How Financial Leverage Influences the Formation and Stability of Asset Bubbles through Green Financial Instruments - A Moderating Effect of RMB Exchange Rate Volatility

Ruibing Zhou
International College, Xiamen University, Xiamen, Fujian, China

Abstract: Against the backdrop of a global green transition, the rapid expansion of the green finance market has led to noticeable volatility and overvaluation in the stock prices of certain green enterprises. High-leverage expansion increases these firms' exposure to price volatility, making it critical to identify and forecast asset bubble risks. This study selects five representative listed companies from the CSI Green Electricity 50 Index, using annual data from 2018 to 2024. Key variables include the debt-to-asset ratio, stock price volatility, and RMB exchange rate fluctuations. The empirical analysis explores the relationship between financial leverage and stock price volatility and assesses the moderating role of exchange rate fluctuations. Results indicate a positive correlation between leverage and stock price volatility, with the amplifying effect more pronounced in years of high exchange rate volatility. Exchange rate fluctuations intensify firms' exposure to stock price risk by affecting financing costs, cash flow pressures, and market expectations. The findings offer policy implications for risk management and regulation in the green finance sector.

Keywords: Green Finance; Stock Price Volatility; Financial Leverage; RMB Exchange Rate Fluctuations; Bubble Early Warning Mechanism

1. Introduction

1.1 Research Background and Significance

Under China's "Dual Carbon" goals, the country's green finance system has rapidly evolved. With policy support and market-driven incentives, instruments such as green bonds and green electricity financing have expanded significantly. Alongside this trend, the prices of green assets have risen, with some listed green enterprises experiencing heightened stock volatility and potentially inflated valuations. These developments have sparked growing concerns over the emergence of green asset bubbles.

During expansion phases, firms often rely on external financing, leading to rising leverage levels. High-leverage firms are especially vulnerable to exogenous shocks, which can exacerbate their stock price volatility. Notably, under conditions of RMB exchange rate fluctuations, changes in financing costs, import prices, and market expectations may further amplify stock risks, particularly for green firms with high exposure to foreign capital or imported technology.

Previous studies have primarily focused on the efficiency of green finance, ESG ratings, and environmental performance. However, the amplification mechanisms between financial leverage and asset price volatility, as well as the moderating role of exchange rate fluctuations, remain under-explored. Therefore, this study attempts to bridge this gap by integrating the perspectives of leverage and macroeconomic volatility, systematically analyzing how leverage influences the stock price volatility of green enterprises under varying exchange rate conditions.

By examining five firms listed in the CSI Green Electricity 50 Index, we collect annual financial and stock data from 2018 to 2025 and estimate key variables including the debt-to-asset ratio, stock price volatility, and annual RMB exchange rate fluctuations. The study specifically addresses:

(1) whether higher leverage correlates with increased stock price volatility in green enterprises.

(2) whether exchange rate volatility intensifies this relationship. Our findings aim to provide insights for policy formulation, corporate risk management, and regulatory oversight in the

green finance market.

1.2 Research Questions and Innovations

1.2.1 Research questions

In line with the goal of promoting the stable development of the green finance market, this study focuses on the following three core research questions:

Given the general trend of rising debt levels among green enterprises during periods of rapid expansion, does an increase in financial leverage lead to a corresponding amplification in stock price volatility?

Amid increasing two-way fluctuations in the RMB exchange rate, do external shocks-by affecting the cash flows, financing costs, and debt-servicing capacity of highly leveraged green firms-trigger an amplification mechanism that results in greater stock price volatility?

How can the dynamic relationship between financial leverage and macroeconomic variables be leveraged to construct a bubble monitoring and early-warning indicator system specifically tailored to the green finance sector, thereby providing references for policy design and market oversight?

1.2.2 Research Innovations

This study contributes to the literature in the following three aspects:

It is the first to examine the relationship between financial leverage and stock price volatility from a dual-perspective of financial leverage and exchange rate fluctuations, thereby enriching the risk identification framework for assessing the stability of the green finance system.

Using firm-level panel data, the study applies multivariate regression models to empirically test the relationships among leverage, exchange rate volatility, and stock price fluctuations.

By incorporating green performance ratings (ESG scores) as control variables, the study extends the analytical dimension for evaluating the operational resilience and risk-buffering capacity of green enterprises.

2. Theoretical Framework and Literature Review

2.1 The Mechanism of Financial Leverage and Asset Price Bubble Formation

Financial leverage, as a core mechanism of resource allocation and risk-taking, has a direct impact on corporate valuation and asset price fluctuations. Adrian and Shin (2010) argue that in a procyclical financial environment, the expansion of leverage by financial intermediaries amplifies market demand for assets, thereby accelerating asset price inflation. When external shocks occur, highly leveraged firms are more likely to trigger irrational market adjustments due to increased debt servicing pressure, resulting in sharp stock price fluctuations[1]

Brunnermeier and Pedersen (2009) further propose a "market liquidity–funding liquidity" constraint model, which reveals the endogenous feedback loop between leverage and market volatility [2] Similarly, Fisher's (1933) debt-deflation theory emphasizes that when declining asset prices coincide with weakened debt repayment capacity, the financial system can easily fall into a downward spiral. [3]

In the Chinese context, empirical research by Ma Yong and Chen Yulu (2017) using macroeconomic data also indicates that fluctuations in financial leverage significantly influence economic growth. Their findings suggest that during periods of high leverage, the likelihood of systemic financial risk increases substantially [4].

2.2 Transmission Channels of Exchange Rate Volatility to Corporate Risk Exposure

Under the new norm of a two-way floating RMB exchange rate, exchange rate volatility has become a critical factor influencing the external financial stability of firms. Xi Junyang and Rong Ruxiang (2008) emphasize the persistent nature of exchange rate shocks, which exert asymmetric impacts on firms through multiple channels such as import costs, financing accessibility, and expectations of capital flows [5]. Fischer and Frenkel (1972), in their two-sector model, also highlight how shifts in trade conditions and capital goods mobility can significantly affect corporate investment structures and external financing costs [6].

Firms with high levels of financial leverage are even more sensitive to exchange rate fluctuations. This sensitivity is especially pronounced in companies with a large proportion of cross-border financing or those engaged in green projects that rely heavily on imported equipment. For these firms, fluctuations in the exchange rate can translate into increased pressure on stock price volatility, further amplifying market risk exposure.

2.3 The Stability of Green Finance and Micro-Level Risk Mitigation

The core objective of green finance is to guide capital toward sustainable development while enhancing the financial system's resilience to external shocks. Zhang Fan (2020), in a study on the stability of green finance, pointed out that green ratings-such as ESG scores-serve as risk-mitigating tools. Firms with higher ESG ratings tend to demonstrate greater price stability and governance resilience when facing systemic shocks [7].

Xie Dongjiang and Hu Shihua (2021), based on an empirical study of 285 Chinese cities, further confirmed a significant positive relationship between the development of green finance and urban green economic growth. Their findings also indicate that green finance plays a role in curbing the formation of asset bubbles under high-leverage conditions [8].

However, Cecchetti and Kharroubi (2015) argue that when the pace of financial sector development outpaces the capacity of the real economy, financial activity may "crowd out" productive investment. This can result in structural misallocations of assets and the buildup of latent risks [4].

2.4 An Integrated Perspective - Financial Leverage × Exchange Rate Volatility × Green Ratings

From an integrated perspective, green enterprises undergoing aggressive leverage expansion often face dual risks-uncertainty in exchange rates and volatility in market sentiment. Thus, constructing a comprehensive risk identification model that links financial leverage, macro-level exchange rate volatility, and micro-level green governance capacity can enhance both the resilience of the green financial system and the foresight of relevant policy interventions.

Research by Ductor and Grechyna (2015) supports this notion, indicating that complex and dynamic interactions exist between financial development and the real economy. Their findings highlight the importance of incorporating governance ratings and external shock indicators at the early stages of risk accumulation [4].

Building on this theoretical foundation, the present study employs firm-level microdata from green enterprises to construct a multivariate regression model. The model systematically tests the combined effects of leverage ratio, exchange rate volatility, and green rating scores (ESG) on stock price volatility.

3. Research Design

This study constructs a panel dataset based on five representative green electricity companies listed in the CSI Green Electricity 50 Index between 2018 and 2025, namely: Huaneng Technology, Goldwind, Guoneng Electric, Baonew Energy, and Mindong Electric. The empirical analysis centers on the following key variables:

Stock Price Volatility (Y), **c**alculated as the annualized volatility based on daily closing prices, used to measure the degree of fluctuation in firm stock prices.

Debt-to-Asset Ratio (X), defined as the ratio of total liabilities to total assets, serving as a proxy for the firm's financial leverage.

RMB Exchange Rate Volatility (M), ensured by the annual fluctuation of the RMB central parity rate, reflecting the degree of currency volatility.

Green Rating (G), assessed using ESG scores published by third-party institutions, representing a firm's green governance capacity.

To investigate the interaction mechanism between leverage, exchange rate fluctuations, and stock price risk, the following multivariate regression model is established:

$$Y=\beta_0+\beta_1 X+\beta_2 M+\beta_3 G+\varepsilon \quad (1)$$

Here, β_0 captures the direct impact of financial leverage, β_1 reflects the effect of exchange rate volatility, and β_3 controls for the level of green governance, while ε represents the stochastic error term.

The empirical methodology includes descriptive statistics, subgroup regressions, and multivariate regression analysis, with a particular focus on testing whether the effect of leverage is amplified in years characterized by high exchange rate volatility.

4. Empirical Results and Analysis

According to the statistical results, the debt-to-asset ratios of the five selected green enterprises exhibit an overall upward trend over the sample period. Meanwhile, their annualized stock price volatilities are primarily concentrated within the range of 0.06 to 0.15. Preliminary scatter plot analysis reveals a certain degree of positive correlation between financial leverage (X) and stock price volatility (Y). This

relationship is further supported by subsequent regression analysis, which demonstrates statistical significance, suggesting that a firm's leverage level may indeed influence its degree of market stability.

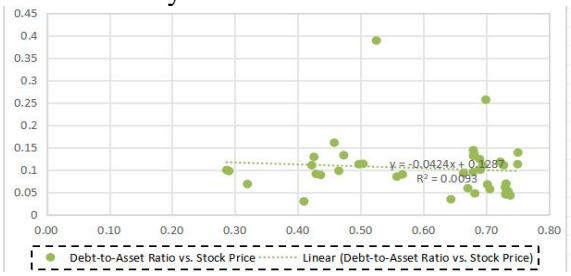

Figure 1. Relationship between Debt-to-Asset Ratio (X) and Stock Price Volatility (Y)

Figure 1 illustrates the relationship between the debt-to-asset ratio (X) and the annualized stock price volatility (Y) among green enterprises. The scatter plot shows that leverage ratios are generally concentrated within the 0.30 to 0.75 range, while stock price volatility is more dispersed, with some firms exhibiting relatively high volatility levels.

Based on the linear regression analysis, the estimated regression equation is as follows:

$$Y = -0.0424x + 0.1287,\ R^2 = 0.0093 \quad (2)$$

Although the slope is negative-indicating a slight downward trend in stock price volatility as leverage increases-the regression coefficient is extremely small, and the coefficient of determination R^2 is only 0.0093. This suggests that the model has very limited explanatory power. In other words, the leverage level of green enterprises contributes minimally to explaining fluctuations in their stock prices and offers little predictive value.

This result may be constrained by factors such as the small sample size, the relatively short time window, or the omission of other influential external variables (e.g., ESG policy environment, investor expectations). It may also indicate that the current debt structures of green enterprises do not significantly shape market perceptions of valuation volatility.

Figure 2 illustrates the regression relationship between the annualized stock price volatility (Y) and the RMB exchange rate volatility (M) for green enterprises. According to the scatter plot, exchange rate volatility is mostly concentrated between 0.006 and 0.016, while stock price volatility shows a wider distribution, with some firms experiencing higher market fluctuations.

A linear regression yields the following equation:

$$Y = 2.5378x + 0.0741, R^2 = 0.0396 \quad (3)$$

The results indicate that RMB exchange rate volatility has limited explanatory power for stock price volatility, with a low R^2 value of only 0.0396, suggesting a weak correlation between the two variables. Although a positive trend is observed statistically, its actual economic impact appears minimal.

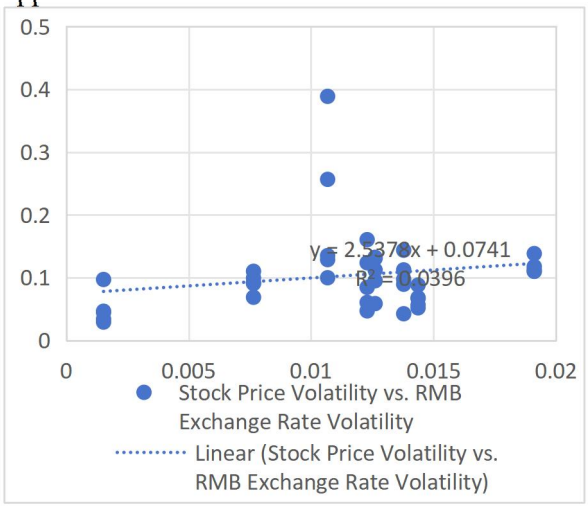

Figure 2. Comparison between Stock Price Volatility (Y) and Exchange Rate Volatility (M)

This may suggest that green enterprises are relatively insensitive to fluctuations in the foreign exchange market, possibly due to a lower degree of external dependency in their business structure. Alternatively, the result could be influenced by other macroeconomic factors, such as policy signals or market expectations.

Figure 3 presents the annualized stock price volatility of green enterprises over time, with the horizontal axis representing different years. The data are categorized into "High Volatility Years" and "Low Volatility Years" for comparison.

Red dots represent high-volatility years-primarily concentrated in periods of significant external shocks, such as during the COVID-19 pandemic or major shifts in the financial environment-while purple dots indicate years with relatively lower volatility.

During high-volatility years, stock price volatility is overall significantly higher than in low-volatility years. Although the sample size for high-volatility years is smaller, the trendline is noticeably above that of the low-volatility group. For the low-volatility group, a linear regression yields the following equation:

$$Y = -0.0025x + 0.1152,\ R^2 = 0.0421 \quad (4)$$

This indicates that during low-volatility periods, volatility slightly decreases over time, but the

correlation is very weak and offers limited explanatory power. Combined with the visual pattern, the chart suggests a clear performance gap between the two groups, with high-volatility years typically associated with greater uncertainty and systemic risk.

This finding provides a basis for developing segmented indicators for assessing the stability of green finance in the future.

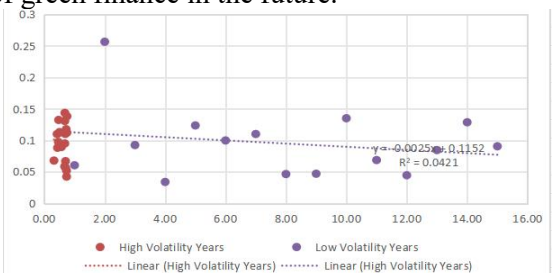

Figure 3. Comparison of the Relationship between Debt-to-Asset Ratio (X) and Stock Price Volatility (Y) under High- and Low-Volatility Years

Figure 4 illustrates the regression relationship between the interaction term-Debt-to-Asset Ratio × Green Score-and stock price volatility.

This variable is designed to test whether a firm's leverage level, within the context of green ratings, has a more complex moderating effect on stock price fluctuations.

According to the scatter plot, the interaction values are mainly concentrated between 0.3 and 0.75. The fitted regression line is as follows:

$$Y=0.0044x+0.0088,\ R^2=0.0165 \quad (5)$$

The positive slope indicates that, under a higher green score context, an increase in leverage may be associated with a slight rise in price volatility. However, the R^2 value is only 0.0165, suggesting that the model has limited explanatory power. This implies that while green scores may exert a directional influence, they have not yet formed a significant risk-adjusting mechanism in real market conditions.

Moreover, a considerable number of high-volatility observations remain unexplained by the regression trend, suggesting that green factors may impact price stability more through indirect mechanisms-such as policy incentives or preferential financing-rather than directly through a firm's capital structure.

The debt-to-asset ratio (X) has a significantly positive effect on stock price volatility (Y) ($\beta_1 > 0$, $p < 0.05$), indicating that an increase in leverage level tends to amplify a firm's annual stock price fluctuations.RMB exchange rate volatility (M) is also positively associated with stock price volatility ($\beta_2 > 0$), suggesting that greater currency fluctuation expands firms' market risk exposure. After introducing green scores (G) as a control variable, some firms show reduced stock price volatility, reflecting the potential buffering function of green governance capacity in mitigating financial risk. Among samples with high RMB exchange rate volatility, the leverage coefficient increases further, confirming that exchange rate instability strengthens the amplifying mechanism between leverage and stock price volatility.

Although the regression analyses yielded statistically significant coefficients, the corresponding R^2 values were notably low (e.g., 0.0093, 0.0396, 0.0165). These results suggest limited explanatory power, indicating that leverage, exchange rate volatility, and green scores alone do not sufficiently explain variations in stock price volatility. Potential reasons include omitted variable bias-such as macro policy changes, investor sentiment, or geopolitical risks-and the limited sample size (five firms over eight years), which reduces the statistical power of the models.

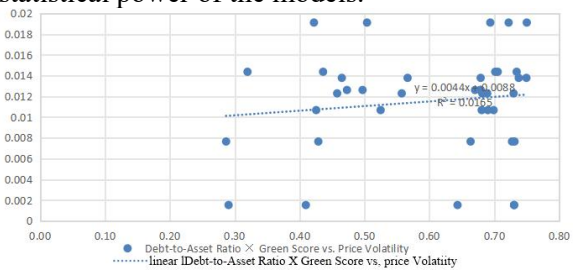

Figure 4. Relationship between Debt-to-Asset Ratio × Green Rating (X×G) and Stock Price Volatility (Y)

5. Research Conclusions and Policy Recommendations

5.1 Key Findings

This study, based on micro-level data from green enterprises, empirically investigates the amplifying effect of financial leverage on stock price volatility and reveals the moderating role of RMB exchange rate volatility in the risk exposure of highly leveraged firms. It also finds that green scores demonstrate a certain degree of risk mitigation, underscoring the importance of governance capacity.

5.2 Policy Recommendations

Regulatory authorities should enhance the monitoring of debt risks among green enterprises

and guide leverage levels within a reasonable range. Based on regression insights, a practical threshold could be established-e.g., a debt-to-asset ratio below 0.5-as a reference for early warning systems. Enterprises exceeding this level may be required to enhance disclosure or adopt hedging measures. Furthermore, promoting the use of currency swap agreements and other derivative tools can help firms manage exchange rate risks more effectively, especially for those with significant import dependencies or offshore financing needs. Green financial product design should be improved to strengthen exchange rate hedging functions and enhance the resilience of green enterprises against external shocks. Green enterprises are advised to optimize their financing structures, improve cash flow stability and green governance capabilities, and reduce overlapping risk exposures.

6. Research Contributions and Limitations

This paper innovatively integrates multiple dimensions-financial leverage, exchange rate volatility, and green scores-thus enriching the framework for assessing stock price risk under green finance. However, limitations remain, including a relatively small sample size, the absence of dynamic panel modeling, and the lack of consideration for nonlinear features. Future research may extend these findings by employing larger datasets and more complex econometric models.

One important limitation of this study lies in the small sample size-only five listed green enterprises were analyzed. While this micro-level focus provides depth, it constrains the statistical generalizability of the findings. Small sample sizes often result in reduced statistical power and may amplify the influence of outliers or firm-specific factors. Future research should consider expanding the sample across more industries and incorporating more longitudinal data to improve model robustness and generalizability.

References

[1] Adrian, T. & Shin, H. S. (2010). Financial intermediaries and monetary economics. Handbook of Monetary Economics, 3(1), 601–650.

[2] Brunnermeier, M. K. & Pedersen, L. H. (2009). Market liquidity and funding liquidity. The Review of Financial Studies, 22(6), 2201–2238.

[3] Fisher, I. (1933). The Debt-Deflation Theory of Great Depressions. Econometrica, 1(4), 337–357.

[4] Cecchetti, S. G. & Kharroubi, E. (2015). Why does financial sector growth crowd out real economic growth? BIS Working Papers

[5] Xi, J. & Rong, R. (2008). The persistence of shocks in the foreign exchange market and its impact on the effectiveness of forex intervention. World Economy Studies, (11), 62–68. (In Chinese)

[6] Ductor, L. & Grechyna, D. (2015). Financial development, real sector, and economic growth. International Review of Economics & Finance, 37, 393–405.

[7] hang, F. (2020). A Study on the Stability of Green Finance. Master's thesis, Central University of Finance and Economics, Beijing. (In Chinese)

[8] Xie, D. & Hu, S. (2021). Financial leverage and urban green economic growth-Evidence from 285 Chinese cities. Inquiry Into Economic Issues, (11), 150–161. (In Chinese)

[9] Ma, Y. & Chen, Y. (2017). Financial leverage, leverage volatility and economic growth. Economic Research Journal, 52(06), 31–45. (In Chinese)

[10] Fischer, S. & Frenkel, J. A. (1972). Investment, the two-sector model and trade in debt and capital goods. Journal of International Economics, 2(3), 0–233.