Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 4051379, 12 pages
https://doi.org/10.1155/2022/4051379

Research Article

Relationship between Green Financing and Investment Logic and Effectiveness Evaluation of Financing Decisions

Lei Kong,[1,2] Yu Lei,[3] Qian Zhang ,[4] Jing Zhang,[5] Xingzhi Guo,[4] and Daoyuan Shi[4]

[1]*International Education College, Zhengzhou University of Light Industry, Zhengzhou 450002, China*
[2]*Business School, Edinburgh Napier University, Edinburgh EH141DJ, UK*
[3]*Zhengzhou Railway Vocational and Technical College, Zhengzhou 450000, China*
[4]*School of Art & Design, Zhengzhou University of Light Industry, Zhengzhou 450002, China*
[5]*Henan Civil Affairs School, Zhengzhou 450002, China*

Correspondence should be addressed to Qian Zhang; 2007017@zzuli.edu.cn

Received 16 November 2021; Revised 17 December 2021; Accepted 21 December 2021; Published 19 April 2022

Academic Editor: Ahmed Farouk

Green financing diverts more funds to green industries such as environmental protection, and clean energy, enabling the industries to realize structural adjustment. On green financing, the existing studies at home and abroad mainly focus on the definition of concepts and service scope and system construction. There are few attempts to combined green financing efficacy with corporate investment from the angles of investment level, investment efficiency, and investment risks. This paper associates green financing policy with corporate investment, analyzes the logical connection between the two, and thereby evaluates the effectiveness of green financing decisions. Specifically, a decision model was established for the government participation in green financing via green product subsidy, and a solving algorithm was developed for the model. After that, the authors analyzed the correlations of green financing with the investment level and investment efficiency of green enterprises. Next, the effectiveness of green financing decisions was discussed under dynamic operation risks. Finally, the proposed approach was demonstrated through simulation and empirical analysis.

1. Introduction

The sustainable development of all industries is severely bottlenecked by environmental pollution and resource depletion, which arise from the traditional high-pollution and high-consumption development model [1–6]. The long-term development of the green economy hinges on the optimization of industrial structure [7–9]. To achieve green industry restructuring, it is necessary to integrate green development philosophy into the financial system, which plays an important role in the allocation of social resources, and divert more funds to green industries such as environmental protection and clean energy [10–13]. Short supply, weak incentives, and period mismatch are the main problems with the green financing policy, the result of government-led policy guidelines, and system arrangements [14–16]. Green enterprises, as undertakers of green investment, often encounter inefficient investment issues, such as insufficient investment and excessive investment [17–22]. Therefore, exploring the logic relationship between green finance and green enterprise investment would provide an important reference for further optimization of green finance policy.

Wu et al. [23] highlighted how critical the commercialization of emerging green technology is to the sustainability of the industrial process, put forward two mixed-integer linear programming models to optimize the innovation financing strategies, and demonstrated the optimization effect through a case study on a biorefinery. Tan et al. [24] researched nonsymmetric competitive supply chain models with financing risks and compared the optimal quantity, optimal price, and optimal profit under two scenarios. It was found that under complete information, the financing risks of capacity investment do not affect the selection of equilibrium price and quantity of the two supply chains. Criscuolo and Menon [25] detailed the risk capital investment of 29 countries in the green sector from 2005 to 2010 and explained the possible role of policy in the observed cross-country differences.

Green bonds are becoming a major financial source of green infrastructure, including air and water projects. Ludvigsen [26] introduced the important factors for the issuance of green bonds and the latest technical standard for water affairs of Climate Bonds Standard 2.1. Yatim et al. [27] regarded the green economy as an important path towards sustainable development goals, as well as a promoter of economic growth, and the innovation of new low-carbon production technologies and products. They also elaborated extensively on the current financing policy and measures, such as Green Technology Financing Scheme (GTFS). Dong and Li [28] summarized the recent research results on green finance, defined the basic connotations of green finance, explained the action mechanism of green finance, and provided suggestions on green credit, green insurance, green securities, and green risk investment. Koester et al. [29] pointed out that millions of new capitals from risk fund, private equity fund, and hedge fund are being diverted to clean technology, creating a huge innovation opportunity for clean technology development. In addition, they discussed the optimal organizational form, intellectual property protection, stock options, risk investment locations, offshore finance, financing options, and so on.

As green financing attracts more and more attention, many domestic and foreign scholars have defined the concept of green financing, delineated the service scope of green financing, and constructed green financing systems. However, few of them studied green financing efficiency and corporate investment from the angle of investment level, investment efficiency, and investment risk. Neither have many evaluated the effect of green financing policies from macroperspectives such as economic operation and institutional environment. There is no in-depth research into the niches. As a result, corporate managers lack a theoretical basis for implementing green financing.

To evaluate the green financial decision, this paper links the macroconcept of green financing policy with the microconcept of corporate investment and analyzes the correlation between green financing and the green corporate investment logic. The research effectively solves the information loss in the traditional discretization process. The association rules of technical indices extracted in this research greatly reduce the computing load of further research.

The main contents are organized as follows: (1) Section 2 models the government decision to participate in green financing in the form of green product subsidy, and provides the solving algorithm; (3) Section 3 analyzes the correlations between green financing, green corporate investment level, and investment efficiency; (4) Section 4 discusses how to analyze the effectiveness of green financing decision under dynamic operating risks; and (4) Section 5 carries out simulations and presents the empirical results.

2. Model Construction and Solution

2.1. Model Construction. Referring to the existing results on the interplay between green financing policy and green corporate investment, this paper defines the investment subject as a two-level supply chain involving a green product manufacturer and a green product service provider. Under the effect of the government's environmental policy, green enterprises are forced to further invest in environmental protection. The resulting shortage of funds calls for financing by financial institutions. Thanks to the guidance of the government, the financing policy of financial institutions favors green enterprises. As a result, green financing helps lower the financing cost and increase the financing efficiency of green enterprises. In this paper, two green financing scenarios are considered, namely, government subsidy for green product manufacturing and green service provision. The specific mechanism of the subsidy is illustrated in Figure 1.

This paper mainly studies the government participation in green financing in the form of green product subsidy, in order to optimize the financing decisions of the relevant enterprises. Let MD be the potential market demand of the green products being invested; SE be the sensitivity coefficient of consumers to the price of green products/services; PR be the production cost per unit of green products; SQ be the amount of government subsidy per unit of green products; LR be the sales profit per unit of green products; TP be the unit price of green products; h be the green level of green products; l be the green sensitivity of consumers to green products/services; ω be the ratio of the investment cost of green products to that of the relevant green services; and FU ($\mathrm{FU} > 0$) be the initial fund of the green manufacturer. Without any fund constraint, the green financing amount of a green product manufacturer needs to satisfy:

$$\mathrm{FU} \geq (\mathrm{PR} - \mathrm{SQ})[\mathrm{MD} - \mathrm{SE}(\mathrm{LR} + \mathrm{TP}) + lh] + \frac{\omega}{2}h^2. \tag{1}$$

Formula (1) shows that when the initial fund is fewer than the required green financing amount, the green product manufacturer needs to obtain green financing from banks, venture capital, and other financial institutions. The fund size FI required by the green product manufacturer is defined as follows:

$$\mathrm{FI} = (\mathrm{PR} - \mathrm{SQ})[\mathrm{MD} - \mathrm{SE}(\mathrm{LR} + \mathrm{TP}) + lh] + \frac{\omega}{2}h^2 - \mathrm{FU}. \tag{2}$$

Considering the government participation in green financing in the form of green product subsidy, the overall objective of green financing decision was defined as the maximization of total social welfare ZF, composed of the profit of green product manufacturer and green service provider, the consumer surplus, and the environmental protection and governance cost. Let E be consumer demand; LV be the bank interest rate; GZ be consumer surplus; φ_{ZH} be the profit of green product manufacturer; φ_{SU} be the profit of green service provider; and $\mathrm{CZ} = \mathrm{SQ}$. E be the government's financial discount expenditure. Then, the functions of φ_{SU}, φ_{ZH}, and ZF can be expressed as follows:

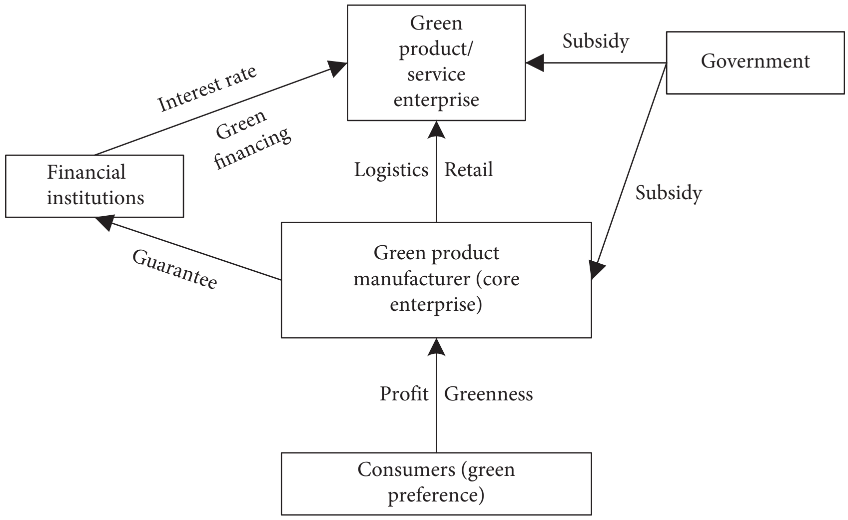

Figure 1: Financing flow of green enterprises with government participation.

$$\begin{aligned}\phi_{SU} &= (\mathrm{TP}-\mathrm{PR}+\mathrm{SQ})E-\frac{\omega}{2}h^2-\mathrm{FI}\cdot\mathrm{LV},\\ \phi_{ZH} &= \mathrm{LR}\cdot E-\frac{1}{2}h^2,\\ \mathrm{ZF} &= \phi_{SU}+\phi_{ZH}+\mathrm{GZ}-\mathrm{CZ}.\end{aligned} \tag{3}$$

Substituting E, FI, GZ, and CZ separately into (3), we get

$$\phi_{SU} = (\mathrm{TP}-\mathrm{PR}+\mathrm{SQ})[\mathrm{MD}-\mathrm{SE}(\mathrm{LR}+\mathrm{TP})+lh]-\frac{\omega}{2}h^2-\left\{(\mathrm{PR}-\mathrm{SQ})[\mathrm{MD}-\mathrm{SE}(\mathrm{LR}+\mathrm{TP})+lh]+\frac{\omega}{2}h^2-\mathrm{FU}\right\}\mathrm{LV}, \tag{4}$$

$$\phi_{ZH} = \mathrm{LR}[\mathrm{MD}-\mathrm{SE}(\mathrm{LR}+\mathrm{TP})+lh]-\frac{1}{2}h^2, \tag{5}$$

$$\begin{aligned}\mathrm{ZF} = {} & (\mathrm{TP}-\mathrm{PR})[\mathrm{MD}-\mathrm{SE}(\mathrm{LR}+\mathrm{TP})+lh]-\frac{\omega}{2}h^2-\left\{(\mathrm{PR}-\mathrm{SQ})[\mathrm{MD}-\mathrm{SE}(\mathrm{LR}+\mathrm{TP})+lh]+\frac{\omega}{2}h^2-\mathrm{FU}\right\}\mathrm{LV}\\ & +\mathrm{LR}[\mathrm{MD}-\mathrm{SE}(\mathrm{LR}+\mathrm{TP})+lh]-\frac{1}{2}h^2+\frac{1}{2}[\mathrm{MD}-\mathrm{SE}(\mathrm{LR}+\mathrm{TP})+lh]^2.\end{aligned} \tag{6}$$

The game between the government and the enterprises can be modeled as follows:

$$\max_{\mathrm{SQ}\geq 0}\mathrm{ZF}(\mathrm{SQ}),$$
$$s.t.\begin{cases}\text{LR and } h \text{ are the optimal solution to the following programming:}\\ \max\limits_{m\geq 0, g\geq 0}\phi_{ZH}(LR,h),\\ s.t\begin{cases}\text{TP is the optimal solution to the following programming:}\\ \max\limits_{\mathrm{TP}\geq 0}\phi_{SU}(\mathrm{TP}).\end{cases}\end{cases} \tag{7}$$

As shown in (7), the government leads the actions of enterprises. Therefore, the decision on green product subsidy SQ should be made first with ZF maximization as the top priority. Then, the green product manufacturer decides the greenness h of products, and the sales profit LR per unit of green products, with the aim to maximize the sales profit of its own products. Finally, the green service provider decides the unit price TP of green products, aiming to maximize the profit of service provision.

2.2. Model Solution. The proposed model was solved reversely. For simplicity, the following equation can be defined first:

$$\begin{aligned} g_1 &= \mathrm{MD} - \mathrm{SE}\cdot\mathrm{PR}(1+\mathrm{LV}),\\ g_2 &= \mathrm{SE}(\mathrm{SE}-2),\\ g_3 &= l^2(-1+\omega+\omega LV),\\ g_4 &= l^2 - 4\mathrm{SE},\\ g_5 &= \mathrm{SE}^2(1+\mathrm{LV}) + \mathrm{SE}(6\mathrm{LV}-2),\\ g_6 &= l^2\left(-1+\mathrm{LV}+\omega+2\mathrm{LV}\omega+\mathrm{LV}^2\omega\right). \end{aligned} \tag{8}$$

By (4), the first-order derivative of φ_{SU} relative to the unit price TP of green products can be obtained as follows:

$$\begin{aligned} \frac{\partial\phi_{\mathrm{SU}}}{\partial\mathrm{TP}} &= \mathrm{MD} + hl + \mathrm{SE}\cdot\mathrm{LV}(\mathrm{PR}-\mathrm{SQ}) - \mathrm{SE}(\mathrm{LR}+\mathrm{TP})\\ &\quad - \mathrm{SE}(-\mathrm{PR}+\mathrm{SQ}+\mathrm{TP}). \end{aligned} \tag{9}$$

Then, the second-order derivative of φ_{SU} relative to TP can be solved as follows:

$$\frac{\partial\phi_{\mathrm{SU}}^2}{\partial^2\mathrm{TP}} = -2\mathrm{SE} < 0. \tag{10}$$

Since φ_{SU} is a concave function about TP, there is a local maximum of the profit of green product/service enterprise. Suppose the second-order derivative of φ_{SU} relative to TP is zero. Then, TP can be described as a function of SQ, LR, and h as follows:

$$\mathrm{TP} = \frac{\mathrm{MD} + \mathrm{SE}\cdot\mathrm{PR} + hl - \mathrm{SE}\cdot\mathrm{LR} + \mathrm{SE}\cdot\mathrm{PR}\cdot\mathrm{LV} - \mathrm{SE}\cdot\mathrm{SQ} - \mathrm{SE}\cdot\mathrm{LV}\cdot\mathrm{SQ}}{2\mathrm{SE}}. \tag{11}$$

Combining (11) and (10), the derivatives relative to h and LR can be solved as follows:

$$\begin{aligned} \frac{\partial\phi_{\mathrm{ZH}}}{\partial h} &= \frac{l\cdot\mathrm{LR}}{2} - h,\\ \frac{\partial\phi_{\mathrm{ZH}}}{\partial h} &= \frac{1}{2}\left[\mathrm{MD} + hj - (-2\mathrm{LR} - \mathrm{PR} - \mathrm{PR}\cdot\mathrm{LV} + \mathrm{SQ} + \mathrm{LV}\cdot\mathrm{SQ})\right]. \end{aligned} \tag{12}$$

Next, the second-order derivative of φ_{ZH} relative to h and LR can be solved as follows:

$$\begin{aligned} \frac{\partial^2\phi_{\mathrm{ZH}}}{\partial h^2} &= -1,\\ \frac{\partial^2\phi_{\mathrm{ZH}}}{\partial \mathrm{LR}^2} &= -\mathrm{SE},\\ \frac{\partial^2\phi_{\mathrm{ZH}}}{\partial h\,\partial\mathrm{LR}} &= \frac{\partial^2\phi_{ZH}}{\partial\mathrm{LR}\partial h}\,\frac{l}{2}. \end{aligned} \tag{13}$$

The Hessian matrix can be defined as follows:

$$\mathrm{Hessian} = \begin{bmatrix} -\mathrm{SE} & \dfrac{l}{2} \\ \dfrac{l}{2} & -1 \end{bmatrix}. \tag{14}$$

The Hessian matrix is negative definite when its absolute value is greater than 0, expressed as follows:

$$|\mathrm{Hessian}| = \mathrm{SE} - \frac{l^2}{4}. \tag{15}$$

In this case, φ_{ZH} is the combined concave function of h and LR. The simultaneous solution can be solved by

$$\begin{aligned} \mathrm{LR} &= \frac{2(\mathrm{MD} + \mathrm{SE}\cdot\mathrm{PR} - \mathrm{SE}\cdot\mathrm{PR}\cdot\mathrm{LV} + \mathrm{SE}\cdot\mathrm{SQ} + \mathrm{SE}\cdot\mathrm{LV}\cdot\mathrm{SQ})}{4\mathrm{SE} - l^2},\\ h &= \frac{l(-\mathrm{MD} + \mathrm{SE}\cdot\mathrm{PR} + \mathrm{SE}\cdot\mathrm{PR}\cdot\mathrm{LV} - \mathrm{SE}\cdot\mathrm{SQ} - \mathrm{SE}\cdot\mathrm{LV}\cdot\mathrm{SQ})}{l^2 - 4\mathrm{SE}}. \end{aligned} \tag{16}$$

Substituting h and LR into formula (11), TP can be updated as follows:

$$\mathrm{TP} = \frac{\mathrm{MD} + \left(3\mathrm{SE} - l^2\right)(1+\mathrm{LV})(\mathrm{PR}-\mathrm{SQ})}{4\mathrm{SE} - l^2}. \tag{17}$$

Substituting the updated SQ, h, and LR into (6), the first-order derivative of ZF relative to SQ can be obtained, and the second-order derivative of ZF relative to SQ can be solved as follows:

$$\frac{\partial^2\mathrm{ZF}}{\partial\mathrm{SQ}^2} = \frac{\mathrm{SE}^2(1+\mathrm{LV})\left[-2\mathrm{SE}(1-3\mathrm{LV}) + \mathrm{SE}^2(1+\mathrm{LV}) + l^2\left(1-\mathrm{LV}-\omega-2\mathrm{LV}\omega-\mathrm{LV}^2\omega\right)\right]}{\left(l^2 - 4\mathrm{SE}\right)^2}. \tag{18}$$

If (18) is negative, ZF is a concave function of SQ and has a local maximum. Suppose the first-order derivative of ZF relative to SQ equals 0. Then

$$\mathrm{SQ}* = \frac{g_5 - g_6 - g_4 - g_1}{\mathrm{SE}(1+LV)(g_5+g_6)}. \tag{19}$$

When the government participates in green financing in the form of green product subsidy, the following condition must be satisfied:

$$\begin{gathered}\mathrm{SE} > \frac{l^2}{4},\\ \mathrm{SE}^2(1+\mathrm{LV}) + \mathrm{SE}(6\mathrm{LV}-2) < l^2\left(-1+\mathrm{LV}+\omega+2\mathrm{LV}\omega+\mathrm{LV}^2\omega\right).\end{gathered} \tag{20}$$

The optimal TP, LR, h, and SQ can be expressed as follows:

$$\begin{aligned}\mathrm{TP}* &= \frac{g_1(g_4+\mathrm{SE})}{\mathrm{SE}(g_6-g_5)} + \frac{\mathrm{MD}}{\mathrm{SE}},\\ \mathrm{LR}* &= \frac{2g_1}{g_6-g_5},\\ h* &= \frac{lg_1}{g_6-g_5},\\ \mathrm{SQ}* &= \frac{g_5-g_6-g_4-g_1}{\mathrm{SE}(1+\mathrm{LV})(g_5-g_6)}.\end{aligned} \tag{21}$$

3. Dynamic Risk-Based Analysis on Green Financing Decision

3.1. Correlation between Green Financing and Green Enterprise Investment. Figure 2 presents the associations between green financing and green corporate investment level. To verify the hypothesis that green enterprises invest more than nongreen enterprises under green financing, this paper takes investment level $IL_{i\tau}$ and the double differential cross-term $(G_i \times T_\tau)$ as the explained variable and the explanatory variable, respectively, and denotes the control variable as CV, individual fixed effects as ξ_i, time fixed effects as β_τ, and the random disturbance term as $\rho_{i\tau}$. Then, the fixed-effects double differential model can be established as follows:

$$\mathrm{IL}_{i\tau} = e_0 + e_1 G_i \times T_\tau + \beta\mathrm{CV} + \xi_i + \mu_t + \rho_{i\tau}. \tag{22}$$

The above model characterizes the associations between green financing and green corporate investment level. Our focus lies on the estimated value of e_1, which represents the degree of impact of green financing on the green corporate investment level. If the estimated value is positive, then the hypothesis holds; if the estimated value is negative, then the hypothesis fails.

3.2. Correlation Analysis between Green Financing and Green Corporate Investment Level. Figure 3 presents the association mechanism between green financing and green corporate investment level. The following parameters were defined to test the interaction between green financing, the sufficiency of green corporate investment, and investment efficiency: the actual new capital investment CA_i of the green enterprise in year τ; the Tobin's Q $TB\text{-}Q_{it-1}$ representing the growth opportunity of the green enterprise in year $\tau-1$; the working fund $ZY_{i\tau-1}$ of the green enterprise in year $\tau-1$; the asset-liability ratio $DR_{i\tau-1}$ of the green enterprise at the end of year $\tau-1$; the scale growth rate $SC_{i\tau-1}$ of the green enterprise; the listing time $MA_{i\tau-1}$ of the green enterprise; the profitability $YL_{i\tau-1}$ of the green enterprise; the actual new capital investment $CA_{i\tau\tau-1}$ of the green enterprise in year $\tau-1$; and the dummy variables ND and HY of year and industry, respectively. Then, the investment efficiency of the green enterprise can be measured by

$$\begin{aligned}\mathrm{CA}_{i\tau} = r_0 &+ r_1\mathrm{TB\_Q}_{i\tau-1} + r_2\mathrm{ZY}_{i\tau-1} + r_3\mathrm{DR}_{i\tau-1}\\ &+ r_4\mathrm{SC}_{i\tau-1} + r_5\mathrm{MA}_{i\tau-1} + r_6\mathrm{YL}_{i\tau-1} + r_7\mathrm{CA}_{i\tau-1}\\ &+ \sum\mathrm{ND} + \sum\mathrm{HY} + \rho_{i\tau}.\end{aligned} \tag{23}$$

Based on the regression residual of (23), the underinvestment $CA\_V_{i\tau}$, overinvestment $CA\_ZG_{i\tau}$, and investment efficiency $CA\_A_{i\tau}$ of the green enterprise were calculated separately. Then, $CA\_V_{i\tau}$, $CA\_ZG_{i\tau}$, and $CA\_A_{i\tau}$ were treated as explained variables, and $(G_i \times T_\tau)$ as the explanatory variable to build the double differential fixed-effects models (26–28), which test the interaction between green financing, the sufficiency of green corporate investment, and investment efficiency. Let us denote the control variable as CV, individual fixed effects as ξ_i, time fixed effects as β_τ, and the random disturbance term as $\rho_{i\tau}$. Then, we have

$$\begin{aligned}\mathrm{CA\_}V_{i\tau} &= d_0 + d_1 G_i \times T_\tau + \beta\mathrm{CV} + \xi_i + \mu_\tau + \rho_{i\tau},\\ \mathrm{CA\_ZG}_{i\tau} &= d_2 + d_3 G_i \times T_\tau + \beta\mathrm{CV} + \xi_i + \mu_\tau + \rho_{i\tau},\\ \mathrm{CA\_}A_{i\tau} &= d_4 + d_5 G_i \times T_\tau + \beta\mathrm{CV} + \xi_i + \mu_\tau + \rho_{i\tau}.\end{aligned} \tag{24}$$

The above models focus on the estimation of parameters d_1, d_3, and d_5, which characterize how much green financing affects the sufficiency of green corporate investment and investment efficiency. If d_1 is estimated to be positive, then the green financing policy worsens the insufficiency of corporate investment; if d_1 is estimated to be negative, then the policy alleviates the insufficiency of corporate investment; if d_3 is estimated to be positive, then the green financing policy intensifies the excessiveness of corporate investment; if d_3 is estimated to be negative, then the policy alleviates the excessiveness of corporate investment; if d_5 is estimated to be positive, then the green financing policy increases corporate investment efficiency; and if d_5 is estimated to be negative, then the policy drags down that efficiency.

3.3. Dynamic Operation Risks and Green Financing Decision. This paper takes the net occupation of green credit and short-term financial debt ratio as the explained variables. Let GCD and GCS be the corporate demand and supply of green credit, respectively; GFAT, GFBP, GFP, GFACR, GFNR, and GFADR be the accounts payable, notes payable, prepayment,

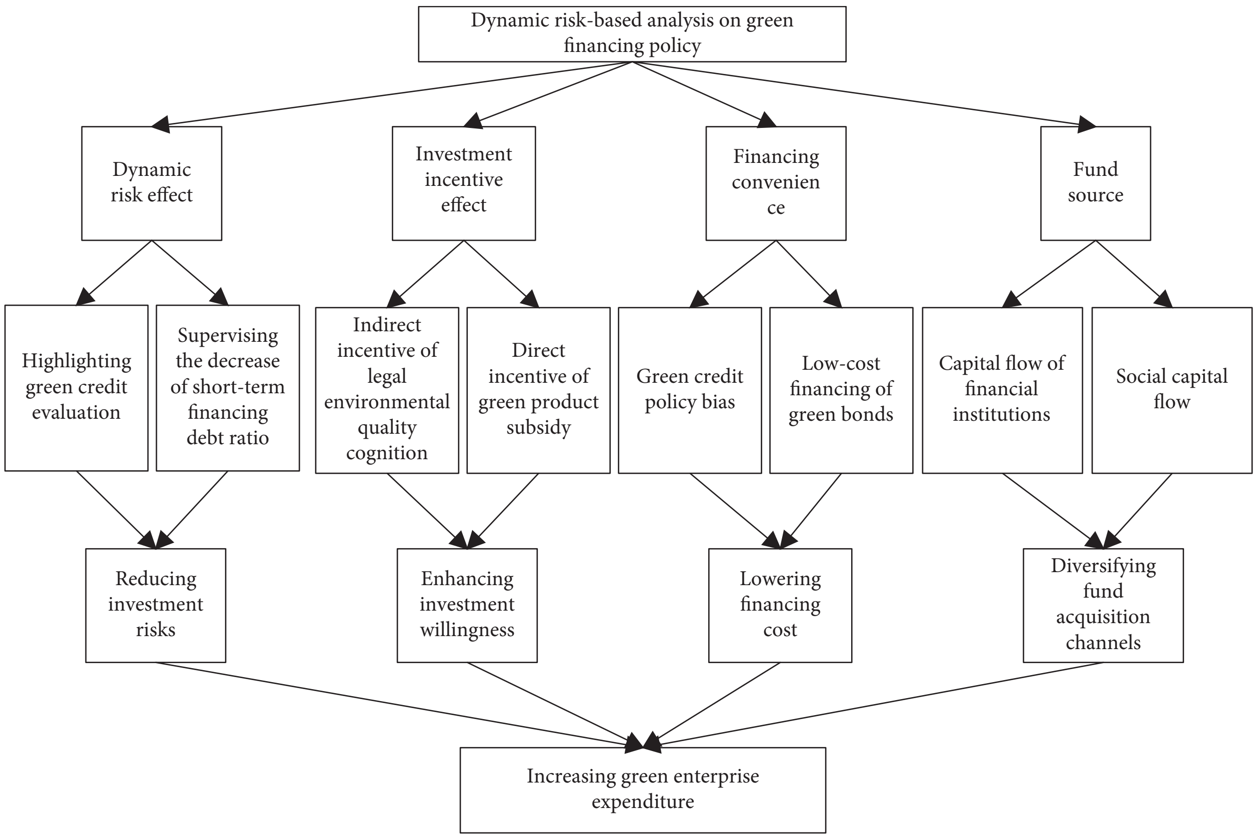

Figure 2: Associations between green financing and green corporate investment level.

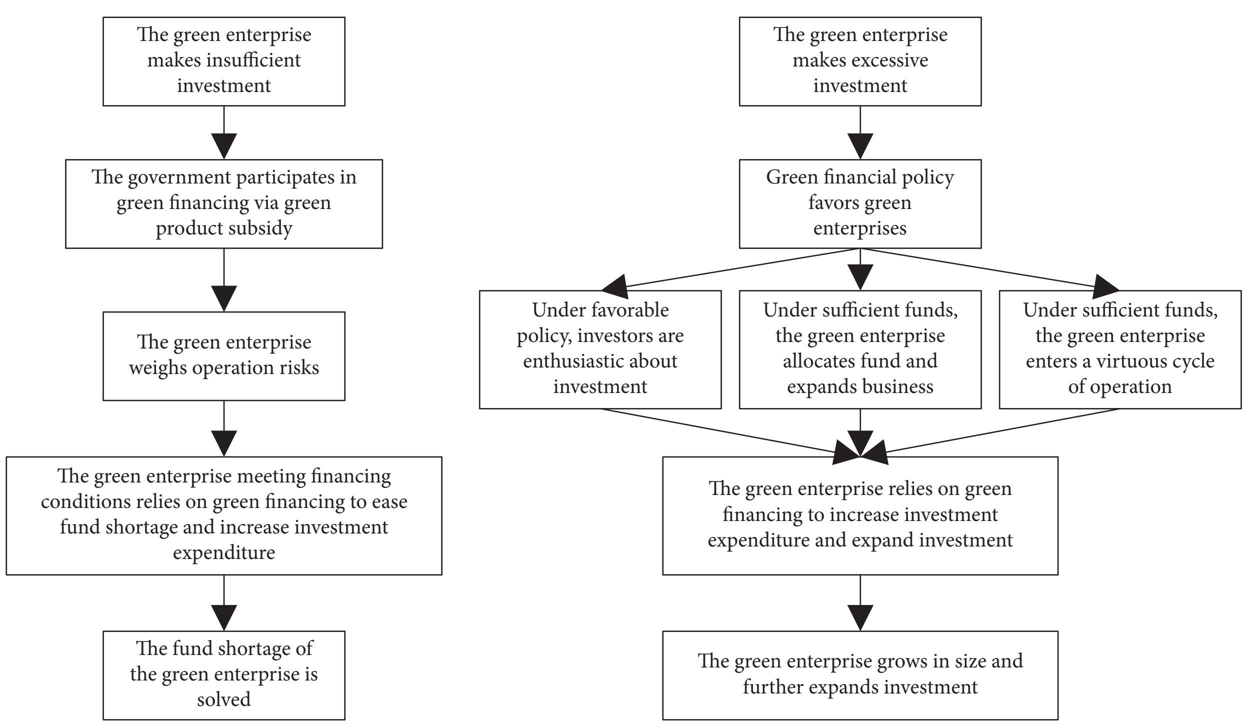

Figure 3: Association mechanism between green financing and green corporate investment level.

accounts receivable, notes receivable, and deposit received of green financing, respectively; and GPOI be the operation income of green products of the green enterprise. Then, the net occupation of green credit NO can be calculated by

$$\mathrm{NO} = \mathrm{GCD} - \mathrm{GCS} = \left[\mathrm{GFAT} + \mathrm{GFBP} - \mathrm{GFP} - \frac{\mathrm{GFACR} + \mathrm{GFNR} - \mathrm{GFADR}}{\mathrm{GPOI}}\right]. \tag{25}$$

Let STB be the short-term borrowing of green financing; IP be the interest payment of green financing; NCL be the noncurrent liabilities expired within the year; TFL be the trading financial liabilities; CA be the current assets; and OCL be the operating current assets. Then, the short-term financial debt ratio STF can be calculated by

$$\mathrm{STF} = \frac{\mathrm{STB} + \mathrm{IP} + \mathrm{NCL} + \mathrm{TFL}}{\mathrm{CA} - \mathrm{OCL}}. \tag{26}$$

In this paper, the dynamic operation risks of the green enterprise are evaluated under the assumption that the enterprise's profitability changes dynamically with the operation risks. Let η_τ be the operation risks in year τ; QP_τ be the profit before interest, taxes, depreciation, and amortization in year τ; and $ZC_{\tau-1}$ be the total capital in year τ−1. Then, we have

$$\begin{aligned} \eta_\tau &= \sqrt{\frac{1}{\psi - 1}\sum_{\tau}^{\psi}\left(P_\tau - \frac{1}{\psi}\sum_{\tau=1}^{\psi} P_\tau\right)\hat{2}}, \\ P_\tau &= \frac{\mathrm{QP}_\tau}{\mathrm{ZC}_\tau - 1}. \end{aligned} \tag{27}$$

Because the green financing decision of the green enterprise is affected by many factors, several other control variables were chosen in addition to dynamic operation costs. Let B represent NO and STF; α_0, α_1, α_2, α_3, α_4, α_5, and α_6 denote regression coefficients; IL denotes green product inventory level; NCF be the net cash flow of the operation activities of the green enterprise; CS be the scale of the green enterprise; CG be the growth of the green enterprise; PRO be the profitability of the green enterprise; and OR be the operating risks of the green enterprise. Then, the regression analysis model can be established as follows:

$$B = \alpha_0 + \alpha_1 \mathrm{IL} + \alpha_2 \mathrm{NCF} + \alpha_3 \mathrm{CS} + \alpha_4 \mathrm{CG} + \alpha_5 \mathrm{PRO} + \alpha_6 \mathrm{OR} + \rho. \tag{28}$$

Model (28) mainly measures how much the operation risks of the green enterprise influence NO and STF.

4. Simulation and Empirical Analysis

The dynamic operation risks of the green enterprise are immensely impacted by market status and industry cyclicity. To ensure the reliability of experimental results, our data samples are Chinese enterprises of the same grade in the noncyclic industry of environmentally friendly electric vehicle manufacturing. After removing the enterprises lacking operation and economic data, a balanced panel data of 28 environmentally friendly electric vehicle manufacturers were established for 2010–2020, which include a total of 540 observations.

The associations between green financing and green enterprise investment change with the time series. However, the changes in the associations do not impede the time series from helping the decision-maker of green financing. The decision-maker can still acquire valuable association rules from the panel data time series. Our sample data were obtained from enterprise annual reports and bank credit disclosures and were clustered by an improved fuzzy c-means (FCE) algorithm, producing the membership matrix of the attributes of the financing time series. These attributes were then applied to association rule analysis. Figure 4 depicts the flow of our association rule analysis algorithm. A total of 30 experiments was carried out with the following parameters: the population size of the genetic algorithm (GA) was set to 25, the fuzzy weighting index to 2, the maximum number of iterations to 500, and the number of classes to 3. Table 1 compares the clustering results of different algorithms.

As shown in Table 1, our algorithm achieved the best clustering effect, although it was a bit slower than standard FCM and GA-based fuzzy clustering. This means our algorithm is very unlikely to fall into local optimum and strong in global search. Figure 5 presents the curve of the mean optimal solution to the fitness of each algorithm. It is evident that our algorithm could easily jump out of local convergence, while the other two algorithms often fell into the local optimum, during the clustering of the panel data time series. The main reason is that our algorithm adaptively optimizes crossover and mutation.

The membership matrix of the sample data could be obtained through cluster analysis. Several data were selected from the membership matrix of each kind of panel data time series, forming the financing decision form under the operation risks of green enterprises (Table 2).

Next is to demonstrate the effectiveness of our model in characterizing the influence of green financing over green enterprise investment level and investment efficiency. For this purpose, the main variables of our model were subjected to descriptive statistics. Table 3 shows the statistics on the model of the relationship between green financing and green enterprise investment level. The mean of $IL_{i\tau}$ stood at 0.045, that is, the investment level of the surveyed green enterprises averaged at 0.045; the maximum and minimum of the investment level were −0.033, and 0.235, respectively, which represent the difference between green enterprises in investment level. Meanwhile, the mean, maximum, minimum, and standard deviation of $TB\text{-}Q_{it-1}$ were 2.627, 11.125, 0.912, and 1.865, respectively, suggesting that different green

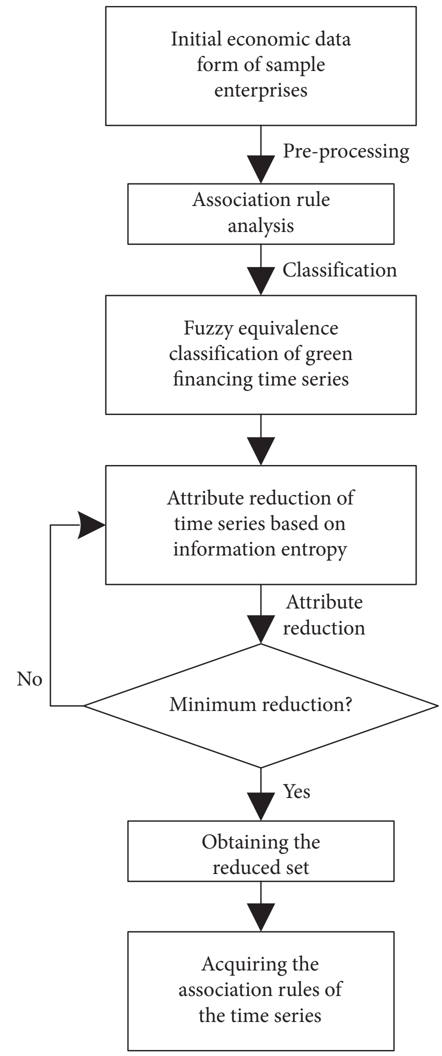

Figure 4: Flow of our association rule analysis algorithm.

Table 1: Clustering results of different algorithms.

Algorithm	Standard FCM	GA-based fuzzy clustering	Our algorithm
Number of correctly clustered samples	472	485	503
Accuracy	89.6	91.7	92.8
Runtime	262.7	335.1	343.6

enterprises vary in growth opportunity. Likewise, the other variables also differed across green enterprises.

The double differential model must satisfy the null hypothesis of parallel trend. This paper tests the effect of our model on green financing. Figure 6 presents the time trends of green enterprise investment level in 2010–2020. One of the curves is about the test group, and the other is about the control group. It can be observed that before 2015, the investment levels of the two groups declined similarly. This is because the investment expenditure grows slower than the total assets, due to the cluster analysis and normalization of total assets of green enterprises and relevant economic panels. After 2015, the investment level of the test group dropped at a slower pace and even slightly rebounded, while that of the control group continued to fall. After 2017, the gap between the two groups widened. The results confirm the hypothesis that green enterprises invest more than nongreen enterprises under green financing.

Table 4 gives the descriptive statistics for the model of the relationship between green financing and green enterprise investment efficiency. In 2010–2020, the annual mean of the new investment of green enterprises took up 4.5% of the total assets; the maximum, minimum, and standard deviation were 18.5%, −3.4%, and 4.2%, respectively. This means green enterprises make only a few new investments, and the enterprises differ in the investment scale. It could be similarly deduced that different enterprises varied significantly in profitability, scale growth rate, cash holding level, leverage

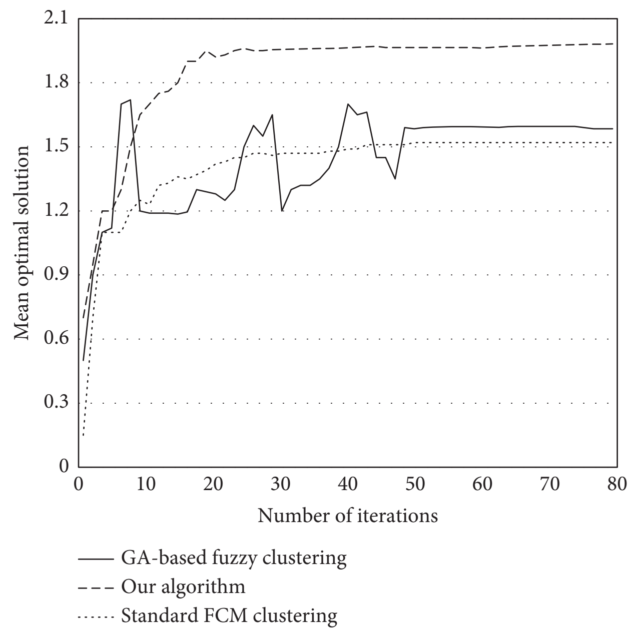

Figure 5: Curve of the mean optimal solution to the fitness of each algorithm.

Table 2: Financing decision form under the operation risks of green enterprises.

	α_0	α_1	α_2	α_3	α_4	α_5
IL	0.00167752	0.00516724	−0.010235	0.06341292	0.01216235	0.03623194
NCF	0.423759	−0.01683	0.005724	0.005362	0.017523	0.033574
CS	0.006521	−0.00975	0.005365	0.035219	−0.0006	0.043245
CG	−0.00759	−0.0012	0.005362	0.035709	−0.00362	0.025162
PRO	0.45529	−0.01493	0.012224	0.007762	0.018323	0.052174
OR	0.014261	−0.01085	0.008965	0.041219	−0.0016	0.031145
Decision attributes	(1,0,0)	(1,0,0)	(0,1,0)	(0,1,0)	(0,0,1)	(0,0,1)

Table 3: Descriptive statistics for the model of the relationship between green financing and green enterprise investment level.

Variable	$IL_{i\tau}$	$G_i \times T_\tau$	$ZY_{i\tau-1}$	$TB\text{-}Q_{it-1}$	$SC_{i\tau-1}$	$YL_{i\tau-1}$	$MA_{i\tau-1}$
Mean	0.045	0.056	0.432	2.627	0.179	0.052	4.762
Median	0.032	0.001	0.462	1.965	0.095	0.056	4.981
Standard deviation	0.042	0.223	0.262	1.865	0.367	0.052	0.695
Minimum	−0.032	0.001	0.045	0.912	−0.256	−0.126	2.753
Maximum	0.235	1.002	0.885	11.125	2.153	0.276	5.799
Quantity	11867	11867	11867	11867	11867	11867	11867

ratio, working funds, and so on. That is, the new investment scale differs between enterprises, owing to the disparity between them in terms of the influencing factors on the new capital investment.

Table 5 summarizes the investment efficiency of green enterprises. The mean of $CA\_A_{i\tau}$ was 0.032, a sign of the heavy presence of inefficient investment among Chinese green enterprises, which drags down investment efficiency. The mean and quantity ratio of $CA\_V_{i\tau}$ were 0.025 and 63.26%, respectively; the mean and quantity ratio of $CA\_ZG_{i\tau}$ were 0.041 and 36.74%, respectively. Hence, underinvestment is more common among green enterprises than overinvestment. The main causes include internal factors of these enterprises, such as the long lifecycle of projects, and low environmental risk evaluation, as well as the defects of green financing and relevant financial services, namely, unreasonable financing policy, credit discrimination, and imperfect guarantee system. The underinvestment becomes a prominent problem for the following reasons: the green financing market in China started later than that in developed countries. The financing mechanism needs to be optimized; the financing channels are not diverse; and the financing instruments are outdated. Most green enterprises face different degrees of financing obstacles and constraints.

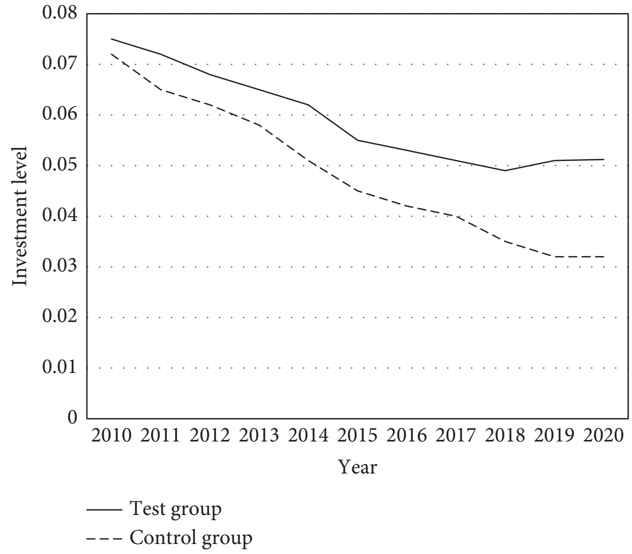

Figure 6: Time trends of green enterprise investment level.

Table 4: Descriptive statistics for the model of the relationship between green financing and green enterprise investment efficiency.

Variable	$CA_{i\tau\tau}$	$CA_{i\tau\tau-1}$	$DR_{i\tau-1}$	$ZY_{i\tau-1}$	$TB\text{-}Q_{it-1}$	$SC_{i\tau-1}$	$MA_{i\tau-1}$	$YL_{i\tau-1}$
Observations	11,954	11,954	11,954	11,954	11,954	11,954	11,954	11,954
Mean	0.045	0.052	0.436	0.176	02.536	0.185	4.617	0.053
Standard deviation	0.042	0.043	0.218	0.145	1.732	0.357	0.875	0.056
Minimum	−0.034	−0.025	0.047	0.012	0.915	−0.235	0.672	−0.129
Maximum	0.185	0.236	0.895	0.677	10.765	2.162	5.735	0.278

Table 5: Statistics on green enterprise investment efficiency.

Variable	$CA\_A_{i\tau}$	$CA\_V_{i\tau}$	$CA\_ZG_{i\tau}$
Mean	0.032	0.025	0.041
Median	0.023	0.019	0.025
Standard deviation	0.027	0.012	0.036
Minimum	0.001	0.001	0.001
Maximum	0.139	0.063	0.138
Quantity	1235	720	584
Quantity ratio (%)	98.05	63.26	36.74

As for green credit, the approval cycle is rather long, and the qualification review is too strict. To solve the problem, more favorable policies should be rolled out to support green financing.

5. Conclusions

From the angle of dynamic risks, this paper tries to clarify the relationship between green financing and the investment logic and evaluates the effectiveness of financing decisions. Firstly, a decision model was established for the government participation in green financing via green product subsidy, and the solving algorithm was designed for the model. Next, the authors analyzed the correlations of green financing with the investment level and investment efficiency of green enterprises and then proposed a method to analyze the effectiveness of green financing decisions under dynamic operation risks. Through experiments, the associations between green financing and green enterprise investment were analyzed, followed by the cluster analysis and association rule analysis on the collected panels. In this way, the analysis results were obtained, and the operation risk-based financing decisions of green enterprises were summarized in a form. In the end, the main variables of our model were subjected to descriptive statistical analysis, which confirm that our model can effectively represent the influence of green financing on green enterprise investment level and investment efficiency.

The proposed association analysis model for green financing and green corporate investment mainly targets investment level and investment efficiency. Many other issues are yet to be analyzed from the perspective of dynamic risks. For example, one state or phenomenon under dynamic risks could be described by multiple variables. Hence, future research will deal with the prediction based on multivariate time series.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This paper is supported by 2021 Philosophy and Social Science Planning Project of Henan Province, research on the strategy of screening, protection, and utilization of rural red cultural resources in Central Plains, 2021BYS051; research on color identification system and planning path of traditional villages in central China under the background of rural revitalization strategy, Special Application for Key Research and Development and Promotion of Henan Province, project no. 212400410381; research on Strategies for Memory Protection and Inheritance of Industrial and Trade Traditional Villages in Henan from the Perspective of Village Culture, project no. 2021-ZZJH-453; research on Spatial Satisfaction Evaluation and Renewal Protection Strategy for Inheritance of Traditional Village Context in Southern Henan province, project no. 2021-ZDJh-422; research on the characteristic landscape color recognition system and planning approach of traditional villages in western Henan province, Humanities and Social Sciences research project of Education Department of Henan Province in 2020, project no. 2020-ZZJH-513; research on promoting the characteristic development of Henan cultural industry with social innovation, Subject of Henan Social Science Planning, project no. 2018BYS022; and research on Spatial Feature Improvement design of Traditional Village Landscape in Southern Henan Under Protection Early Warning Strategy, project no. 2020-ZZJH-519.

References

[1] A. Farinmade, O. Soyinka, and K. W. M. Siu, "Assessing the effect of urban informal economic activity on the quality of the built environment for sustainable urban development in Lagos, Nigeria," *Sustainable Cities and Society*, vol. 41, pp. 13–21, 2018.

[2] H. Aimon, A. P. Kurniadi, and S. Amar, "Analysis of fuel oil consumption, green economic growth and environmental degradation in 6 Asia Pacific countries," *International Journal of Sustainable Development and Planning*, vol. 16, no. 5, pp. 925–933, 2021.

[3] T. E. Amalu and A. O. Ajake, "Developing natural lakes for socio-economic development: the case of Nike Lake Enugu state, Nigeria," *Geojournal*, vol. 84, no. 2, pp. 519–531, 2019.

[4] M. A. Ahmed, A. Arshad, M. Anwar ul Haq, and B. Akram, "Role of environmentalism in the development of green purchase intentions: a moderating role of green product knowledge," *International Journal of Sustainable Development and Planning*, vol. 15, no. 7, pp. 1101–1111, 2020.

[5] L. Charfeddine and M. Kahia, "Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: a panel vector autoregressive (PVAR) analysis," *Renewable Energy*, vol. 139, pp. 198–213, 2019.

[6] S. Wang and W. Wei, "Comprehensive evaluation on environmental impact of green buildings considering sustainable development," *International Journal of Design & Nature and Ecodynamics*, vol. 15, no. 3, pp. 449–453, 2020.

[7] Z. Zhang, X. Zhang, and M. Shi, "Urban transformation optimization model: how to evaluate industrial structure under water resource constraints?" *Journal of Cleaner Production*, vol. 195, pp. 1497–1504, 2018.

[8] C. F. Ren, P. Guo, M. Li, and J. J. Gu, "Optimization of industrial structure considering the uncertainty of water resources," *Water Resources Management*, vol. 27, no. 11, pp. 3885–3898, 2013.

[9] A. M. Hong and C. C. Cheng, "Industrial structure forecasting based on grey neural network optimized by integration algorithm," *ICIC Express Letters*, vol. 10, no. 10, pp. 2467–2472, 2016.

[10] L. V. Gallego, E. P. Moral, I. S. Román, and J. P. Sánchez, "Analysis of environmental taxes to finance wastewater treatment in Spain: an opportunity for regeneration?" *Water*, vol. 10, no. 2, p. 226, 2018.

[11] Z. Liu and A. Guo, "Application of green building materials and multi-objective energy-saving optimization design," *International Journal of Heat and Technology*, vol. 39, no. 1, pp. 299–308, 2021.

[12] C. Fischer, "Environmental protection for sale: strategic green industrial policy and climate finance," *Environmental and Resource Economics*, vol. 66, no. 3, pp. 553–575, 2017.

[13] A. B. Yishay, A. Fraker, R. Guiteras et al., "Microcredit and willingness to pay for environmental quality: evidence from a randomized-controlled trial of finance for sanitation in rural Cambodia," *Journal of Environmental Economics and Management*, vol. 86, pp. 121–140, 2017.

[14] M. Vochozka and A. Maroušková, "Implications of the EU green energy policy on financial performance of crop production and water management of topsoil," *Clean Technologies and Environmental Policy*, vol. 19, no. 2, pp. 603–609, 2017.

[15] J.-Y. Liu, Y. Xia, Y. Fan, S.-M. Lin, and J. Wu, "Assessment of a green credit policy aimed at energy-intensive industries in China based on a financial CGE model," *Journal of Cleaner Production*, vol. 163, pp. 293–302, 2017.

[16] D. Yang, Z. Chen, Y. Yang, and P. Nie, "Green financial policies and capital flows," *Physica A: Statistical Mechanics and Its Applications*, vol. 522, pp. 135–146, 2019.

[17] D. Metzger and O. Schinas, "Fuzzy real options and shared savings: investment appraisal for green shipping technologies," *Transportation Research Part D: Transport and Environment*, vol. 77, pp. 1–10, 2019.

[18] H. Sun, Y. Wan, L. Zhang, and Z. Zhou, "Evolutionary game of the green investment in a two-echelon supply chain under a government subsidy mechanism," *Journal of Cleaner Production*, vol. 235, pp. 1315–1326, 2019.

[19] P. A. O. Dalby, G. R. Gillerhaugen, V. Hagspiel, T. Leth-Olsen, and J. J. J. Thijssen, "Green investment under policy uncertainty and Bayesian learning," *Energy*, vol. 161, pp. 1262–1281, 2018.

[20] H. Gerlach and X. Zheng, "Preferences for green electricity, investment and regulatory incentives," *Energy Economics*, vol. 69, pp. 430–441, 2018.

[21] M. Saunila, J. Ukko, and T. Rantala, "Sustainability as a driver of green innovation investment and exploitation," *Journal of Cleaner Production*, vol. 179, pp. 631–641, 2018.

[22] K. Linnerud and M. Simonsen, "Swedish-Norwegian tradable green certificates: Scheme design flaws and perceived investment barriers," *Energy Policy*, vol. 106, pp. 560–578, 2017.

[23] T. Wu, L.-G. Zhang, and T. Ge, "Managing financing risk in capacity investment under green supply chain competition," *Technological Forecasting and Social Change*, vol. 143, pp. 37–44, 2019.

[24] R. R. Tan, K. B. Aviso, and D. K. S. Ng, "Optimization models for financing innovations in green energy technologies,"

Renewable and Sustainable Energy Reviews, vol. 113, Article ID 109258, 2019.

[25] C. Criscuolo and C. Menon, "Environmental policies and risk finance in the green sector: cross-country evidence," *Energy Policy*, vol. 83, pp. 38–56, 2015.

[26] P. J. Ludvigsen, "Green Bonds: Innovative Financing for Climate Change Mitigation and Adaptation Projects," *Air and Waste Management Association, A and WMA—Finding Common Ground on Climate Change Mitigation and Adaptation*, pp. 521–538, Air & Waste Management Association, Arlington, VA, USA, October 2017.

[27] P. Yatim, L. Ngan, and H. L. Lam, "Financing green growth in Malaysia: enabling conditions and challenges," *Chemical Engineering Transactions*, vol. 61, pp. 1579–1584, 2017.

[28] Z. Dong and Y. Li, "Social Responsibility, Green Finance, and the New Urbanization Construction," in *Low-carbon City and New-type Urbanization*, pp. 385–392, Springer, Berlin, Heidelberg, 2015.

[29] E. Koester, "How to structure, finance, and fund your clean technology venture: start-ups, corporate governance, venture capital, strategic alliances, and private equity in a "green" marketplace," in *Proceedings of the Society of Plastics Engineers—Global Plastics Environmental Conference, GPEC 2007—Environmental Innovation: Plastics Recycling and Sustainability*, pp. 1196–1223, 2007.