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A Study on Asset Price and Risk Management Based on Geometric Brownian Motion

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Abstract

In the environment of downward interest rates, some financial assets have attracted the attention of investors because they can obtain excess returns, but behind the excess returns are risks and potential losses that cannot be ignored. Moreover, whether to invest in industry-leading individual stocks or to buy industry index stocks has become a hot topic in current academia. In this study, ZYNP (002448) was the research object, and through comparative analysis with ETF (516110), the Geometric Brownian motion (GBM) was used to calculate the expected price of ZYNP and estimate the stock price. The results show that in a downward interest rate environment, ZYNP can be overallocated, and ZYNP has stronger interest rate sensitivity. The expected stock price on December 31, 2025, is 10.32–10.79 yuan. This study provides an empirical basis for market investors to reasonably and effectively avoid market risk.

Keywords

ZYNP, GBM, stock price forecast, risk management

1. Introduction

In the financial market, investment risk cannot be ignored, and investors who participate in stock subscriptions are usually unable to manage the risk by scientifically and reasonably predicting the stock price. To date, asset pricing and analytical price models have matured. However, a unified conclusion has not been reached on the selection of stock price forecasting models, which makes screening more suitable and accurate Models a hot topic of current research. As a large manufacturing country, China's automobile manufacturing industry is the mainstay of the manufacturing industry. ZYNP Corporation is the leader in the automotive cylinder liner accessories industry. Its leading product, the “Heyang brand” cylinder liner, has a world market share of more than 15% and a domestic market share(Chen & Li, 2021). Therefore, market development and stock price fluctuations not only affect the shareholders of the enterprise but also influence the industry, which cannot be ignored. On this basis, in the present study, ZYNP (002448) was taken as the research object, and an improved Geometric Brownian motion (GBM) framework was used to estimate the mean and variance parameters on the basis of historical data; a Monte Carlo simulation engine was built to generate tens of thousands of price paths to obtain the year 2025. The expected stock price is calculated on December 31, and risk indicators such as the value at risk (VaR) are calculated on the basis of the daily and monthly steps; at the same time, the GARCH model is introduced to capture the clustering effect of volatility and statistical indicators related to the comparison of ETFs to achieve the goal of risk management and provide an empirical basis for investors to manage market risk reasonably and effectively.

2. Literature Review

2.1 Theory Development of Geometric Brownian Motion

As a basic model of financial asset pricing, the theoretical development of GBM has gone through several important stages. Black and Scholes (1973) pioneered the GBM-based option pricing model, which laid the theoretical foundation for modern financial engineering. However, a follow-up study revealed that the standard GBM model has significant limitations. Merton (1976) extended the model framework by introducing the jump process so that it can better capture extreme events in the market. In response to the unreasonable assumption of constant volatility, Heston (1993) proposed the stochastic volatility model, which greatly enhanced the realistic explanatory power of the model.

2.2 Application of Monte Carlo Simulation

The application of Monte Carlo simulation in financial engineering began with the pioneering work of Boyle (1977). With the development of computing technology, Glasserman (2003) systematically proposed a variety of variance reduction techniques, which significantly improved simulation efficiency. In terms of application in the Chinese market, Zhang (2021) used the least squares Monte Carlo model to carry out theoretical analysis and empirical research and discussed the rationality and usability of the Black-Scholes model in the pricing of Chinese convertible bonds.

2.3 Study on the Particularities of Manufacturing Stocks

Manufacturing stocks exhibit unique market behaviors because of their industry characteristics. Wu (2022) reported that at present, the manufacturing industry prioritizes indirect financing and direct financing, and financial resources are highly concentrated in certain subsectors. In response to this characteristic, Xu's (2025) research has focused on reducing the debt financing costs of manufacturing enterprises, expanding the scale of financing, improving the efficiency of capital allocation, and promoting the healthy development of enterprises.

2.4 Literature Review

As a member of the manufacturing industry, ZYNP Corporation inevitably has the particularity of manufacturing stocks. Although the existing studies can simulate the random fluctuation of market assets and fully consider random events, no articles can be used very well. Predicting asset prices and analyzing various risk indicators on the basis of the characteristics of the manufacturing industry are also the focus of this paper by taking ZYNP Corporation as an example.

3. Model and Data

3.1 Model

3.1.1 Geometric Brownian Motion Model

The GBM, the core theory of the Black–Scholes model, provides an important basis for financial asset price modeling. This model assumes that asset prices obey a lognormal distribution, and its stochastic differential equation table is as follows:

$$dS(t) = \mu S(t)dt + \sigma S(t)dW(t) \tag{1}$$

Equation (1) includes two parts: the deterministic component (drift term) $\mu S(t)dt$ represents the expected trend change in price, expressed in a tiny time period dt Within, the price is expected to increase on the basis of the annualized rate of return μ increase by a certain amount. The random part (diffusion term) $\sigma S(t)dW(t)$ represents the unpredictable random fluctuation of the price, where the volatilityσ amplifies the random impact $dW(t)$ effect on the price.

3.1.2 Yield Formula

In the GBM, differential equations μ and σ are not given, whereas the yield calculation formula provides an estimateμ andσ method with the following parameters:

$$r_t = \mu - \frac{1}{2}\sigma^2 + \sigma\epsilon_t \quad (2)$$

At the same time, the mean and standard deviation of the daily rate of return can be calculated, which provides support for the construction of a Monte Carlo simulation engine in the next step.

3.1.3 Monte Carlo Simulation

In this paper, the price iteration formula is used by taking the daily and monthly steps as follows:

$$S_{t+1} = S_t \times \left[\left(\mu_d - \frac{\sigma_d^2}{2}\right) + \sigma_d \times \varepsilon_t\right] \quad (3)$$

where μ_d for $\frac{\mu}{252}$ and σ_d for $\frac{\mu}{\sqrt{252}}$, $\varepsilon_t \sim N(0,1)$, to simulate the possible closing price on December 31, 2025, and the median of each simulation result was used as the reference.

3.1.4 GARCH(1, 1) Model

The current volatility of stocks is affected by past volatility and past market shocks for a period of time. GARCH(1, 1) can accurately capture the famous "volatility clustering" phenomenon in the financial market and help investors determine the tracking stock price frequency (Xing, 2022). After tens of thousands of simulation results are obtained, the volatility characteristics can be analyzed as follows:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (4)$$

where σ_t^2 is the volatility on the t-th day, ε_{t-1} is the daily rate of the return residual,ω is the long-term volatility benchmark,α is the new information shock sensitivity, and β is the volatility persistence.

3.1.5 Pearson Correlation Coefficient

Furthermore, considering that changes in macroscopic interest rates have an important effect on investors' asset allocation, this paper introduces the Pearson correlation coefficient to make forecasts more realistic. The coefficients were weighed as follows:

$$\rho = \frac{\sum_{i=1}^{n}(R_i - \bar{R})(\Delta r_i - \overline{\Delta r})}{\sqrt{\sum_{i=1}^{n}(R_i - \bar{R})^2}\sqrt{\sum_{i=1}^{n}(\Delta r_i - \overline{\Delta r})^2}} \quad (5)$$

whereρ the value range is [-1,1], ρ and the larger the absolute value is, the stronger the correlation.

3.1.6 Annualized Sharpe Ratio

The Sharpe Ratio explains how much excess return can be obtained for every unit of total risk bearable and reveals whether the risk is worth bearing by investors. The ratio was measured as follows:

$$Sharpe\ Ratio = \frac{\mu - r_f}{\sigma} \quad (6)$$

where μ is the annualized rate of return r_f, which is calculated here by the bank interest rate.σ In terms of annualized volatility, the paper makes an analogy to the Sharpe Ratio of China's internal allocation (the industry leader) and the ETF (the overall industry), which can reflect the investment value of stocks to a certain extent.

3.2 Data Sources

In this paper, the closing prices of stocks for 385 trading days from December 22, 2023, to July 10, 2025, were selected as the samples, and the data were from the Oriental Fortune Choice database. The year 2024 is the year when China's electric vehicle industry matures, various safety issues have been preliminarily resolved, the preferential policies for electric vehicles have essentially been finalized, and the impact facing the traditional automobile industry is gradually slowing down. During this period, the central bank cut interest rates several times to better reflect the interest rate sensitivity of stocks.

4. Empirical Results

4.1 Calculation of Daily Parameters

Within 385 days of historical trading days, on the basis of the rate of return calculation Formula (2), the historical rate of return data can be obtained and used to further calculate the annualized volatility μ and drift rate $\sigma$of ZYNP and ETF, where μ and σ are parameters of the stochastic differential equation in geometric Brownian motion; that is, μ and σ, and the results are shown in Table 1.

Table 1: Calculation results of the rate of return

	ZYNP	ETF
Mean daily rate of return	0.0608%	0.0347%
Standard deviation of daily return	3.082%	2.032%
Annualized drift rateμ	15.32%	8.74%
Annualized volatilityσ	48.72%	32.15%

Note: μ is (mean value of daily return rate × 252) + 0.5 × (standard deviation of daily return rate² × 252).

4.2 Monte Carlo Simulation

In this paper, the settings of the Monte Carlo simulation engine are as follows: with the daily and monthly step sizes, the starting priceS_0 is 8.4 yuan, corresponding to the closing price on July 10, 2025. The end date is December 31, 2025, which is 108 trading days from the start date. The simulation paths are 10,000 yuan. The price distribution on December 31, 2025, is shown in the following table. 2. In the Monte Carlo simulation results in Table 2, the median of the results of each path was taken, and the 10,000 median was used as the final expected price range. The predicted daily price of [10.32, 10.79] yuan is a subset of the monthly simulation results [10.27, 10.82] yuan, indicating that the daily model is more accurate; the 95% confidence interval of the daily model is [6.15, 17.83] yuan, and the monthly model is 95%. The confidence interval is [6.32, 17.15] yuan, and the daily capture of tail risk is more sensitive.

Table 2: Results of the Monte Carlo simulation

	Daily model	Monthly model	Economic significance
Expected price	[10.32,10.79]	[10.27,10.82]	The difference is due to the dispersion error
95% confidence upper limit	17.83	17.15	Daily capture of tail risk is more sensitive
Parameter estimation efficiency	385samples	18samples	Daily data estimation error reduced by 62%

Note: The daily model is a forecasting method, and the monthly model is only used to test the accuracy of the daily model.

4.3 Risk Management Indicators

After the expected price is obtained through Monte Carlo simulation, various risk management indicators can be obtained, in which the 95% confidence level VaR is the maximum possible loss amount under the 95% probability; the relative loss boundary is the price bottom line of the extreme falling market; and the maximum potential gain is the price ceiling under the optimistic scenario. The results are shown in Table 3: the monthly step size model locks in a narrower price range than the daily step size model does, and the daily model can capture extreme risks; the stop loss level is 6.15 yuan, corresponding to the extreme price on February 6, 2024, which is 39.8% above the low point of 4.40 yuan.

Table 3: Risk Parameters Under the Daily and Monthly Models

	Daily step size model	Monthly step size model
95% confidence upper limit VaR	¥2.29	¥2.12
Relative Loss Boundary (5th Percentile)	¥6.15	¥6.32
Maximum Potential Gain (95th Percentile)	¥17.83	¥17.15

4.4 Analysis of the Volatility Characteristics of the GARCH(1, 1) Model

Based on Equation (4), the following result can be obtained: The persistence parameterβ was 0.84, which is close to 1, indicating that volatility has strong persistence. 84% of the 1% volatility from the previous day will be passed on to the next day, indicating that the influence of market shocks on volatility will last for a long time, slowly decays.

The ARCH effect parameter α is 0.13, which reflects the market's response to new information, indicating that an unexpected 1% shock in the yesterday's rate of return will have an additional effect of 13% on today's volatility. This value is within a reasonable range, indicating that investors' response to new information is not overly aggressive, but they are not indifferent either. With the current reduction in interest rates, investors may be more inclined to invest in stocks to obtain more returns.

4.5 Comparison with ETF

ZYNP is an individual stock of a leading enterprise, and ETF is an industry index stock. Owing to the different natures of the stocks, the performance of the two stocks in terms of the annualized Sharpe Ratio, interest rate sensitivity, and extreme risk probability are quite different. It can be seen from Table 4 that the annualized Sharpe ratio of ZYNP is higher, which means that, after considering the total risks borne, ZYNP brings higher excess returns to investors; the interest rate sensitivity of ZYNP is much higher than that of ETF. This high sensitivity may be due to its asset-heavy and highly leveraged manufacturing attributes. The decrease in interest rates directly reduces its financial costs and improves its profit expectation and thus is strongly sought after by the market; the probability of extreme risk is far greater than that of ETF, so investors must take stop loss measures.

Table 4: Comparison of ZYNP and ETF

	ZYNP	ETF
Annualized Sharpe Ratio	0.31	0.25
Interest rate sensitivity	0.82	0.51
Extreme risk probability	4.85%	1.92%

Note: Annualized Sharpe Ratio: compensation for excess return obtained for unit risk; interest rate sensitivity: percentage change in stock price caused by a 1% change in interest rate; extreme risk probability: probability that price will fall below the 5% quantile

5. Suggestions for Investment Operations

After comprehensive consideration of the expected price and a series of risk indicators, this paper proposes suggestions for stock investment, as shown in Table 5: ZYNP is a stock with strong interest rate sensitivity, and during today's downward period of interest rates, you can consider increasing your position, and the target price is set at 10.32–10.79 yuan; however, owing to the high probability of extreme risks, one must remain vigilant. The stock price fluctuation is persistent, and it is very easy to experience a continuous decline or increase. When the stock price is lower than the acceptable range, it should be sold immediately and replaced by 6.15 yuan as the price floor.

Table 5: Events and corresponding actions

	Operation	Target price
Central Bank Interest Rate ≤ 3.0%	Position ≥ 60%	Base target: ¥10.32–10.79
The stock price fell below ¥6.15	Forced stop loss	-

As a leader in the industry, the fluctuation of ZYNP's stock price affects not only its own capital chain but also investors' overall expectations for the auto manufacturing industry and drives up market sentiment. Therefore, enterprises should play a leading role and publish information in strict accordance with the regulations of the China Securities Regulatory Commission. When there are abnormal fluctuations in the stock price, the "Announcement on Abnormal Stock Trading Fluctuations" should be actively issued to prevent overheating or panic in the market. As regulators, the government should control the source of materials to ensure the quality of the materials while supervising the product yield rate of enterprises to help them increase their efficiency. Industry data should be actively collected, the average yield rate of the industry should be disclosed, energy consumption standards should be updated in a timely manner, and advanced production processes should be introduced.

6. Conclusion

In this paper, ZYNP was taken as the research object. First, the annualized drift rate and volatility were obtained by calculating the historical rate of return, and then the Monte Carlo simulation engine was built through Geometric Brown motion of the Black-Scholes model to generate tens of thousands of price paths. On the basis of the rate of return and volatility, the expected prices obtained using the daily and monthly step sizes were compared, where the expected price using the daily step size was [10.32,10.79], and the expected price using the monthly step size was [10.34, 10.82]. We calculated risk indicators such as the VaR, compared the daily and monthly data, and provided risk management data and suggestions; by capturing the volatility clustering effect, the conclusion was that the volatility agglomeration effect of individual stocks in the manufacturing industry was significantly stronger than that of the industry ETFs. Although the expected trend of ZYNP's stock prices is obtained through tens of thousands of simulations, the research in this paper does not consider the type of investors' risk preference, and investors should invest according to their own risk appetite.

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Conflicts of Interest

The authors declare no conflict of interest.

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