years | 3 | >30 | 0.8 |
| | | 15~30 | 0.6 |
| | | <15 | 0.4 |
| Education | 2 | PH.D | 0.8 |
| | | Master | 0.6 |
| | | Bachelor | 0.4 |
| Major | 2 | Economics | 0.8 |
| | | Social Science | 0.6 |
| | | Management | 0.4 |
| Experience | 2 | Experience in financial research or practice | 0.8 |
| | | No experience in financial research or practice | 0.4 |
| Title | 1 | Professor | 0.8 |
| | | Associate Professor | 0.6 |
| | | Lecturer | 0.4 |

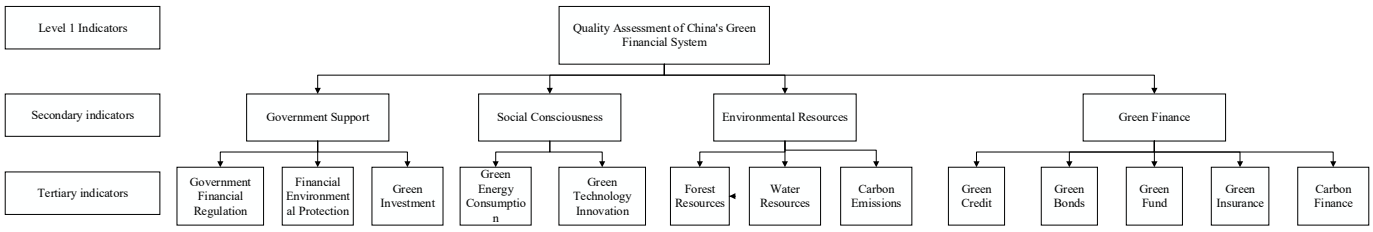


**Figure 10.** Hierarchical model of the indicator system.

### *6.2. Results of Calculating the Importance of Green Financial Development Quality Indicators*

#### 6.2.1. Expert Identification Information Weighting Method

The initial assessment data in the G1 method need to be obtained by manual expert assessment, and the credibility criteria of the experts have four dimensions: length of service, education, profession, experience, and title. The specific criteria weights are shown in Table 3 below.

The reliability of experts can be calculated according to the expert weight scoring as in Table 3. The reliability calculation formula of experts is as follows:

$$R_e = \frac{\sum_{i=1}^{5} r_i s}{10} \tag{1}$$

The weight of experts can be further calculated as follows:

$$w_e = \frac{R_e}{\sum_{e=1}^{n} R_e} \tag{2}$$

#### 6.2.2. The Process of Calculating Index Weights Based on QFD Theory

We found five experts from the Institute of Economic Research of the Chinese Academy of Social Sciences to quantitatively assess the indicators in our study of the quality assessment indicators of the green financial development system, and the identity information weights of the experts are shown in Table 4 below.

**Table 4.** Expert identification information form.

| No. | Working Years | Education | Major | Experience | Title |
|---|---|---|---|---|---|
| 1 | 35 | PH.D | Social Science | Experience in financial research or practice | Professor |
| 2 | 42 | PH.D | Social Science | No experience in financial research or practice | Professor |
| 3 | 17 | PH.D | Economics | Experience in financial research or practice | Associate Professor |
| 4 | 24 | PH.D | Management | No experience in financial research or practice | Associate Professor |
| 5 | 5 | PH.D | Economics | Experience in financial research or practice | Lecturer |

Based on Equations (1) and (2), we derived the results of the credibility values and identity weight values of the five experts' evaluations, as shown in Table 5 below.

**Table 5.** Expert evaluation trustworthiness values and identity weighting values.

| No. | Reliability Value | Expert Status Weight Value |
|---|---|---|
| 1 | 0.880 | 0.233 |
| 2 | 0.760 | 0.201 |
| 3 | 0.800 | 0.212 |
| 4 | 0.640 | 0.169 |
| 5 | 0.700 | 0.185 |

According to the G1 method subjective assignment calculation guidelines, firstly, five experts should rank the 13 indicators in terms of preliminary importance, and the specific ranking results are shown in Table 6 below.

**Table 6.** Results of initial subjective importance ranking of indicators by five experts.

| No. | Initial Importance Ranking Results |
|---|---|
| 1 | $C_{141} > C_{122} > C_{112} = C_{113} > C_{145} > C_{142} > C_{111} = C_{121} > C_{133} > C_{131} > C_{144} > C_{143} > C_{132}$ |
| 2 | $C_{141} > C_{145} > C_{111} > C_{112} > C_{113} > C_{142} > C_{122} = C_{133} > C_{143} = C_{144} > C_{121} > C_{131} = C_{132}$ |
| 3 | $C_{141} > C_{145} > C_{142} > C_{122} > C_{121} > C_{133} > C_{113} > C_{144} > C_{112} > C_{131} > C_{143} > C_{132} > C_{111}$ |
| 4 | $C_{141} > C_{145} > C_{122} > C_{142} > C_{113} > C_{133} > C_{121} > C_{143} = C_{144} > C_{112} > C_{131} = C_{132} > C_{111}$ |
| 5 | $C_{141} > C_{145} > C_{142} > C_{122} > C_{133} > C_{112} > C_{144} > C_{121} > C_{113} > C_{132} = C_{143} > C_{111} > C_{131}$ |

Secondly, according to the G1 method, the results are shown in Table 7a–e below.

Based on the G1 method and combined with QFD theory, we give the process and results of index weight calculation as shown in Figure 11 below, where it is worth explaining that we used the data from the National Bureau of Statistics, World Bank, and China Securities Regulatory Commission 2010–2021 in the entropy method calculation process, because on 22 December 2015, the People's Bank of China issued the Announcement on Matters Relating to the Issuance of Green Fund Bonds in the Interbank Bond Market to symbolize the launch of the green bond market, so the green bond data 2010–2015 are recorded as USD 0. China's carbon trading market started since 2013 with the Shenzhen carbon emission trading platform, so the data 2010–2012 are recorded as USD 0. In the portfolio assignment method, after expert discussion, 0.5 was adopted as the subjective preference coefficient, then the objective preference coefficient, as shown in Figure 11.

**Table 7.** (a) Expert 1′s G1 method indicator assignment results $m_1$. (b) Expert 2′s G1 method indicator assignment results $m_2$. (c) Expert 3′s G1 method indicator assignment results $m_3$. (d) Expert 4′s G1 method indicator assignment results $m_4$. (e) Expert 5′s G1 method indicator assignment results $m_5$.

| | $C_{111}$ | $C_{112}$ | $C_{113}$ | $C_{121}$ | $C_{122}$ | $C_{131}$ | $C_{132}$ | $C_{133}$ | $C_{141}$ | $C_{142}$ | $C_{143}$ | $C_{144}$ | $C_{145}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (a) | | | | | | | |
| $C_{111}$ | 1.0 | 1/1.2 | | | | | | | | | | | |
| $C_{112}$ | 1.2 | 1.0 | 1.0 | | | | | | | | | | |
| $C_{113}$ | | 1.0 | 1.0 | 1.2 | | | | | | | | | |
| $C_{121}$ | | | 1/1.2 | 1.0 | 1/1.4 | | | | | | | | |
| $C_{122}$ | | | | 1.4 | 1.0 | 1.8 | | | | | | | |
| $C_{131}$ | | | | | 1/1.8 | 1.0 | 1.3 | | | | | | |
| $C_{132}$ | | | | | | 1/1.3 | 1.0 | 1/1.4 | | | | | |
| $C_{133}$ | | | | | | | 1.4 | 1.0 | 1/1.8 | | | | |
| $C_{141}$ | | | | | | | | 1.8 | 1.0 | 1.4 | | | |
| $C_{142}$ | | | | | | | | | 1/1.4 | 1.0 | 1.7 | | |
| $C_{143}$ | | | | | | | | | | 1/1.7 | 1.0 | 1/1.1 | |
| $C_{144}$ | | | | | | | | | | | 1.1 | 1.0 | 1/1.7 |
| $C_{145}$ | | | | | | | | | | | | 1.7 | 1.0 |
| | | | | | | (b) | | | | | | | |
| $C_{111}$ | 1.0 | 1.1 | | | | | | | | | | | |
| $C_{112}$ | 1/1.1 | 1.0 | 1.1 | | | | | | | | | | |
| $C_{113}$ | | 1/1.1 | 1.0 | 1.4 | | | | | | | | | |
| $C_{121}$ | | | 1/1.4 | 1.0 | 1/1.3 | | | | | | | | |
| $C_{122}$ | | | | 1.3 | 1.0 | 1.5 | | | | | | | |
| $C_{131}$ | | | | | 1/1.5 | 1.0 | 1.0 | | | | | | |
| $C_{132}$ | | | | | | 1.0 | 1.0 | 1/1.5 | | | | | |
| $C_{133}$ | | | | | | | 1.5 | 1.0 | 1/1.6 | | | | |
| $C_{141}$ | | | | | | | | 1.6 | 1.0 | 1.5 | | | |
| $C_{142}$ | | | | | | | | | 1/1.5 | 1.0 | 1.2 | | |
| $C_{143}$ | | | | | | | | | | 1/1.2 | 1.0 | 1.0 | |
| $C_{144}$ | | | | | | | | | | | 1.0 | 1.0 | 1/1.7 |
| $C_{145}$ | | | | | | | | | | | | 1.7 | 1.0 |
| | | | | | | (c) | | | | | | | |
| $C_{111}$ | 1.0 | 1/1.3 | | | | | | | | | | | |
| $C_{112}$ | 1.3 | 1.0 | 1/1.3 | | | | | | | | | | |
| $C_{113}$ | | 1.3 | 1.0 | 1/1.1 | | | | | | | | | |
| $C_{121}$ | | | 1.1 | 1.0 | 1/1.1 | | | | | | | | |
| $C_{122}$ | | | | 1.1 | 1.0 | 1.6 | | | | | | | |
| $C_{131}$ | | | | | 1/1.6 | 1.0 | 1.1 | | | | | | |
| $C_{132}$ | | | | | | 1/1.1 | 1.0 | 1/1.5 | | | | | |
| $C_{133}$ | | | | | | | 1.5 | 1.0 | 1/1.8 | | | | |
| $C_{141}$ | | | | | | | | 1.8 | 1.0 | 1.5 | | | |
| $C_{142}$ | | | | | | | | | 1/1.5 | 1.0 | 1.7 | | |
| $C_{143}$ | | | | | | | | | | 1/1.7 | 1.0 | 1/1.1 | |
| $C_{144}$ | | | | | | | | | | | 1.1 | 1.0 | 1/1.7 |
| $C_{145}$ | | | | | | | | | | | | 1.7 | 1.0 |

**Table 7.** *Cont.*

| | $C_{111}$ | $C_{112}$ | $C_{113}$ | $C_{121}$ | $C_{122}$ | $C_{131}$ | $C_{132}$ | $C_{133}$ | $C_{141}$ | $C_{142}$ | $C_{143}$ | $C_{144}$ | $C_{145}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (d) | | | | | | | | | | | | | |
| $C_{111}$ | 1.0 | 1/1.2 | | | | | | | | | | | |
| $C_{112}$ | 1.2 | 1.0 | 1/1.3 | | | | | | | | | | |
| $C_{113}$ | | 1.3 | 1.0 | 1.2 | | | | | | | | | |
| $C_{121}$ | | | 1/1.2 | 1.0 | 1/1.3 | | | | | | | | |
| $C_{122}$ | | | | 1.3 | 1.0 | 1.5 | | | | | | | |
| $C_{131}$ | | | | | 1/1.5 | 1.0 | 1.0 | | | | | | |
| $C_{132}$ | | | | | | 1.0 | 1.0 | 1/1.3 | | | | | |
| $C_{133}$ | | | | | | | 1.3 | 1.0 | 1/1.6 | | | | |
| $C_{141}$ | | | | | | | | 1.6 | 1.0 | 1.4 | | | |
| $C_{142}$ | | | | | | | | | 1/1.4 | 1.0 | 1.3 | | |
| $C_{143}$ | | | | | | | | | | 1/1.3 | 1.0 | 1.0 | |
| $C_{144}$ | | | | | | | | | | | 1.0 | 1.0 | 1/1.5 |
| $C_{145}$ | | | | | | | | | | | | 1.5 | 1.0 |
| (e) | | | | | | | | | | | | | |
| $C_{111}$ | 1.0 | 1/1.3 | | | | | | | | | | | |
| $C_{112}$ | 1.3 | 1.0 | 1.2 | | | | | | | | | | |
| $C_{113}$ | | 1/1.2 | 1.0 | 1/1.1 | | | | | | | | | |
| $C_{121}$ | | | 1.1 | 1.0 | 1/1.4 | | | | | | | | |
| $C_{122}$ | | | | 1.4 | 1.0 | 1.8 | | | | | | | |
| $C_{131}$ | | | | | 1/1.8 | 1.0 | 1/1.1 | | | | | | |
| $C_{132}$ | | | | | | 1.1 | 1.0 | 1/1.4 | | | | | |
| $C_{133}$ | | | | | | | 1.4 | 1.0 | 1/1.7 | | | | |
| $C_{141}$ | | | | | | | | 1.7 | 1.0 | 1.4 | | | |
| $C_{142}$ | | | | | | | | | 1/1.4 | 1.0 | 1.7 | | |
| $C_{143}$ | | | | | | | | | | 1/1.7 | 1.0 | 1/1.2 | |
| $C_{144}$ | | | | | | | | | | | 1.2 | 1.0 | 1/1.7 |
| $C_{145}$ | | | | | | | | | | | | 1.7 | 1.0 |

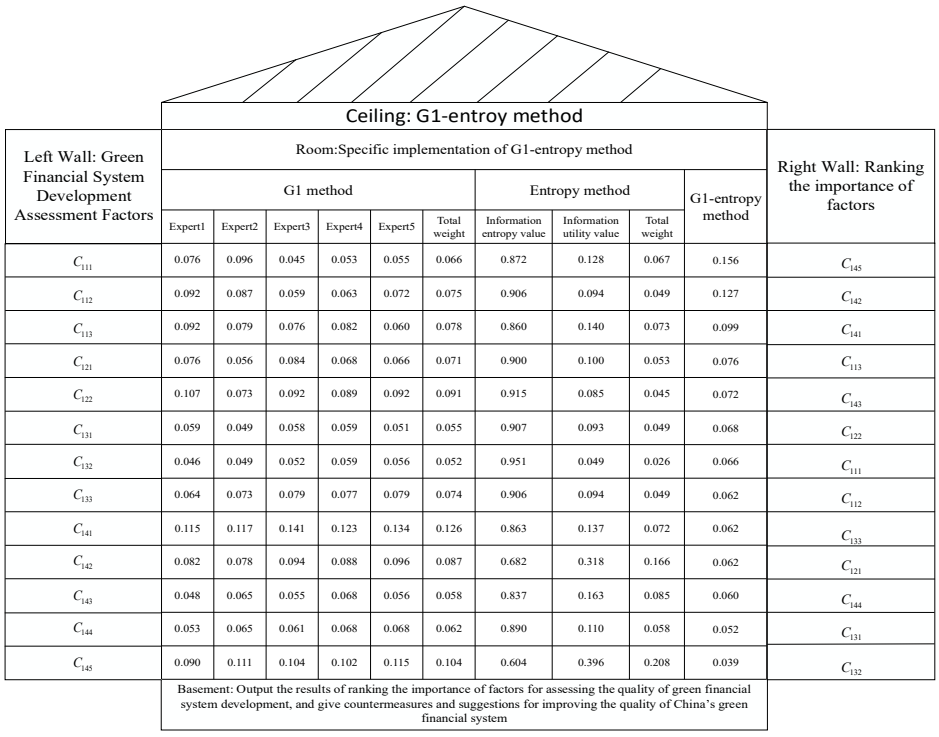


**Figure 11.** The process of calculating index weights based on QFD theory and the result schematic.

According to the calculation results of the indicator weights in Figure 11 above, we can obtain 13 indicators in descending order of importance: carbon finance, green bonds, green credit, green investment, green funds, green technology innovation, government financial regulation, financial environmental protection, carbon emissions, green energy consumption, green insurance, forest resources, and water resources.

### *6.3. Method Discussion*

Hierarchical analysis represents a method to quantify the weight of indicators. We compare the results of the AHP method (Table 8) with the results of the G1-entropy method to illustrate the accuracy of our results (Table 9).

**Table 8.** AHP method results.

| Factors | Eigenvector | Weight | Maximum Eigenvalue | CI |
|---|---|---|---|---|
| $C_{111}$ | 0.782 | 6.01% | | |
| $C_{112}$ | 0.925 | 7.12% | | |
| $C_{113}$ | 0.988 | 7.60% | | |
| $C_{121}$ | 0.904 | 6.95% | | |
| $C_{122}$ | 1.175 | 9.04% | | |
| $C_{131}$ | 0.722 | 5.55% | | |
| $C_{132}$ | 0.689 | 5.30% | 13.011 | 0.001 |
| $C_{133}$ | 0.978 | 7.53% | | |
| $C_{141}$ | 1.663 | 12.79% | | |
| $C_{142}$ | 1.158 | 8.91% | | |
| $C_{143}$ | 0.779 | 5.99% | | |
| $C_{144}$ | 0.841 | 6.47% | | |
| $C_{145}$ | 1.396 | 10.74% | | |

**Table 9.** AHP method and G1-entropy method.

| Factors | AHP Weight | G1-Entropy Weight |
|---|---|---|
| $C_{111}$ | 0.060 | 0.066 |
| $C_{112}$ | 0.071 | 0.062 |
| $C_{113}$ | 0.076 | 0.076 |
| $C_{121}$ | 0.070 | 0.062 |
| $C_{122}$ | 0.090 | 0.068 |
| $C_{131}$ | 0.056 | 0.052 |
| $C_{132}$ | 0.053 | 0.039 |
| $C_{133}$ | 0.075 | 0.062 |
| $C_{141}$ | 0.128 | 0.099 |
| $C_{142}$ | 0.089 | 0.127 |
| $C_{143}$ | 0.060 | 0.072 |
| $C_{144}$ | 0.065 | 0.060 |
| $C_{145}$ | 0.107 | 0.156 |

Our method has the following advantages over hierarchical analysis: (1) We considered the identity weights of the experts and eliminated the problem of credibility of the experts' identity information. (2) The G1 method is an objective assignment method with higher accuracy and credibility. (3) We innovatively combined the G1 method and the entropy method together. Therefore, our method is innovative and advanced.

## 7. Measures to Enhance the Path of Sustainable Development of China's Green Financial System

At present, the research on the green financial system in China mainly focuses on the qualitative analysis level and lacks focus on the quality systems of green financial development. In this study, we combined quantitative research with qualitative analysis, constructed a framework for assessing the quality of the green financial system based on

QFD theory, calculated the importance ranking of indicators through the subjective and objective assignment method of G1-entropy value, and comprehensively discussed the quality of China's green financial development. In order to further improve the sustainable development of China's green finance, we took the top three indicators as the key indicators in the quantitative study of 13 tertiary indicators in Part VI, and propose countermeasures to improve the sustainable development of China's green finance system, as follows.

For the carbon finance indicator: China's carbon finance development path is still at the beginning stage, and domestic financial institutions are not fully involved in the development of sustainable economic development ideas. China's carbon trading and carbon finance product development also has a series of problems, such as lack of a legal system, incomplete supervision and verification system. Therefore, improving the carbon trading market is the focus of carbon finance development. As the commodity attributes of carbon trading continue to strengthen and the market becomes more and more mature, more and more financial institutions will be attracted to enter, forming a comprehensive participation model of state-owned banks, investment banks, hedge funds, private equity funds, security companies and other financial institutions. At the same time, carbon-finance-related talents should be cultivated, and composite talents who are involved in both green enterprises and financial markets should be cultivated. In addition, the government should also build an incentive mechanism, because the development of carbon finance requires the government and regulatory authorities to set a series of standards and rules based on the principle of sustainable development and provide corresponding policy support such as investment, taxation, and credit scale guidance. Finally, the above-mentioned tools can combine to promote the further improvement of the carbon finance market and assist China in achieving its green and sustainable development goals.

For the indicators of green bonds: First, the standard system of green bonds in China should be improved. The Chinese government should develop a unified and comprehensive green bond recognition standard and clarify the classification of green projects. Specifically, it should take into account the differences between different industries. Currently, green bonds are mainly issued by the industrial, utility and financial sectors, so it is necessary to consider the long-term value when formulating policies and provide guidance and support to projects with technological innovation, so as to encourage more green bonds to be invested in the research and development of carbon-neutral technologies and promote low-carbon green development. Second, it is necessary to standardize the third-party certification and evaluation mechanism. The professionalism of third-party certification and evaluation agencies for green bonds should be improved, the standardization of the third-party certification and evaluation process should be enhanced, and the comparability of third-party certification and evaluation reports should be strengthened. Few existing green bond certification and assessment institutions in China have professional environmental backgrounds, insufficient knowledge of green bonds and less understanding of carbon neutral related technologies, so it is necessary to promote cooperation among different fields of industry, finance and environment, so that green bonds can better serve industrial development and play a substantial role in environmental improvement. Third, we should vigorously advocate the concept of green bond investment, increase the social acceptance and recognition of green bonds and cultivate the concept of green investment, promoting the formation of ecological civilization and green values in society as a whole.

For the green credit indicator: First, improve the relevant laws and regulations and systems of green credit, and financial regulators such as the Banking and Insurance Regulatory Commission and the People's Bank of China should issue specific rules for green credit to guide banks to make their green credit operations transparent and standardized, so that small- and medium-sized banks can have a reference, thus narrowing the gap between small- and medium-sized banks and large banks and increasing their enthusiasm. Second, encourage banks to actively fulfill their social responsibility and promote their positive image to the public, so as to enhance the public recognition and motivation of banks to actively implement green credit. Third, improve the information sharing mechanism and

strengthen the information sharing between environmental protection agencies and banks. Specifically, banks should strategically cooperate with environmental protection bureaus and environmental monitoring agencies to jointly establish a complete and interoperable corporate environmental database to ensure that commercial banks have timely access to corporate environmental performance, which provides them with a decision-making basis for assessing loan risks and reviewing the loan approval process. In addition, commercial banks should also provide timely feedback on loan information to environmental protection departments and the general public for follow-up testing by environmental protection departments and for public supervision.

## 8. Conclusions

This paper focuses on the quality assessment of China's green financial system after its establishment and soundness, and proposes a method to quantitatively calculate the weight size of indicators and rank them based on the quality function deployment theory combined with fuzzy mathematical methods, and proposes countermeasures for the sustainable development path of China's green financial system for key indicators. Specifically, the following three conclusions were obtained through this study:

(1) Our study uniquely applies the quality function deployment theory in the field of green financial development quality evaluation, and we combined the theory to build the quantitative analysis process structure for green financial development quality assessment in this paper. The quality function deployment theory can increase the readability and logic of our analysis, and our paper provides ideas for later scholars to draw on for economic development evaluation.

(2) We enhanced the rigor of the G1 method analysis by introducing an expert assessment scoring system to the G1 method in the traditional fuzzy mathematical approach. Our research also achieves the use of quantitative research for qualitative analysis by proposing a combination of the G1 and entropy methods to construct a set of combined assignment methods, and our research method can compensate for the problems of combining subjective and objective methods and reliability in traditional evaluation methods. Our research method can provide methodological guidance for future problems of building economic index systems.

(3) Our research calculated the importance of green finance indicators through quantitative analysis and qualitative analysis. We also propose countermeasures for carbon finance, green bonds, and green credit in the context of China's development status. Our study can provide the government, central bank, and related scholars with relevant countermeasure suggestions to promote the sustainable and high-quality development of green finance in China.

China attaches great importance to the development of green finance. Our research can support the overall evaluation of the future Chinese green financial system once it is completed. In 2015, China established a green finance policy system, becoming the first country in the world to establish such a system. In addition, various policies have been introduced to stimulate the development of green finance. Our research is based on the above background, and our goal is to contribute to the thinking of Chinese scholars in order to support the examination and future development of the quality of China's green economy.

In general, we believe that there are aspects of this study that can be improved. First, the number, precision and year of indicators can be further strengthened. Second, we can also consider using artificial intelligence and machine learning methods to optimize our results and make them more reliable. Third, the number of experts and the range of expertise in the G1 method can be increased. Our future research will incorporate machine learning methods to further optimize the G1-entropy method.

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**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data in this paper are fully disclosed: specifically, the data for the G1 method are shown in 'Table 7a–e', and the data for the entropy method are shown in Appendix A.

**Conflicts of Interest:** The author declares no conflict of interest. We have agreed to submit this paper to your journal and have no other preference for other journals or academic conferences, and hereby declare our interest.

## Appendix A

**Table A1.** Entropy method statistical data collation table.

| Year | Government Financial Regulation | Financial Environmental Protection | Green Investment | Green Energy Consumption | Green Technology Innovation | Forest Resources | Water Resources | Carbon Emissions | Green Credit | Green Bonds | Green Fund | Green Insurance | Carbon Finance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | 429.54 | 2.72% | 1.85% | 9.4 | 66,124 | 0.21 | 3.09 | 8,470,570 | 3.52 | 0 | 5 | 0.20% | 0 |
| 2011 | 452.21 | 2.42% | 1.46% | 8.4 | 84,363 | 0.21 | 2.33 | 9,278,250 | 4.16 | 0 | 4 | 0.22% | 0 |
| 2012 | 452.55 | 2.35% | 1.53% | 9.7 | 104,888 | 0.22 | 2.95 | 9,533,210 | 4.86 | 0 | 13 | 0.28% | 0 |
| 2013 | 215.41 | 2.45% | 1.52% | 10.2 | 119,945 | 0.22 | 2.80 | 9,936,680 | 5.20 | 0 | 21 | 0.33% | 0 |
| 2014 | 205.71 | 2.51% | 1.49% | 11.3 | 127,834 | 0.22 | 2.73 | 9,894,940 | 6.01 | 0 | 25 | 0.33% | 4.89 |
| 2015 | 249.33 | 2.73% | 1.28% | 12.0 | 154,226 | 0.22 | 2.80 | 9,830,430 | 7.01 | 0 | 63 | 0.37% | 7.02 |
| 2016 | 781.56 | 2.52% | 1.24% | 13.0 | 178,342 | 0.23 | 3.25 | 9,814,310 | 7.51 | 2071 | 125 | 0.39% | 7.93 |
| 2017 | 788.81 | 2.77% | 1.15% | 13.6 | 201,405 | 0.23 | 2.88 | 10,017,770 | 7.10 | 2486 | 172 | 0.44% | 7.68 |
| 2018 | 831.72 | 2.85% | 0.98% | 14.5 | 210,727 | 0.23 | 2.75 | 10,313,460 | 8.23 | 2826 | 94 | 0.50% | 7.59 |
| 2019 | 947.72 | 3.09% | 0.93% | 15.3 | 195,708 | 0.23 | 2.90 | 10,707,220 | 10.20 | 3862 | 82 | 0.54% | 9.49 |
| 2020 | 736.21 | 2.58% | 1.05% | 15.9 | 220,649 | 0.23 | 3.16 | 9,899,300 | 11.95 | 2895 | 74 | 0.59% | 12.67 |
| 2021 | 641.87 | 2.25% | 0.96% | 16.6 | 150,054 | 0.23 | 2.95 | 10,523,000 | 15.90 | 7063 | 82 | 0.66% | 76.61 |

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