

Feasible Strategy Analysis of BYD's Portfolio Optimization Based on Markowitz Model under the "Dual Carbon" Goal

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Abstract: Since the world's resources are running out due to global economic integration, low-carbon environmental protection and sustainable development are now the main forces behind global development and the unavoidable energy transformation process. China has publicly announced its "double carbon" strategic goals in the international community and has released macro measures to aid the growth of new energy enterprises. Against this background, BYD, as a benchmark in China's new energy vehicle industry, developing an investment strategy that minimizes investment risk is essential. This paper starts by constructing the listed company stocks suitable for BYD, and from the perspective of quantitative investment, establish the model and build the efficient frontier of the investment portfolio based on the Markowitz model, and obtain the minimum risk portfolio and the maximum Sharpe ratio combination to provide feasible and scientific quantitative investment advice for BYD. The company is still in its early stages of development. In terms of risk distribution, quantitative portfolio investment is just as sustainable as new energy and offers BYD a steady, systematic, and strategic profit model for the company's long-term growth.

Keywords: Feasible Strategy Analysis, BYD's Portfolio Optimization, Markowitz Model, Dual Carbon

1. Introduction

1.1. Research Background

At the general discussion of the 7th United Nations General Assembly on May 22, 2020, Chinese President Xi Jinping declared, "China will increase its nationally determined contributions and adopt more forceful policies and measures to reach carbon dioxide peaking by 2030, endeavor to achieve carbon neutral by 2060." The strategic objectives of "carbon peaking" and "carbon neutrality" indicate that, as a global power, China will preserve the promise of reducing carbon emissions and make a contribution to protecting the global environment, in addition to being the inevitable outcome of the ongoing reduction of primary energy sources like coal, oil, and natural gas. Regarding global environmental responsibility and commitment, the Chinese government has proposed a "double carbon" target and established a number of regulations that encourage the development of alternative energy sources industry. The "14th Five-Year Plan for the Development of Circular Economy" was released by the National Development and Reform Commission, which offers guidelines for the growth of the circular economy in China during the "14th Five-Year Plan" period and plays a key

role in expediting the green transformation and achieving efficient resource utilization and recycling in China's development, making a significant impact on carbon peaking and carbon neutrality [1].

New energy automobiles fully recommend the "double carbon" target, an efficient way to cut greenhouse gas emissions. Between 2012 and 2020, Liu compared the carbon dioxide emissions of traditional fuel vehicles, hybrid vehicles, and pure electric vehicles, and he discovered that, regardless of the year, traditional fuel vehicles had the highest emissions of all the vehicle types, he predicted that, as China's energy structure changes and updates in generations and the efficiency of primary energy converted into electrical energy improves, "zero emission" new energy vehicles will become more and more common [2].

As one of the pioneers of the global new energy vehicle company, BYD started researching and producing battery layouts in its early years when it was founded in 1995, then acquired car factories to enter the automobile manufacturing industry. It insists that energy conservation and pollution reduction are unavoidable global development trends, and it has finally mastered the new energy vehicle industry chain. In the past, BYD expanded rapidly and seized a significant portion of the market; BYD will have taken over 23.5% of China's market share for new energy vehicles by 2022. However, the market is becoming more competitive, and the development of new energy vehicles has progressively reached saturation in recent years; competition from a large number of emerging electric vehicle companies, such as Xiaopeng, Weilai has led to a more segmented market in the new energy vehicle sector. At the same time, the "price war" caused by those new Internet companies in the new energy automobile industry is also challenging BYD's industry-leading position. In addition, The United States signed the "The CHIPS and Science Act" to further suppress the development of China's semiconductor industry in advanced fields. As the brain of new energy smart cars, chips are responsible for processing large amounts of data and running on-board software. The technological regression of chips will inevitably affect the advent of technologies such as autonomous driving. In the short term, this restriction will immediately impact BYD's future planning and development of smart cars.

1.2. Literature Review

In recent years, large and small Chinese banks have been lowering interest rates in response to the Western "trade war" that has impeded China's economic growth and caused it to slow down. As a result, the fixed-income risk-free interest rate has basically dropped below 3% [3]. This may have prompted a change in the public's willingness to invest. China enacts numerous policies that benefit the development of new energy companies and has even derived concepts such as "green finance" and "zero-carbon finance" with good expectations. This will increase public confidence in the stock market for new energy companies. However, listed new energy companies have limited research and development funds. Features such as high investment, a protracted net profit recovery period, and high risk of investment projects have deterred some market investors. Therefore, a crucial step for new energy companies to achieve better outcomes is learning how to maintain an adequate and consistent cash flow and keep the company's debt ratio from getting too high, which increases the danger of bankruptcy. With the improvement of China's financial market system and supervision, investment has emerged as one of the major revenue streams for enterprises. Nevertheless, the financial product information on the market is widely different, and the risks are high, which could prevent new energy companies from gaining from anticipated financial investment or even have a negative impact that leads to the lack of operating funds for enterprises. Consequently, matching asset investments and selecting portfolio investments that are suitable for the risks that the company can bear are important methods to enhance the competitiveness of enterprises.

1.3. Research Gap

According to Guo's analysis, government policy support is a more critical factor than BYD's own excellent new energy vehicle battery production technology and cost management regarding the company's advantages for rapid development [4]. Song, Lu, and Zhu analyzed Under the "dual carbon" national strategy, investment in new energy companies in upstream and downstream industries has ushered in a golden period; the returns of portfolio investment strategies for new energy-listed companies formulated using quantitative models are higher than those of the CSI 300 Index in the same period. On the other hand, it is also proposed that the internal management of listed new energy companies has numerous challenges and a limited development period [5]. Wang found that BYD's equity investment has numerous issues. BYD started making long-term equity investments in 2018 and reached 16.6 billion yuan by 2021; nonetheless, the return on investment is poor, the average annual rate of return is less than 10%, and the investment structure is irrational, majority of investments are accumulated in fields with established benefits of BYD, such as batteries and chips after global car ownership gradually becomes saturated, this action was unable to diversify risks efficiently to increase earnings and accomplish effective investment hedging, in addition, BYD has an insufficient financing channel, the company's obligations have grown significantly as a result of massive bond financing, which has left the capital chain with an inadequate supply and even disrupted business operations [6]. In summary, BYD, as a leading new energy company, lacks effective risk hedging in value investing and has not established an investment strategy that fits its own risk tolerance. The substantial amount of equity BYD invested has not resulted in the company's anticipated profits.

1.4. Research Framework

This article is based on the Markowitz model, selecting value stocks that are hedging risks with BYD company, and provides a modeling and analysis method approach based on listed companies' financial statements for effectively diversified portfolio investment ratios, which are used to determine the efficient frontier, the minimum risk portfolio, max Sharpe portfolio of the investment portfolio.

2. Analysis on the Problem

This part will analyze the feasibility analysis and construction of the Markowitz Model of BYD's portfolio investment.

2.1. Risk Tolerance

Yang, He, and Wang underlined that BYD has had low profits and revenue from its core business since 2014, that its debt ratio is higher than that of comparable companies, and its daily operating activities are greatly affected by the liquidity chain [7]. In contrast to established traditional businesses, new energy enterprises have more disorganized and chaotic internal management [8]. Based on the above information, the tolerance of BYD's investment should be based on minimizing risks and pursuing the highest rate of return. This demonstrates that BYD should focus on "risk aversion" at this stage. The risks of bank fixed deposits and bonds are small. However, interest rates have dropped significantly in recent years and are no longer cost-effective. BYD may need to create a new portfolio strategy under this circumstance.

2.2. Financial Liquidity

Ma conducted a comparison between BYD and SAIC and discovered that, despite BYD's advantage in terms of macro policies and development prospects, the company's high debt ratio, poor debt repayment capacity, and low profitability will affect the company's cash collections and result in financial issues. Due to BYD's global layout strategy, the company's capital chain is highly susceptible to fluctuations in exchange rates [8]. Whether from the company's or investors' perspective, BYD's cash flow flexibility will greatly impact the company's stock price upside potential.

2.3. Markowitz Model Portfolio Investment Implementation

2.3.1. Principle and Application of The Model

The Markowitz model, also known as the mean-variance model, was introduced in 1952 by Harry Markowitz and emphasized the optimization of portfolios through diversification. The model requires data such as the asset's expected return, standard deviation, and historical correlation to build a return-risk model of the portfolio, which could be used to determine the efficient frontier for the investment portfolio and pick the corresponding portfolio weight according to the investor's risk tolerance.

2.3.2. Screening of stocks

As Wang pointed out that BYD's investment areas are too concentrated in the automobile manufacturing field, BYD has a 7.9 billion yuan long-term equity investment book balance as of 2021, with 7.1 billion of that amount coming from the automotive and automobile-related product sectors, 80% of the investment projects are invested in automobile-related R&D and parts industries, therefore, using equity investment to make up for the shortcomings of automotive intelligence is not only beneficial to the company's business risk hedging but also to expand the portfolio investment field [6]. BYD could explore potential listed companies with cloud service platforms, intelligent software, and new AI products to invest in stocks. Li analyzed the efficiency of constructing an investment portfolio by using single-index, double-index, and three-index models and concluded that the optimal portfolio under the three-index model has a higher average return, which three index, including profitability factors, valuation factors, and growth factors [9]. As a new energy company, BYD already possesses high growth stock qualities. It should concentrate on companies with high profitability, cheap valuations, and sufficient cash flow for stock allocation, sort the return on investment in the previous year's annual report, and then filter out the top 30-50 companies with better performance on the stock market. To address the "2-8 phenomenon" highlighted by Li, the poor performance of growth stocks in the portfolio, more weight should be allocated to large-cap financial stocks to hedge against BYD's development business [9]. BYD has already made plans to expand overseas markets. It should implement the aforementioned diversified measures to mitigate the risk of foreign governments controlling exchange rates.

The data required to compute and build the Markowitz model based on the daily closing stock prices in the past 20 years, including annual average return, annual standard deviation.

Calculate Annual average return:

$$AAR = \frac{1}{n} (\sum_{t=1}^n R_e) \times 12 \quad (1)$$

Annual standard deviation:

$$ASD = \sqrt{\frac{1}{n} [\sum_{t=1}^n (R_e - AAR)^2] \times 12} \quad (2)$$

The following data selects the S&P 500 Index and ten of the best overseas companies across various industries for analysis, as shown in Table 1 and Table 2.

Table 1: Company introduction of selected stocks

Ticker	Full Name	Sector (Yahoo! finance)
SPX	S&P 500 Index	
NVDA	NVIDIA Corporation	Technology
CSCO	Cisco System, Inc.	Technology
INTC	Intel Corporation	Technology
GS	The Goldman Sachs Group, Inc.	Financial Services
USB	U.S. Bancorp	Financial Services
TD CN	The Toronto-Dominion Bank	Financial Services
ALL	The Allstate Corporation	Financial Services
PG	The Procter & Gamble Company	Consumer Defensive
JNJ	Johnson & Johnson	Healthcare
CL	Colgate – Palmolive Company	Consumer Defensive

Table 2: Annualized Average Return and Annualized Standard Deviation for selected stocks

Company Ticker	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
Annualized Average Return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
Annualized Standard Deviation	14.850%	55.774%	30.809%	30.503%	29.572%	23.680%	18.134%	24.884%	14.587%	14.785%	15.350%

The mathematical formula for the correlation coefficient used to calculate the correlation between companies is as follows:

Correlation coefficient:

$$\text{Corr}(X, Y) = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}} \quad (3)$$

The correlation coefficient matrix in-stock selection is obtained using Excel data analysis as follows. Compute covariance matrix:

Table 3: Correlation coefficient for selected stocks

Correlations	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
SPX	1	0.526865	0.63653	0.578128	0.708092	0.6090662	0.644503	0.630359	0.412445	0.542222	0.439645
NVDA	0.526865	1	0.487198	0.523781	0.343134	0.1598445	0.338001	0.156912	0.059558	0.165279	0.069448
CSCO	0.63653	0.487198	1	0.614181	0.487495	0.3281413	0.410049	0.297266	0.220244	0.238795	0.164964
INTC	0.578128	0.523781	0.614181	1	0.410737	0.2796324	0.411503	0.285682	0.136363	0.324896	0.110064
GS	0.708092	0.343134	0.487495	0.410737	1	0.4716775	0.493822	0.417367	0.173108	0.295535	0.203125
USB	0.609066	0.159845	0.328141	0.279632	0.471678	1	0.53916	0.540137	0.33585	0.234128	0.217803
TD CN	0.644503	0.338001	0.410049	0.411503	0.493822	0.5391604	1	0.416709	0.230974	0.272732	0.211711
ALL	0.630359	0.156912	0.297266	0.285682	0.417367	0.5401374	0.416709	1	0.346275	0.451773	0.406645
PG	0.412445	0.059558	0.220244	0.136363	0.173108	0.3358497	0.230974	0.346275	1	0.493743	0.483308
JNJ	0.542222	0.165279	0.238795	0.324896	0.295535	0.2341281	0.272732	0.451773	0.493743	1	0.526761
CL	0.439645	0.069448	0.164964	0.110064	0.203125	0.2178027	0.211711	0.406645	0.483308	0.526761	1

Table 3 shows that there are some stocks with an excessively high correlation. As an illustration, the correlation coefficient between SPX and GX is as high as 0.7081. This prompts investors to reduce the holdings of companies with strong correlations when allocating weights or even selecting other companies and replacing one of them with a weak correlation to accomplish the goals of controlling investment risks and diversifying the investment portfolio.

2.3.3. Markowitz Model Construction

The expected return of the portfolio is calculated by the sum of products of the multiplication of weights and return rates of each stock:

$$E(R_e) = \sum_{i=1}^n W_i E(R_i) \quad (4)$$

This article uses an Excel formula to generate 1250 sample portfolios with random weights under constraining randomly: $-1 \leq W_i < 2$. The expected return and standard deviation of different stock weights are calculated through Excel Solver and drawn into a scatter plot as shown in Figure 1:

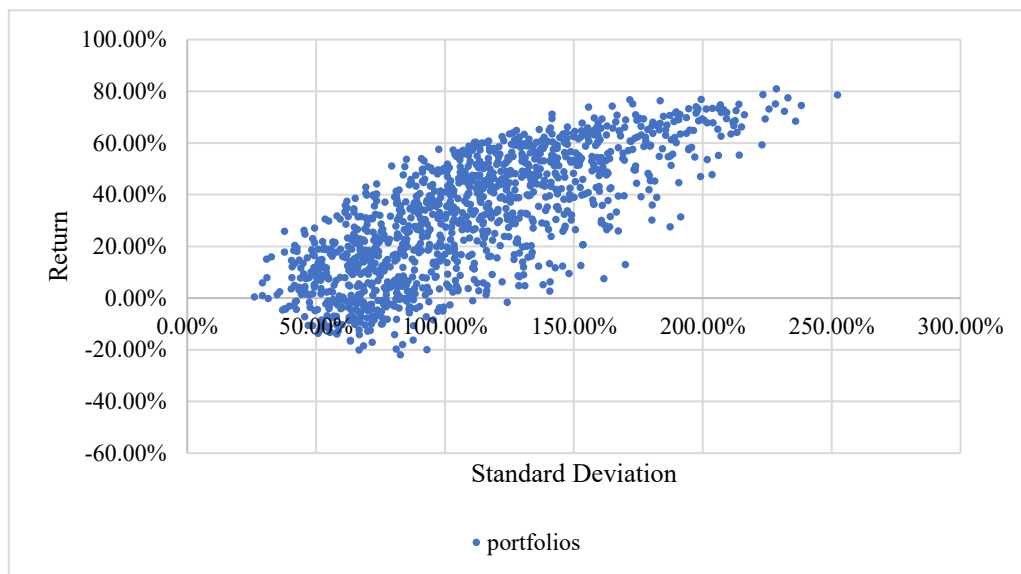


Figure 1: Scatter plot of return and standard deviation for 1250 randomly generated portfolios with different investment weights. Photo credit: Origin

According to the research method of this article, the annual expected return rate of the investment portfolio is between -20% and 80%. The highest standard deviation exceeds 250%, and the lowest standard deviation is the focus of this article.

Using the Solver Table to obtain the efficient frontier in Figure 2 below, the green curve is the portfolio frontier with minimum variance, the blue curve is the efficient frontier for minimal variance, the yellow dot is the global minimal risk portfolio, and the red square is the portfolio with maximum Sharpe ratio portfolio, also known as the efficient risk portfolio.

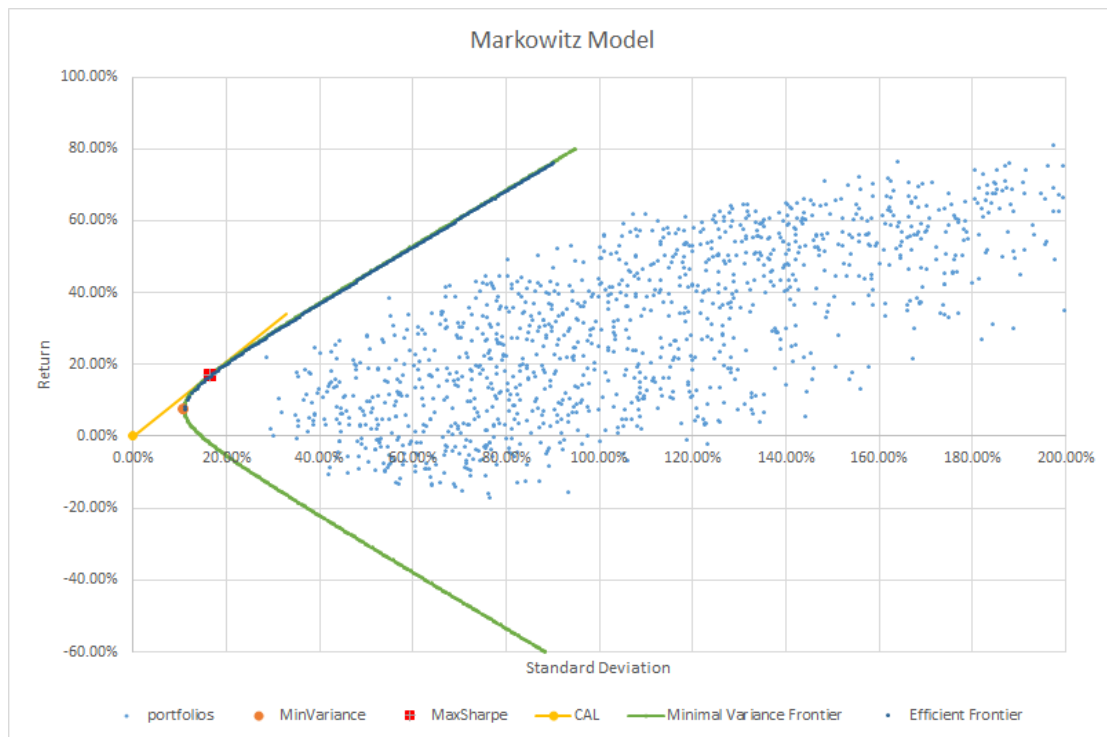


Figure 2: Efficient frontier and meaningful idiosyncratic portfolios based on selected stocks under the Markowitz model. Photo credit: Origin

Using Solver to get a global minimal risk portfolio and max Sharpe ratio portfolio, as shown in Table 4

Table 4: Global minimal risk portfolio and max Sharpe ratio portfolio for selected stocks

Ticker	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe
GMR Weights	0.38366 6	- 0.02968	- 0.0289	0.01327 1	- 0.05899	- 0.00305	0.19414 9	- 0.11481	0.25930 7	0.18833 1	0.19673 8	7.51%	10.95 %	68.54%
MSR Weights	- 1.09974	0.22457 3	0.0089 3	- 0.08186	0.12725 2	0.13212 6	0.46459 7	0.07896 9	0.53497 5	0.42716 7	0.18300 6	16.99 %	16.48 %	103.11 %

In order to determine the optimal portfolio weight ratio, this article uses the well-known Sharpe ratio in finance, introduced by William F. Sharp in 1966, to conduct horizontal and vertical comparisons of return and risk. Through previous analysis of BYD, the company tends to select portfolio weights with a higher Sharpe ratio and less risk. The global minimal risk portfolio has the lowest risk. It is appropriate for BYD's pursuit of steady profits, but the return of 7.51% is even lower than BYD's past equity investments, which are below the company's expectations. According to Zhang, Li, and Sun's analysis, people's expectations shift along with changes in the economic structure and business operations, and the investment portfolio must adapt accordingly, which means the investment portfolio shows dynamic or timely characteristics [10]. Consequently, this article enumerates that when the business is operating well, BYD should select a feasible investment portfolio, ranging from the lowest risk portfolio to the Max Sharpe ratio portfolio. In certain cases, the company should choose a portfolio that offers a higher return on investment over the efficient risk portfolio.

3. Suggestions

3.1. Optimizing the Financing System

In response to BYD's insufficient financing channels, the company should expand financing sources as feasible. BYD can establish subsidiaries according to the development strategies of its different departments. Compared with BYD, the subsidiaries have the advantages of fair internal management architecture and low liabilities. They can vigorously gain investment enthusiasm in the market by promoting BYD's core advantages in the new energy field. Moreover, BYD can consider another round of internal funding to reduce financing risk and strengthen corporate cohesion. As a new energy company, BYD has a large number of technical and management talents with high salaries. The company should increase Equity incentives to ensure the internal flow of corporate funds and increase equity investment into a reasonable portfolio investment to obtain profits, ensuring that the company's cash flow is allocatable in daily operations and investments in the short term to improve the company's long-term and short-term debt repayment capabilities, which create a win-win situation for employees and BYD.

3.2. Attention to risk control

3.2.1. Optimizing the Investment System

BYD should establish a more stringent due diligence report process, have a full understanding of promising investment projects, and conduct comprehensive commercial, financial, and legal due diligence on the company to ensure that the company's operating conditions are improved, the financial data is authentic and credible, and the company has no legal disputes over patent applications, ensure that the business does not face future appeals resulting in forced cessation of operations.

Based on the risk tolerance analysis of BYD Company in the previous article, under the current situation of sharp reduction in fixed income interest rates, BYD Company should seek more alternative investment methods to obtain higher profits. The new investment approach has a broad market outlook compared to the saturated market share of traditional investments. Furthermore, BYD's equity investment is concentrated in the field of automobile manufacturing. Therefore, besides pursuing a new investment approach, BYD should invest in various fields to diversify non-systemic risks and reduce the proportion of high-risk stocks and funds in securities investment, increasing the number and diversity of low-risk stocks for investment.

3.2.2. Strictly Improve the System of Inspecting Talents

Emerging new energy companies have grown quickly in the last few years. One of the leaders, BYD, has had a notable rise in staff, and there is an ongoing need for managers and technical staff. Additionally, as a result, the company's internal management is not as full as it would be in more established businesses that have grown over time. Internal structures are more prone to clutter and inefficiency. In particular, workers in the company's investment department influence whether corporate decision-makers can make project decisions that benefit the company's development. This means that the talents needed by the company need to have a wealth of professional knowledge and extensive practical experience to help BYD manage risks and consistently turn a profit.

3.2.3. Specialized and Scientific Investment Decision-Making

While BYD pursues the core technology of its business, it should also ensure that its investment strategy is scientific. This means that BYD needs to hire more professionals proficient in computer languages, algorithms, and statistics to keep track of the companies past financial data and store them

in BYD's database. BYD needs to recruit talents who obtain a combination knowledge of financial theory and actual data to make use of the historical annualized interest rates, operating indicators, and other data as assistance to establish a set of investment reference models and provide investment suggestions for enterprises, then implement feedback based on subsequent profits to continuously improve investment strategies, so that company's portfolio investment is scientific, objective and stable after quantification.

4. Conclusion

4.1. Key Findings

This article focuses on the development opportunities of new energy companies in transforming the energy industry structure under the "double carbon" strategic goal. BYD is taken as the object of analysis. The current investment status of BYD is not sufficiently scientific, as evidenced by the examination of poor management issues that the company's financial situation may bring. After dismantling, the analysis concluded that BYD needs to modify its approach to investing, adopt quantitative investing as a reference method for decision-making, and evaluate and confirm the highest possible benefits with bearable risk that the efficient portfolio investment of the Markowitz model brings to the company.

4.2. Research Significance

New energy companies have a short establishment time and substantial funding requirements, and the company's internal cash flow is easily affected by operating conditions, which implies development resilience is inadequate. In addition to the support of macro policies and global environmental awareness protection consensus, this article can provide a scientific and stable low-risk investment strategy for the long-term operation of BYD, protecting BYD in achieving its core corporate goals.

4.3. Limitations

The Markowitz model used in this article was created in 1952, a long time ago. The model is constrained and unable to adapt to modern needs. Compared with new models that are constantly investigated and improved, it is not sure whether this model suits the current stock market. In addition, this article's study methodology makes use of fewer data. It only analyzes historical data and corporate correlation coefficients. It is impossible to verify whether the portfolio investment conclusion based on the scant data prediction can serve as a guide for today's intricate and volatile stock market, particularly given its rapid fluctuations.

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