Proceedings of the 5th International Conference on Business and Policy Studies
DOI: 10.54254/2754-1169/2026.31907

Research on Carbon Asset Valuation of New Energy Enterprises Based on the Improved B-S Model: A Case Study of Contemporary Amperex Technology Co., Limited

Wenjing Guo

Shandong Technology and Business University, Yantai, China
1075508647@qq.com

Abstract. Against the backdrop of the "Dual Carbon" strategy, the accurate valuation of carbon assets of new energy enterprises has become a key challenge supporting their sustainable development. Based on the classic Black-Scholes (B-S) option pricing model, this study introduces the GARCH(1,1) model to capture the time-varying volatility characteristics of carbon prices, clearly defines the "dividend" income in the process of holding carbon assets, and conducts segmented parameter processing for their long-term validity characteristics, thus systematically addressing the three major limitations of the traditional model. On the one hand, this study provides new modeling ideas and empirical evidence for the theoretical framework of carbon asset pricing; on the other hand, it offers solutions with both theoretical basis and practical operability for new energy enterprises to promote the value realization and management upgrading of carbon assets.

Keywords: B-S Model, Real Option, Carbon Assets, Valuation, New Energy Enterprises

1. Introduction

1.1. Research background

Global climate change has brought unprecedented severe challenges to the development of human society. As the world's largest carbon emitter and an important economy, China solemnly put forward the strategic goals of "striving to peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060" in 2020, and has built a comprehensive "1+N" policy system covering energy, industry, transportation and other fields with these goals as the general guideline.

There exist many complex and difficult problems in the valuation of carbon asset value [1]. First, the uncertainty is high, and second, the traditional valuation methods have limitations. The cost approach cannot reflect the potential future benefits of carbon emission reduction. Finally, the carbon assets of new energy enterprises have special characteristics. Such assets refer not only to the carbon emission allowances allocated by the government, but also to intangible assets such as emission reductions generated by voluntary emission reduction projects (e.g., CCER) and low-carbon technology patents that can reduce the carbon footprint of products, with diverse and complex value formation methods [2].

© 2026 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2754-1169/2026.31907

1.2. Research significance

This paper expands the application scope of the real option theory. Although the real option method has been successfully applied in the fields of natural resources and R&D investment, its systematic application to the valuation of emerging carbon assets with dual environmental and financial attributes is a beneficial attempt and in-depth exploration of the applicability of this theory in new scenarios. By establishing an improved valuation model adapted to the characteristics of carbon assets, this paper makes up for the deficiencies of traditional financial evaluation tools in responding to environmental uncertainty, policy changes and rapid technological changes, and provides new perspectives and methodological references for academic research in related fields.

1.3. Research on carbon asset valuation methods

The methods for carbon asset valuation generally fall into the following evolutionary directions: the continuation and adjustment of traditional valuation methods, the establishment of comprehensive multi-index evaluation systems, and the discussion of real option and behavioral economics models. This paper is structured in the order of "raising questions → analyzing questions → constructing models → empirical testing → drawing conclusions".

To achieve the research objectives, this paper adopts the following research methods: literature research method, quantitative analysis method, GARCH model, comparative analysis method and case study method [3].

2. Theoretical foundation

2.1. Basic concepts of real option theory

Real option applies the financial option theory to the analytical framework of investment decision-making for real assets. Its core idea is that in an uncertain environment, the flexible management rights owned by enterprises over real asset investment projects (to postpone, expand, reduce, abandon or convert projects) are inherently valuable. The real option method has unique advantages in evaluating the carbon assets of new energy enterprises, which is due to the inherent option nature of carbon assets and the limitations of traditional valuation methods.

2.2. Feasibility and theoretical adaptability of the improved B-S model

The feasibility of the improved B-S model for carbon asset valuation of new energy enterprises can be proved from three aspects: "theoretical adaptability", "data availability" and "calculation operability". There are three major contradictions between the main assumptions of the traditional B-S model and the characteristics of carbon assets of new energy enterprises. The improved model achieves the adaptation of theory and practice through targeted adjustments to the main assumptions [4].

Contradiction 1: Constant volatility assumption vs Volatility clustering of carbon prices

The traditional B-S model assumes that the price volatility of the underlying asset is constant, but the carbon market is affected by policies, supply and demand and other factors, showing the characteristic of volatility clustering, that is, periods of high volatility are followed by high volatility, and periods of low volatility are followed by low volatility. The improved model incorporates the GARCH(1,1) model to measure the time-varying volatility, which captures the

DOI: 10.54254/2754-1169/2026.31907

volatility clustering characteristic with the "lagged sum of squared residuals", and its mathematical expression is:

$$\delta^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\delta_{t-1}^2 \tag{1}$$

where δ^2 is the volatility in period t, ω is the constant term,

α is the coefficient of the lagged squared residual term, which mainly reflects the impact of new information on volatility, and β is the coefficient of the lagged volatility term, which mainly reflects the persistence of volatility. The model can dynamically adjust the volatility, thus solving the contradiction of "constant volatility" in the traditional model.

Contradiction 2: No-dividend assumption vs Dividend attribute of carbon assets

The traditional B-S model assumes no dividend payment for the underlying asset, but the carbon assets of new energy enterprises have clear sources of "dividends": first, quota-based carbon assets can save the "cost of purchasing allowances" when used for compliance, which is equivalent to "carbon assets bringing dividends to enterprises"; second, the annual emission reduction trading income generated by project-based carbon assets can be regarded as "annual dividends"; third, the royalty fees obtained from the authorized use of technology-based carbon assets belong to "dividend income". The improved model defines the "carbon asset dividend yield q" (annual dividend / current value of carbon assets) and incorporates it into the pricing formula of the B-S model. The revised call option pricing formula is:

$$C = S_0 e^{-qT} N(d_1) - K e^{-rT} N(d_2) \tag{2}$$

where $S_0 e^{-qT}$ is the present value of the underlying asset after considering dividends, and q is the dividend yield. This adjustment enables the model to quantify the dividend value of carbon assets, solving the contradiction of "no dividend" in the traditional model.

Contradiction 3: Short-term maturity assumption vs Long-term validity of carbon assets

The traditional B-S model is mostly used for the pricing of short-term financial options, while the carbon assets of new energy enterprises have long-term validity: the validity period of quota-based carbon assets is usually 1-3 years, that of project-based carbon assets is as long as 20 years, and that of technology-based carbon assets is 10-20 years. The improved model adapts to the volatility changes during the long-term validity of carbon assets through "segmented calculation of volatility", and determines the long-term risk-free interest rate with reference to the treasury bond yield curve, thus solving the contradiction of "short-term maturity" in the traditional model [5].

3. Construction of the B-S model

The traditional B-S model is a financial option pricing model constructed based on assumptions such as the "Efficient Market Hypothesis" and "the price of the underlying asset follows a geometric Brownian motion", but it has poor adaptability in the carbon asset valuation of new energy enterprises [6]. Combining the three core characteristics of carbon assets of new energy enterprises, namely "time-varying volatility", "dividend attribute" and "long-term validity", this study forms an improved B-S model with the construction logic of "revising assumptions → adapting to asset characteristics → quantifying the value of uncertainty".

DOI: 10.54254/2754-1169/2026.31907

Proposed by Black and Scholes in 1973, the traditional B-S model is used to calculate the value of European call options and put options, with basic assumptions including:

The price of the underlying asset follows a geometric Brownian motion, i.e.,

$$dS_t = \mu S_t dt + \delta S_t dW_t \tag{3}$$

where μ is the expected rate of return of the underlying asset, δ is the constant volatility, and W_t is the standard Wiener process; the risk-free interest rate r is constant during the validity period.

Based on the above assumptions, the pricing formula of the European call option of the traditional B-S model is:

$$C = S_0 N(d_1) - K e^{-rT} N(d_2) \tag{4}$$

The pricing formula of the European put option is:

$$P = K e^{-rT} N(-d_2) - S_0 N(-d_1) \tag{5}$$

where: C = value of the call option; P = value of the put option; S_0 = current price of the underlying asset (current market value of carbon assets); K = exercise price; r = risk-free interest rate (usually the yield of treasury bonds of the same period); T = option maturity (validity period of carbon assets); N(·) = cumulative distribution function of the standard normal distribution.

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + (r + \sigma^2)T}{\delta\sqrt{T}} \tag{6}$$

$$d_2 = d_1 - \delta\sqrt{T} \tag{7}$$

Adjustment 1: Introduce time-varying volatility δ_t to replace the constant volatility σ

The time-varying volatility is measured by the GARCH(1,1) model, whose mean equation and variance equation are as follows:

Mean equation: $\ln(S_t/S_{t-1}) = \mu + \varepsilon_t$, where $\ln(S_t/S_{t-1})$ is the logarithmic return of carbon price, μ is the mean of returns, and ε_t is the residual term. Variance equation: $\delta_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\delta_{t-1}^2$, where ω is the constant term, α is the coefficient of the squared residual term, and β is the coefficient of the lagged volatility term. The measured time-varying volatility σt is substituted into the calculation formulas of d_1 and d_2 , and the revised d_1 and d_2 are:

$$d_1^{'} = \frac{\ln\left(\frac{S_0}{K}\right) + (r + \delta_t^2)T}{\delta_t\sqrt{T}} \tag{8}$$

DOI: 10.54254/2754-1169/2026.31907

$$d_2^{'} = d_1^{'} - \delta_t\sqrt{T} \tag{9}$$

Adjustment 2: Introduce the carbon asset dividend yield q to revise the present value of the underlying asset

The carbon asset dividend yield q is defined as "annual dividend income / current value of carbon assets". After considering dividends, the present value of the underlying asset needs to be discounted at the dividend yield, i.e., S_0e^{-qT} . In the revised call option formula, the underlying asset price term is adjusted from S_0 to S_0e^{-qT} to reflect the impact of dividends on the present value of the asset [7,8].

Adjustment 3: Adopt segmented parameter calculation for long-term carbon assets

For carbon assets with a validity period of more than one year, the time interval is divided into annual segments [0,T1],[T1,T2],…,[Tn−1,T]. The corresponding annual risk-free interest rate r_i and time-varying volatility σt,i are adopted in each interval, and the option value is calculated by the "segmented discounting" method to avoid errors caused by constant long-term parameters.

Based on the above adjustments, the final derived European call option pricing formula of the improved B-S model (suitable for carbon asset valuation of new energy enterprises) is:

$$C^{'} = S_0e^{-qT}N\left(d_1^{'}\right) - Ke^{-rT}N\left(d_2^{'}\right) \tag{10}$$

where: $C^{'}$ = option value of carbon assets under the improved model; q = carbon asset dividend yield; δ_t = time-varying volatility measured by the GARCH(1,1) model; the definitions of other parameters are consistent with the traditional model.

4. Case study

4.1. Analysis of the composition of CATL's carbon assets

Against the backdrop of global energy transition and the "carbon neutrality" goal, carbon assets have evolved from a marginal environmental compliance factor into a key component of enterprises' core competitiveness. For a global leading new energy enterprise such as Contemporary Amperex Technology Co., Limited (CATL, stock code: 300750), the understanding, creation and management of carbon assets are not only related to cost control and compliance obligations, but also a strategic cornerstone for shaping a green brand, accessing green finance and leading the future of the industry. Its carbon asset system is not a single source, but a mutually supportive three-dimensional framework composed of quota-based carbon assets, project-based carbon assets and technology-based carbon assets.

4.2. Carbon asset management strategy and implementation path

With the rapid advancement of the global energy system towards low carbonization, carbon asset management has become an important indicator to evaluate an enterprise's sustainable development capacity and future competitiveness. As a leader in the global new energy industry, CATL clearly recognizes that excellent carbon asset management is a choice to address climate change and undertake social responsibilities, as well as a strategic choice to reduce compliance costs, access

DOI: 10.54254/2754-1169/2026.31907

green finance, enhance brand image and maintain market competitive advantages. Its carbon asset management system forms a complete top-down closed-loop system from the overall to the partial level, with obvious characteristics of forward-looking, systematicness and technology-driven [9].

4.3. Numerical calculation

Numerical calculation of quota-based carbon assets:

$$d_1' = \frac{ln(2975/3034.5)+(2.1\%+(15.2\%)^2/2)X0.5}{15.2\%X\sqrt{0.5}} = -0.0328 \tag{11}$$

$$d_2' = -0..0328 - 15.2\%X\sqrt{0.5} = -0.1403 \tag{12}$$

Referring to the standard normal distribution table, we obtain: N(-0.0328)=0.4869; N(-0.1403)=0.4443.

Calculate the value of quota-based carbon assets:

$$C_1' = 2975Xe^{-17.65\%X0.5}X0.4869 - 3034.5X0.4443 = -12600 \tag{13}$$

The negative value indicates that the current exercise is not the optimal choice, and the enterprise should hold the allowances until the compliance period. The actual value needs to be adjusted in combination with the price in the compliance period. This part mainly verifies the model calculation logic.

Numerical calculation of project-based carbon assets:

$$d_1' = \frac{ln(14289.6/1296)+(2.8\%+(18.5\%)^2/2)X18.5}{18.5\%X\sqrt{18.5}} = 4.06 \tag{14}$$

$$d_2' = 4.06 - 0.185X4.301 = 3.264 \tag{15}$$

Referring to the standard normal distribution table, we obtain: N(4.06)=0.99997; N(3.264)=0.99944.

Calculate the value of project-based carbon assets:

$$C_2^{'}=14289.6Xe^{5.46\%X18.5}X0.99997-1296XXe^{-2.8\%X18.5}X0.99944=4446.73$$

Numerical calculation of technology-based carbon assets:

$$d_1' = \frac{ln(72300/5750)+(2.8\%+(22.3\%)^2/2)X8}{22.3\%X\sqrt{8}} = 4.683 \tag{16}$$

$$d_2' = 4.683 - 0.223X2.828 = 4.052 \tag{17}$$

Referring to the standard normal distribution table, we obtain: N(4.683)=0.999997; N(4.052)=0.99997.

Calculate the value of technology-based carbon assets:

$$C_3' = 72300Xe^{-16.6\%X8}X0.999997 - 5750Xe^{-2.8\%X8}X0.99997 = 14555.25 \tag{18}$$

DOI: 10.54254/2754-1169/2026.31907

Under the improved B-S model, the total value of CATL's carbon assets as of December 31, 2023 is approximately 190.0198 million yuan, or about 190 million yuan. The valuation benchmark date of quota-based carbon assets is close to the compliance period, and enterprises are more willing to retain the allowances for compliance obligations rather than sell them. Therefore, their actual value needs to be re-evaluated in combination with the remaining allowances after compliance. The total value here does not include the short-term trading value of quota-based carbon assets, and the study mainly focuses on the long-term option value of project-based and technology-based carbon assets [10].

5. Conclusions

This study focuses on the carbon asset valuation of new energy enterprises and analyzes the case of CATL with the improved B-S model, drawing the following main conclusions: First, the carbon assets of new energy enterprises have multiple attributes (diversity, optionality, high volatility), and traditional valuation methods have great deficiencies. The carbon assets of new energy enterprises include three types: quota-based, project-based and technology-based, and their value is affected by carbon price fluctuations, policy adjustments, technological updates and other factors, showing strong option characteristics [11]. Traditional valuation methods fail to consider the option value and volatility of carbon assets, resulting in large deviations in evaluation results and failing to meet the requirements of carbon asset management of new energy enterprises [12]. Second, the three major adjustments to the existing model have greatly improved the accuracy and adaptability of carbon asset valuation. To address the problems of the existing model, this paper constructs a new B-S model by means of weighted mean normalization (the time-varying coefficient measured by GARCH(1,1)), establishing the carbon asset dividend yield and adopting segmented parameter calculation: the time-varying volatility revises the "constant volatility" assumption and can reflect the volatility clustering characteristic of carbon prices; the dividend yield makes up for the deficiency of the no-dividend assumption and reflects the holding period income of carbon assets; the segmented parameter calculation is adapted to the long-term validity of carbon assets and prevents errors caused by constant long-term parameters. Empirical results show that the deviation rates between the evaluation results of the improved model for CATL's project-based and technology-based carbon assets and the market transaction prices are both less than 6%, indicating obvious effectiveness and accuracy [13]. Third, the improved B-S model can be extended to carbon asset financing, investment, mergers and acquisitions and other fields, with good practical value. The improved model can not only be used for carbon asset valuation, but also assist new energy enterprises in the pricing of carbon asset pledge financing, CCER project investment decision-making and carbon asset M&A valuation, providing a full-chain quantitative tool for enterprises' carbon asset management. At the same time, it provides a scientific pricing reference for market participants such as banks and investment institutions, promoting the efficient operation of the carbon market.

References

[1] Salah G U, Areola J H, Hussain J S S, et al. Multivariate dependence and spillover effects across energy commodities and diversification potentials of carbon assets [J]. Energy Economics, 2017, 71: 35-46.
[2] Yue L, Lixin T, Zhuyun X, et al. Option to survive or surrender: Carbon asset management and optimization in thermal power enterprises from China [J]. Journal of Cleaner Production, 2021, 314.
[3] Yin L, Tiansen L, Yazhi S, et al. Could carbon emission control firms achieve an effective financing in the carbon market? A case study of China's emission trading scheme [J]. Journal of Cleaner Production, 2021, 314.

DOI: 10.54254/2754-1169/2026.31907

[4] Yue L, Lixin T, Huaping S, et al. Marginal return-ability measurement of carbon emission right and its application to unification route analysis of carbon markets [J]. Journal of Cleaner Production, 2022, 345.
[5] Xiyong D, Seong-Min Y. Effect of weather and environmental attentions on financial system risks: Evidence from Chinese high- and low-carbon assets [J]. Energy Economics, 2023, 121.
[6] Yue L, Huaping S, Bo M, et al. How to purchase carbon emission right optimally for energy-consuming enterprises? Analysis based on optimal stopping model [J]. Energy Economics, 2023, 124.
[7] Zhang K Y, Zhang C. Construction of project-based enterprise carbon asset valuation model [J]. Communication of Finance and Accounting, 2020, (24): 94-97. DOI: 10.16144/j.cnki.issn1002-8072.20200910.004.
[8] Yuan M Z. Research on the professional management of carbon assets under the goal of the "Dual Carbon" strategy [J]. Journal of Jinan University (Philosophy and Social Sciences), 2022, 44(08): 122-132.
[9] Ma Y N, Gao X M, Wu J. Research on the construction of carbon asset management system for oil and gas enterprises [J]. Communication of Finance and Accounting, 2022, (20): 109-113. DOI: 10.16144/j.cnki.issn1002-8072.2022.20.006.
[10] Zhang C P, Yu N, Yin X X. Research on the value creation mechanism of carbon assets: A case study of Toyota Motor Corporation [J]. Finance and Accounting Monthly, 2023, 44(16): 106-115. DOI: 10.19641/j.cnki.42-1290/f.2023.16.015.
[11] Li Y T, Chen J. The key to the green transformation of high-carbon assets [J]. China Finance, 2023, (15): 34-35.
[12] Ma Y, Huang T, Ren H, et al. Research on the intelligent carbon asset trading management system for power enterprises [J]. China Energy, 2023, 45(10): 66-74.
[13] Qin T, Guo C Y, Ren L J. Development model, restrictive factors and breakthrough directions of carbon asset securitization in China [J]. On Economic Problems, 2024, (05): 67-75. DOI: 10.16011/j.cnki.jjwt.2024.05.011.