Pricing Mechanisms and Development Prospects of Green Financial Derivatives

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Abstract. Nowadays, green finance has become a significant way to guide the direction of investment because of the growing global climate pressures like the aggravation of greenhouse effect and the urgent need for the low-carbon transition. Therefore, tools like green bonds and green loans are widely used. For example, China's green credit balance was over 35.75 trillion CNY by the third quarter of 2024. However, green financial derivatives are not well developed, such as green bond futures, carbon-linked options, especially in emerging economies. This paper put forward an improved pricing framework which uses an ESG-GARCH model to put ESG risk indicators and climate data together, in order to track the dynamic impact of volatility. This paper also uses a vector automatic progress (VAR) model to analyze the connections between green fusion variables. The study uses data from futures in the EU emissions trading system, risks and climate value of the green index. Analysis shows that policy uncertainty, environmental externalities and cash liquidity fluctuations caused by ESG factors are core issues in pricing. The study ultimately provides practical advice to businesses, financial institutions and policy makers to enhance market development and point out future research directions to improve the accuracy of models and market credibility. This study aims to connect theory and practice and improve the financial system's ability to manage climate risks and expand sustainable investment.

Keywords: Green Financial Derivatives, Pricing Mechanism, ESG-GARCH Model, VAR Model.

1. Introduction

With growing global climate pressures and the urgent need for low-carbon economic transition, green finance has become a key way to guide money into sustainable projects [1]. Tools like green bonds and green loans are widely used—2024 third quarter data from the People's Bank of China shows that China's green credit balance was over 35.75 trillion CNY [1]. Nevertheless, green financial derivatives are not well developed, especially in emerging economies like China. These derivatives include green bond futures, carbon-linked options, ESG-linked swaps and so on. They are very important for hedging climate risks, improving liquidity, and stabilizing green asset prices [2]. Without them, the financial system is less able to deal with uncertainties like policy changes or climate disasters [2].

Traditional pricing models (such as Black-Scholes model, Capital Asset Pricing Model) are based on ideal assumptions, and do not include sustainable development factors. Therefore, they cannot catch the real impact of ESG performance and climate risks. This leads to wrong prices and slows market development. To solve these problems, this study builds an improved pricing framework, which puts ESG risks and climate data into quantitative financial models. This paper uses the ESG-GARCH model to simulate the dynamic impact of ESG factors on volatility, and uses the Vector Autoregression (VAR) model to analyze the links between green finance variables. The empirical data comes from EU Emissions Trading System futures data, climate Value at Risk indicators, and major green indices.

This paper is structured as follows. First, it will review relevant literature on green derivatives and pricing models. Then, this article will introduce the theoretical basis and empirical design of the proposed framework Next, it will discuss practical significance, implementation challenges, and gives policy advice to promote the development of green derivatives market. This research helps link theoretical models and market practice, and provides support for more effective risk management and sustainable capital allocation.

2. Literature Review

2.1. Definition of Green Finance

The International Capital Market Association (ICMA) clearly defines green finance as a system of financial activities in its Green Bond Principles. In this system, financial institutions, market subjects and other related parties use various financial products and services—such as credit, bonds, insurance, funds, equity investment [3]. At the same time, they also systematically put environmental factors (like dealing with climate change, controlling environmental pollution, protecting ecology, efficient use of resources) into investment and financing decision-making frameworks [4]. Its core goal is to direct money into green industries (such as solar energy, wind energy and other clean energy fields), promote low-carbon transition of traditional high-energy-consumption, high-pollution industries, and finally realize the coordinated development of sustainable economic growth and ecological environmental protection (ICMA, 2023) [4]. In practical application, commercial banks' special green credit for solar power station projects, and enterprises' green bonds issued for building sewage treatment facilities, are typical applications of green finance in the real economy, which show the support of financial tools for environmental protection projects [5].

2.2. Development of Green Finance and Instruments

At present, green finance is developing well, and its coverage is concentrated in three core fields. First, it supports low-carbon transition of traditional industries such as steel and non-ferrous metals, and the development of green buildings; second, it covers new energy fields like solar energy and wind energy, and the whole industrial chain of new energy vehicles; third, it involves ecological restoration projects in key areas and measures related to Eco-environment-oriented Development (EOD) model [6].

In terms of participating institutions, banks are the core force. Institutions like Industrial and Commercial Bank of China, Agricultural Bank of China, Industrial Bank play a leading role in green credit issuance and bond underwriting. Insurance companies such as Ping An Insurance and People's Insurance Company of China carry out green insurance business; securities companies like CITIC Securities actively participate in green bond issuance and related wealth management services.

In the past ten years, the scale of green finance has expanded greatly. This is mainly due to the promotion of global policies such as the Paris Agreement and the United Nations Sustainable Development Goals (SDGs). Green bonds, in particular, have become common tools for financing low-carbon infrastructure. Studies have found that the issuance of green bonds is related to better corporate environmental performance and higher transparency, which is very important [1]. Other studies show that shareholders of green bond-issuing companies may get higher valuations and reduce long-term risks [2].

2.3. The Role and Status of Green Derivatives

Even with these developments, green derivatives are still in the early stage of development. Some studies point out that the lack of clear standards and verification systems reduces investors' confidence in green financial products [3]. In China, some researches show that there is little research and clear regulations about green financial derivatives, such as carbon-linked tools and ESG-based options [4]. Therefore, the slow development restricts the financial system to hedge the climate risks and raise funds for green projects.

2.4. ESG Integration and Climate Risk in Pricing Models

Traditional asset pricing models (such as Black-Scholes model, Capital Asset Pricing Model) are usually based on two assumptions which are the efficient market and a neutral view of risk. However, these models often do not consider the climate risks, such as extreme weather (physical risks) and policy changes (transition risks). To solve this problem, some researchers come up with ideas that add carbon exposure indicators to these models. This way, the models can better reflect how the investors make decisions and assess risks. [5]. Other studies have found that ESG factors have a great impact on corporate valuation. Therefore, it is crucial to make up several kinds of pricing methods, which contains ESG factors [6].

3. Analysis of the Pricing Mechanism of Green Financial Derivatives

3.1. Challenges of Pricing Mechanism

3.1.1. External factors of the environment and market changes

Green financial derivatives are different from traditional ones because their underlying assets are affected by market supply, demand and price changes. They are also directly affected by environmental factors [7]. For example, products like carbon emission futures, renewable energy certificates, green electricity trading are now significantly depending on the natural environment and steady energy supply. When extreme climate occurs, energy structure adjustments or sudden environmental risks will happen. At this moment the market pricing models cannot calculate possible losses easily, and that will cause more uncertainty in pricing. This environmental impact makes it more troublesome to estimate risk premiums and more difficult to design risk hedging strategies for green financial derivatives.

3.1.2. Impact of policy risks

Green financial derivatives now heavily rely on the policy support. Rules which are about carbon emission quotas, renewable energy subsidies, green industry standards can directly change the valuation of underlying assets [8]. For example, if the government cuts new energy subsidies or limit carbon emission, the cash flow of related derivatives may change greatly, which can cause serious price fluctuations. Unclear policies also increase market volatility and require investors to assess risks more carefully. Compared with traditional financial products, policy factors play a more important role in the pricing of green financial derivatives, which is a key challenge.

3.1.3. Impact of ESG factors

ESG factors must also be considered in the pricing of green financial derivatives. Traditional financial assets mainly depend on cash flow and discount rate, but the cash flow of green products also depends on the environmental and social performance of enterprises [9]. For example, if an enterprise reduces carbon emissions and manages the environment well, its future cash flow may be more stable, which supports the value of derivatives. In addition, investors' preferences will affect the discount rate. As people pay more attention to green issues, the market may give lower risk premiums and higher valuations to enterprises with good ESG performance. ESG factors drive long-term return expectations and directly affect pricing through discount rates.

3.2. Limitations of Traditional Models

In the traditional financial derivatives market, common pricing methods include Black-Scholes option pricing model, binomial tree model, and other tools based on stochastic processes and risk-neutral pricing theory. These models work well in pricing assets like stocks, interest rates, and foreign exchange, and can clearly reflect market risks and time value. However, when used for green financial derivatives, they have many problems.

First, the assumptions are too ideal. Taking the Black-Scholes model as an example. It assumes no market friction, asset prices follow geometric Brownian motion, and volatility is constant. Meanwhile, green financial derivatives are often affected by policy changes, environmental risks, and external factors. Their prices may jump suddenly, which is not a smooth and continuous process. The simple assumptions of traditional models cannot catch these non-linear changes, so their pricing results are inconsistent with real market conditions.

Second, they do not include all risk factors. Traditional models mainly consider financial risks (such as interest rates and volatility). At the same time, green derivatives also have non-traditional risks—such as environmental risks, policy risks, and ESG performance risks. Because these risks are not included in the models, it is easy to underestimate risk premiums or ignore major systemic risks.

Third, they cannot describe uncertain cash flows. The future cash flow of green financial products often depends on emission reduction quotas, renewable energy output, or green project results. These are very uncertain and hard to predict. Traditional models are based on stable cash flows and fixed discount rates, so they cannot accurately reflect the volatility of green assets.

Finally, they do not include policy and social preference changes. The green derivatives market is closely linked to policies and investors' green preferences. However, traditional models usually assume that investors are rational, risk-neutral, or risk-averse. They do not consider social responsibility and environmental preferences. This means that traditional models cannot reflect how ESG preferences affect the prices of green finance.

In short, traditional derivative pricing models have great limitations in green finance. Their inability to capture the unique characteristics of the market makes it necessary to develop new green pricing models.

3.3. Recommendation of the Advanced Models

3.3.1. Aspects of improvement

This study used the ESG-GARCH model (an extension of the traditional GARCH model) to explore the dynamic link between ESG factors and volatility in financial assets. Its main idea is to incorporate ESG indicators into the equations of the GARCH model to measure conditional volatility, which also helps to quantify the impact of ESG on volatility in asset returns. The ESG-GARCH model is typically represented by the following set of equations:

$$r_t = \mu + \varepsilon_t, \tag{1}$$

Where r_t represents the asset return at time t, and μ is the constant mean of the return series. ε_t is the error term at time t, where $\varepsilon_t = \sigma_{t z_t}$, with z_t being a white noise process having zero mean and unit variance. The conditional variance equation is:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \, \sigma_{t-j}^2 + \sum_{k=1}^{s} \gamma_k \, ESG_{t-k}. \tag{2}$$

In this equation, the first two terms on the right - hand side are the same as those in the traditional GARCH (p, q) model. ω is a constant term $\omega > 0$ to ensure non-negative variance. α_i (ARCH terms coefficients) measure the impact of past squared errors on the current conditional variance, and β_j (GARCH terms coefficients) capture the persistence of past conditional variances.

Additionally, the VAR model is also adopted here, a multivariate time series method which it is used to analyze how multiple related economic variables influence each other. The main logic of the VAR model is to model each endogenous variable as a linear function of lagged values of all variables in the system. ESG-GARCH is widely used in financial risk management and sustainable investment research, while VAR is commonly used for macroeconomic forecasting and policy analysis. The traditional VAR(p) model is:

$$y_t = c + A_1 y_{t-1} + \cdots + A_v y_{t-v} + \varepsilon_t, \tag{3}$$

Where y_t is the endogenous variable vector, A_i are coefficient matrices, p is the lag order, and ε_t is the white noise disturbance.

In green financial derivative pricing, traditional models fail to capture non-financial risk transmission and inter-variable linkages, limiting pricing accuracy. This study adopts the ESG-

GARCH model and VAR model to fill these gaps via targeted optimizations over traditional frameworks.

The ESG-GARCH model performs better than the traditional GARCH model in green financial derivative pricing because the model solves a critical limitation: traditional GARCH model ignores non-financial ESG risks. Unlike traditional GARCH (p, q) model, which only relies on historical volatility (squared errors and past conditional variances) to estimate asset risk, the ESG-GARCH model adds past ESG data into the model's formula for calculating volatility. This addition brings two key improvements. First, the γk coefficient measures how ESG factors dynamically affect volatility. For example, if $\gamma k < 0$ means better ESG reduces asset risk. This catches a unique feature of green assets whose risk can be reduced by the ESG, and this is what the old models missed. Secondly, it calculates the volatility that is adjusted for ESG factors. This helps tell green asset's risk apart from traditional ones, so things like carbon options or green bond futures do not end up with wrong estimates of risk premiums.

The VAR model performs better than the traditional single-variable models like ARIMA, and single-variable GARCH for pricing the green financial derivatives because the model addresses their key limitation: ignoring inter-variable linkages. Unlike traditional models that only analyze a single variable (e.g., asset returns), the VAR model brings together key variables in green finance (e.g., carbon returns, ESG scores, green interest rates) into a unified framework:

$$y_t = c + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t. \tag{4}$$

For this model, it brings two critical improvements. Firstly, the model's matrices (A_i) measure how variables affect each other in both directions like carbon prices which reflects how complex the financial systems really are. Secondly, it avoids pre-assumed one-way causality. Instead, it uses data-driven tools (Impulse Response Functions, Variance Decomposition) to prevent misjudgments (e.g., overlooking carbon price-driven ESG upgrades). This helps to better support accurate derivative pricing.

4. Current Status of the Green Finance Derivatives Market

4.1. Overview of Global Market Development

4.1.1. The market size of the product and the benefits generated

The global green finance derivatives market has two main parts: Compliance Carbon Markets (CCM) and Voluntary Carbon Markets (VCM). In recent years, the compliance market has grown greatly. Public data shows that the annual trading volume and revenue have reached tens of billions of dollars. In 2023, the revenue from carbon pricing hit a new high. This shows that compliance systems play an important role in reducing global emissions [8].

In contrast, the voluntary market has changed a lot during the same period. It is now being checked for credibility, and its value is being adjusted. World Bank and industry reports say that carbon pricing revenue has kept rising, reaching nearly tens of billions of dollars in 2023. These figures show that compliance systems are still the main way to achieve emission reduction goals.

From 2022 to 2023, the value of VCM fell and people's trust in it decreased. This means the market needs structural changes to become more environmentally credible and win back trust [9].

These markets bring many benefits. First, they use market prices to make enterprises take responsibility for carbon emissions. This encourages enterprises to reduce emissions and use cleaner technologies. Second, carbon pricing brings in a lot of revenue, which can support green transition projects. Financially, these markets provide institutions with risk hedging tools and new investment opportunities—such as carbon futures, carbon options, and derivatives linked to renewable energy certificates [10]. In addition, studies show that compliance markets have helped regulated industries reduce emissions effectively.

4.1.2. Main trading markets

The EU ETS is the world's most mature and stable compliance carbon market. It has high trading volume and clear price signals. It has long been a model for other countries' emission trading systems—though it has also revised its rules many times.

China's National ETS and regional exchanges have become one of the world's largest compliance markets since their launch. From 2024 to 2025, new rules and interim management measures have made the market more standardized. Domestic trading platforms (like the Shanghai Environment and Energy Exchange) and better policy coordination have driven market activity.

In North America, California's cap-and-trade system and its linked market with Quebec are important regional models. Their measures—such as quota auctions, cross-market links, and cost control measures—can provide reference for other regions to design carbon pricing tools.

Around the world, many other national and exchange platforms (like other ETS systems, regional energy exchanges, and international platforms such as EEX and ICE) provide places for trading carbon and related derivatives. These markets differ in covered industries, compliance rules, quota allocation methods, and offset systems.

4.1.3. The main participants and roles

The key participants in carbon markets and their respective roles are diverse, and their interactions significantly influence market efficiency, price stability, and environmental protection outcomes [11]. The major participants include the following:

First, high-emission companies (regulated entities) engage directly in the buying and selling of emission quotas. Their efforts to reduce emissions and comply with regulatory requirements directly determine the supply and demand dynamics in the market, thereby influencing short-term price fluctuations in the spot market.

Second, financial institutions—such as banks, hedge funds, market makers, and exchanges—enhance market liquidity and facilitate price discovery by providing risk management instruments, including futures, options, and structured products [12]. Additionally, through derivative trading, they integrate carbon risk into their investment portfolios.

Third, governments and regulatory bodies establish emission reduction targets, allocate quotas, and implement compliance verification mechanisms. Their policy frameworks shape long-term market expectations and affect the overall supply of allowances.

Fourth, project developers and certification bodies operate primarily in voluntary markets, where they supply certified emission reductions or carbon sequestration projects. The methodologies and verification processes they employ are critical to ensuring the environmental integrity and credibility of carbon credits.

Finally, corporate buyers and end-users, including large enterprises pursuing carbon neutrality goals, constitute essential sources of demand in VCM. Their participation, alongside oversight by supervisory agencies, underpins market credibility and operational efficiency.

4.2. Case Analysis

4.2.1. Domestic cases

China's national carbon market has shown significant impact through a market-based emission reduction mechanism. Since its launch, it has expanded to more industries and improved rules. Especially those who have introduced new temporary regulatory regulations and supporting documents since 2024. These changes help improve price discovery and support energy mix adjustments and technology upgrades in high-emission industries. There is data showing that transaction volume and quota activity have been rising, which provides more data support for pricing models and risk management tools. The core experience is about allocation, early decision-making in industry coverage. Offset rules have a great impact on price formation and long-term incentives, which suggests that strict regulation and clear data disclosure are important.

However, the market also faces the risk of reputation and shifting the system. There is a risk of reducing emissions in China and other regions with loose shift standards or without independent verification. This is reflected in the debate about China's CCER system, such as whether its approach is reliable and whether the quota is compatible. These uncertainties increase the difficulty of pricing offsetting the derivative-based product-based and may reduce its effectiveness in risk hedging

4.2.2. Foreign cases

EU ETS is one of the most influential compliant carbon markets in the world. It has undergone several revisions over the past 20 years, for example, introducing the Market Stable Reserve (MSR). These adjustments help reduce emissions (especially in the industry and the power sector) and provide stable long-term price signals to guide low-carbon investments. Research and policy reports agree with this. Despite design flaws, EU ETS still helps carbon reduction become more institutionalized.

In contrast, the VCM raises more questions about the quality and environmental effectiveness of carbon credit quality. There are concerns about whether these projects actually reduce emissions, whether the effects are long-term and whether the verification is strict. In some years, this has led to a decline in market value and reduced trust. Research shows that poor credit quality can lead to overstated emission reductions, which makes derivative prices less reliable it will lower the investors' confidence. A major risk is that derivatives based on low-quality credits may increase financial and reputational risks.

Regional systems like California's cap-and-trade program have promoted fuel switching and emission reduction in the power sector. Nevertheless, they still face challenges, such as cost control, cross-market linking, and fairness. Cases from Australia and other countries also show that weak project credibility, lack of third-party verification, or inadequate regulation can damage the market's legitimacy. These experiences indicate that clear rules, independent verification, and supervision are needed for the long-term stability and credibility of carbon markets and their derivatives.

5. Suggestion

5.1. Enterprise

In order to improve the effectiveness and credibility of the green finance market, enterprises are advised to take the following actions: First, standardize ESG disclosures. Follow international frameworks such as the Climate-Related Financial Disclosure Working Group (TCFD). Disclose clear data (such as carbon intensity and green investment ratio). This can reduce information asymmetry and improve the accuracy of pricing of green financial instruments. Next, use green derivatives. Actively use tools such as carbon futures and renewable energy certificates (REC) connected products. These hedging risks due to climate policy changes and market volatility will help stabilize cash flows on low-carbon projects and make it easier for these projects to raise funds. Finally, cooperate with financial institutions, it can develop industry-specific derivatives. For example, ESG connectivity swaps for industries with high transition risks or green innovation potential (such as electric vehicle manufacturing). These products can match risk management strategies to business needs and support financial and sustainability goals.

5.2. Financial Institution

Financial institutions should consider several strategic recommendations to enhance their role in climate-related financial markets. First, pricing models require improvement. Existing frameworks, such as ESG-GARCH and VaR models, should be refined through the incorporation of high-frequency climate data and physical risk indicators. Such enhancements would allow more accurate capture of climate-related volatility and transition risks. Additionally, it is essential to develop user-friendly pricing tools tailored to small and medium-sized enterprises (SMEs), thereby reducing barriers to adopting green risk-hedging instruments.

Second, innovation in financial products is needed. Institutions should accelerate the creation of derivatives aligned with decarbonization objectives—such as green bond futures, carbon-neutral-linked swaps, and other structured products. Providing stable and reliable pricing for these instruments can improve price discovery mechanisms and stimulate activity in secondary markets. Ultimately, these developments would contribute to sustaining long-term green investment flows.

5.3. The Government

To establish a reasonable and transparent green finance derivatives market, the government is advised to implement the following three measures.

First, it should clarify regulatory frameworks. The government should establish unified standards for the verification of green assets and carbon credits—such as China's CCER—to ensure consistency and credibility. Interdepartmental coordination is essential to reduce policy ambiguity and create a coherent market structure.

Second, it can introduce fiscal and financial incentives. Tax benefits should be provided to corporations that utilize green derivatives for risk management purposes. Additionally, research subsidies could be offered to financial institutions engaged in developing innovative sustainable financial products. These incentives should first be piloted in selected regions to evaluate effectiveness, with subsequent scaling up following necessary refinements.

Third, enhancing supervisory mechanisms is very important. Dedicated regulatory bodies should be established to monitor market activities, prevent market manipulation, and mitigate risks of "greenwashing"—such as inaccurate claims regarding green certificates. The adoption of distributed ledger technology could improve transactional transparency and traceability. Furthermore, aligning domestic regulations with international standards—such as those issued by the International Organization of Securities Commissions (IOSCO)—would facilitate cross-border cooperation and strengthen the credibility of the regulatory system.

6. Conclusion

This study explores the pricing mechanisms and development paths of green finance derivatives, aiming to fill key gaps in sustainable finance. The results show that these derivatives are crucial to hedging climate risks and expanding sustainable investment. To address pricing issues, this study proposes an improved pricing framework. It uses the ESG-Garch model to capture the dynamic effects of ESG risk, which can analyze the links between green financial variables and data from the EU ETS futures, climate VARs and green indexes. This approach helps accurately assess risk premiums and reveals how environmental impacts, policy changes and ESG performance affect asset value.

This study has some limitations. It uses data from mature markets, so the model may not be fully applicable to emerging economies. It also uses composite ESG indicators and linear assumptions that cannot capture nonlinear relationships and detailed risk factors. In addition, there is no in-depth study on the role of certification bodies and public supervision in maintaining market credibility.

Future research should use high-frequency and more detailed data (e.g., hourly climate data) and nonlinear dynamic models to better understand the behavior of the green derivatives market. It should do more case studies of specific products in emerging economies. It should also expand interdisciplinary research on cross-border regulatory cooperation and market governance.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

[1] Zhu, H., Feng, T., Li, X. Green finance, green development and decarbonization of the energy consumption structure. PloS One, 2024, 19 (4): e0300579.

[2] Chen, S., Huang, F., Lin, J. Borrowing-firm emission trading, bank rate-setting behavior, and carbon-linked lending under capital regulation. Sustainability, 2022, 14 (11): 6633.

[3] Chebochok, M. C., Bayale, N. Effects of financial inclusion on tax revenue mobilization: Evidence from WAEMU countries. African Development Review, 2023, 35 (2): 226 - 238.

[4] Li, M., Wang, J. Spatial-temporal evolution and influencing factors of total factor productivity in China's logistics industry under low-carbon constraints. Environmental Science and Pollution Research International, 2022, 29 (1): 883 - 900.

[5] Cao, Y., Yan, L., Wu, B., Wei, D., Ouyang, B., Chen, P., Zhang, T., Wang, H., Huang, L. Metal cobalt dot-doped carbon structures with specific exposure surfaces for high-performance capacitive deionization. Journal of Environmental Chemical Engineering, 2024, 12 (2): 112189.

[6] Chong, T., Loh, L. Innovating ESG integration as sustainable strategy: ESG transparency and firm valuation in the palm oil sector. Sustainability, 2023, 15 (22): 15943.

[7] Feng, H., Zhang, Y., Lan, Z., Wang, K., Wang, Y., Chen, S., Feng, C. Developing China's electricity financial market: Strategic design of financial derivatives for risk management and market stability. Energies (Basel), 2024, 17 (23): 5854.

[8] Guiyuan, X., Yin, W., Wenjuan, N., Chen, C., Xiaojun, Z., Jian, T. Analysis of the impact of carbon emission trading mechanism on the electricity market under dual carbon targets. Journal of Physics. Conference Series, 2023, 2418 (1): 12073.

[9] Lee, C., Wang, C., Thinh, B. T. Green development, climate risks, and cash flow: International evidence. Pacific-Basin Finance Journal, 2023, 79: 102021.

[10] Stede, J., Pauliuk, S., Hardadi, G., Neuhoff, K. Carbon pricing of basic materials: Incentives and risks for the value chain and consumers. Ecological Economics, 2021, 189: 107168.

[11] Heider, F., Hoerova, M., Holthausen, C. Liquidity hoarding and interbank market rates: The role of counterparty risk. Journal of Financial Economics, 2015, 118 (2): 336 - 354.

[12] Skvortsova, S. V., Verkhov, F. K., Nikolaenkova, E. B., Rakhmanova, M. I., Kokina, T. E., Sukhikh, T. S., Shekhovtsov, N. A., Bushuev, M. B. Interplay of the cu cu distance and coordination geometry as a factor affecting the quantum efficiency in dimeric copper () halide complexes with derivatives of 4-pyrazolylpyrimidine-2-thiol. Dalton Transactions: An International Journal of Inorganic Chemistry, 2025, 54 (22): 9 - 915.