

Investment portfolios construction under the industrial chains of new-energy vehicles

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Abstract. New-energy vehicles are getting increasingly prevailing all around the world. Driven by the booming market, the whole industrial chains of new-energy are thriving. This essay combines the finance of a specific industry with the machine learning. It puts forward new suggestions and ideas for controlling the risks and expands the returns of the investment portfolio. This essay focuses on several new-energy leading enterprises in China and constructs a portfolio based on the Markowitz theory and gives the prediction to stock prices in one year based on Monte-Carlo Method to offer individual investors reasonable investment suggestions. It selects the daily stock prices of Tinci, Tianqi Lithium Corporation, Huayou Cobalt, CATL and BYD as the raw data including its opening price, closing price, highest possible price, lowest price, volume as well as the trading amount from 11st Jun 2018 to 28th Sep 2022. The experiment research shows that this method is effective in expanding returns and bringing risks down.

Keywords: New-energy industry; Markowitz portfolio; Monte Carlo-Method.

1. Introduction

As the penetration rate of new-energy technology develops and more consumers accept new-energy vehicles, the new-energy industry in China has come to its new stage. The production of the power battery in China is 220GWh, rising 175 percent year on year. Besides, the sales volume of new-energy cars in China has reached 3.521million, rising 157.57percent year on year. These data demonstrate the flourishing of new-energy industry in China. From the research report of CICC, the new-energy industry has come to a new period of development. It is leading relevant markets becoming more and more thriving. Also, the stock prices of relevant companies change following the trend of the industry circumstances. More and more individual investors' participation makes the new-energy stock market become increasingly booming in recent years. It is essential for individual investors to study development rules on the stock market.

Focusing on the prices change of several key enterprises from 2018 to 2022, this essay uses Monte-Carlo Method to predict the future prices of these new-energy enterprises and make a portfolio based on the Markowitz's portfolio Selection Model.

2. Literature Review

Monte-Carlo Method is a classical numerical analysis based on the probability and statistics theory. Through setting the random process, scholars often use it to perform lots of stimulation experiments. The core concept is when the problem waiting to be solved can be transformed into analyzing the probability of an event, and using this method to create numerous simulations and regarding the result as the approximate solution to the problem [1]. Consequently, this method is often utilized in predicting the price action in the business analysis and studying the financial market by doing the simulation of the market.

Markowitz Portfolio theory successfully introduced the numerical analysis into choosing a suitable portfolio [2]. By calculating the expectation of returns and minimizing the risk of the stock price variation, it offers investors novel ideas on investments. Commonly, Markowitz Portfolio is suitable for the risk diversification and determination of the weight of every stock [3,4].

3. Methodology and Data

3.1 Monte-Carlo Method

3.1.1 Method Description

Monte Carlo method, also known as Monte Carlo simulation, is extracting random numbers from a population as a sample for simulation experiments, to obtain statistical eigenvalues of the sample and make it the numerical solution to the problem waiting to be solved. And then use the Monte Carlo method to calculate the calculation weight of each measured value according to the measurement signal error, comprehensively to consider the data quality weight and the measurement error weight, and calculate the final true signal value by the weighted average of all signals.

3.1.2 The formula of Monte-Carlo

The process of change in stock prices follows geometric Brownian motion.

$$\Delta S/S = \mu \Delta t + \sigma \varepsilon \sqrt{\Delta t} \quad (1)$$

S is price of the stock. μ is the expected rate of return. Δt is the time interval. σ is the risk of the stock. ε is random variable. The formula above is equals to:

$$\Delta S = S(\mu \Delta t + \sigma \varepsilon \sqrt{\Delta t}) \quad (2)$$

From this model, it can be easily considered that the reason of fluctuation in stock prices consists of two parts. One is yield fluctuation and the other is random fluctuation.

3.2 Markowitz Portfolio Theory

3.2.1 Method Description

Markowitz Portfolio Theory was first proposed by Markovitz in 1952, and its goal is to rationally allocate investment funds to multiple assets, maximizing returns while controlling risk [5,6]. The key idea of the theory is to allocate assets by maximizing the expected return while minimizing the standard deviation, also known as Mean-ANOVA.

3.2.2 The formula of Markowitz Portfolio Theory

Assuming that there are n different financial assets in the market, for an asset i , use r_i to represent the random variable of the return of the asset. $E(r_i)$ represents the mean of the portfolio rate of return series. σ_p represents the portfolio standard deviation. w_i represents the asset weight, and uses the portfolio variance and means to define the portfolio risk and return, the model expression is:

$$\sigma_p = \sum_{i=1}^n w_i w_j \text{cov}(r_i, r_j) \quad (3)$$

$$E(r_i) = \frac{\sum_{i=1}^m r_i}{m} \quad (4)$$

3.3 Experimental Process

All the raw data needs to be cleaned. After the pre-process, this essay uses Markowitz portfolio to calculate the desired value and variance based on the data. Then it uses them to make the plot of the feasible set and draws the effective frontier of it. The frontier is the effective set of the portfolio where the optimal solution lies [7,8].

In the process of solving the model, this essay creates 50000 different portfolio and selects the portfolio with the highest Sharpe ratio as the best portfolio.

As for the prediction of the stock price, this essay uses Monte-Carlo Method to create 4000 random predictions. From the statistical perspective, it is easy to see that the interval of future stock prices in one year. These predictions give investors investment suggestions.

3.4 Data

Commonly, individual investor will not choose many stocks to construct their portfolio. Many scholars believe that it is reasonable to construct a portfolio with 5 to 10 stocks. From the industry research from CSC and CICC on new-energy industry, leading companies play the dominant role in driving stock prices of this industry. Consequently, select daily stock prices of Tinci(002709.SZ), Tianqi Lithium Corporation(002466.SZ), Huayou Cobalt(603799.SH), CATL(300750.SZ) and BYD(002594.SZ) as the raw data including its opening price, closing price, highest possible price, lowest price, volume as well as trading amount from 11st Jun, 2018 to 28th Sep, 2022. All the data are from Wind. Tianqi LithiumHuayou CobaltHuayou CobaltHuayou CobaltCATLBYD

Table 1. Stock data at daily level

code	name	date	open	high	low	close	quant	vol
002594.SZ	BYD	2018-06-11	50.12	50.13	49.30	49.42	212.52	4280600.0
002594.SZ	BYD	2018-06-12	49.69	50.20	49.00	50.03	229.63	4621200.0
002594.SZ	BYD	2018-06-13	50.10	50.12	48.91	49.06	240.48	4882000.0
002594.SZ	BYD	2018-06-14	48.68	49.44	48.60	49.05	186.78	3812600.0
002594.SZ	BYD	2018-06-15	49.09	49.28	48.13	48.18	239.52	4937600.0
002709.SZ	Tinci	2018-06-11	41.75	42.58	41.03	41.54	173.83	4153000.0
002709.SZ	Tinci	2018-06-12	41.58	41.87	40.11	41.20	174.88	4275000.0
002709.SZ	Tinci	2018-06-13	41.20	41.20	40.00	40.12	128.60	3178400.0
002709.SZ	Tinci	2018-06-14	40.15	40.78	39.93	40.54	94.72	2342500.0
002709.SZ	Tinci	2018-06-15	40.23	40.65	39.57	39.76	118.94	2979500.0
300750.SZ	CATL	2018-06-11	30.17	36.20	30.17	36.20	2.85	78800.0
300750.SZ	CATL	2018-06-12	39.82	39.82	39.82	39.82	1.06	26600.0
300750.SZ	CATL	2018-06-13	43.80	43.80	43.80	43.80	1.97	45000.0
300750.SZ	CATL	2018-06-14	48.18	48.18	48.18	48.18	3.58	74300.0
300750.SZ	CATL	2018-06-15	53.00	53.00	53.00	53.00	13.60	256500.0
002466.SZ	Tianqi Lithium	2018-09-26	38.60	38.97	38.26	38.90	643.99	16668100.0
002466.SZ	Tianqi Lithium	2018-09-27	38.84	39.76	38.22	38.30	882.13	22555400.0

002466.SZ	Tianqi Lithium	2018- 09-28	37.96	38.19	37.05	38.03	603.80	16016200.0
002466.SZ	Tianqi Lithium	2018- 10-08	37.25	37.98	35.95	36.18	563.26	15182400.0
002466.SZ	Tianqi Lithium	2018- 10-09	36.50	37.03	35.83	36.10	485.14	13322000.03
603799.SH	Huayou Cobalt	2018- 06-11	101.36	106.00	101.36	105.34	1389.89	13279700.0
603799.SH	Huayou Cobalt	2018- 06-12	104.87	105.49	102.00	104.68	1005.33	9703300.0
603799.SH	Huayou Cobalt	2018- 06-13	103.98	104.18	102.02	102.12	735.28	7143900.0
603799.SH	Huayou Cobalt	2018- 06-14	100.20	100.47	98.01	99.05	1027.90	10334900.0
603799.SH	Huayou Cobalt	2018- 06-15	99.60	100.99	97.78	98.12	926.22	9376800.0

Table.1 Raw Data of the stock prices. Raw data has been processed by calculating the daily return and drawing the distribution so that it can be better used for the model.

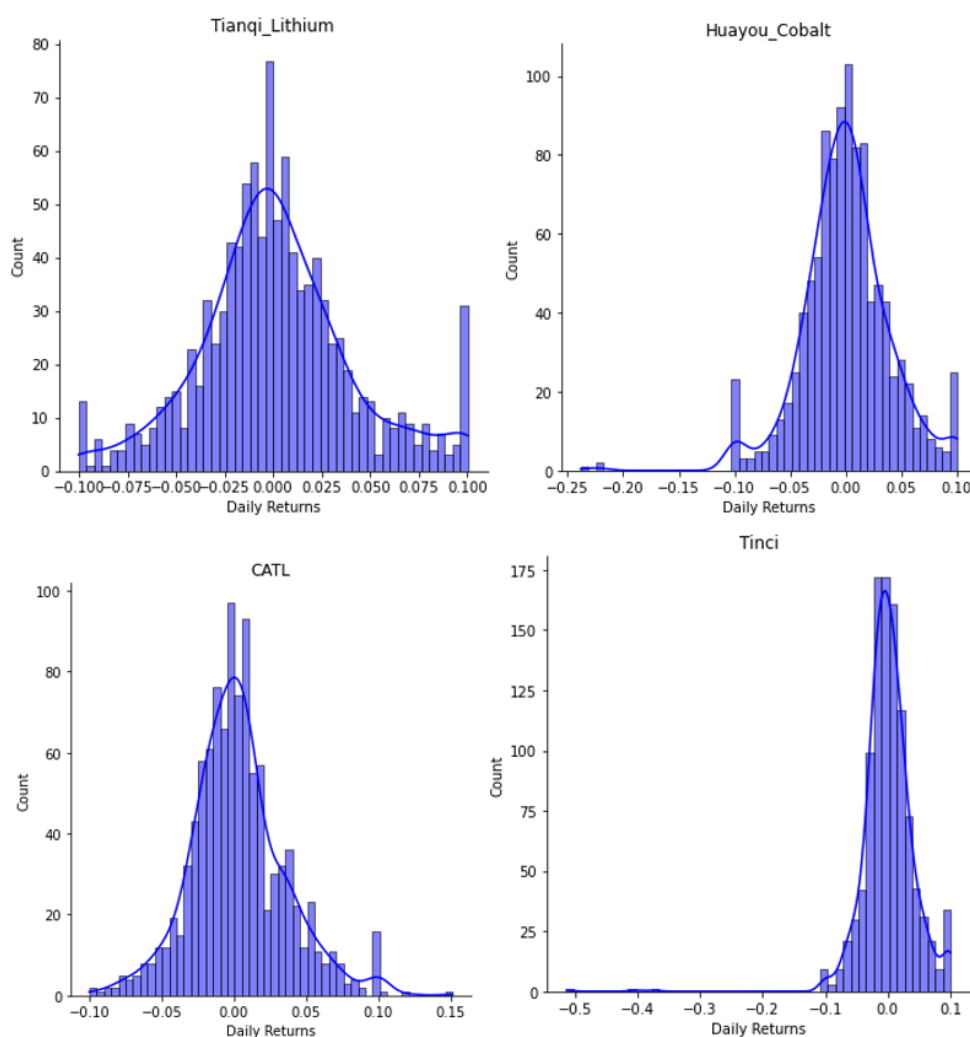


Fig.1 Daily Returns of the stock prices

From Figure 1, it is easy to see daily returns of the new-energy stocks are stable. However, they ever harvested the rapid growth and hardly decreased. It shows that the new-energy industry is relatively robust which supports the portfolio construction.

4. Result

Create dataframe with stock returns and draw the pairplot to demonstrate the relation between every two stock's prices. From Figure 2, it is easy to see that there is a strong correlation between them.

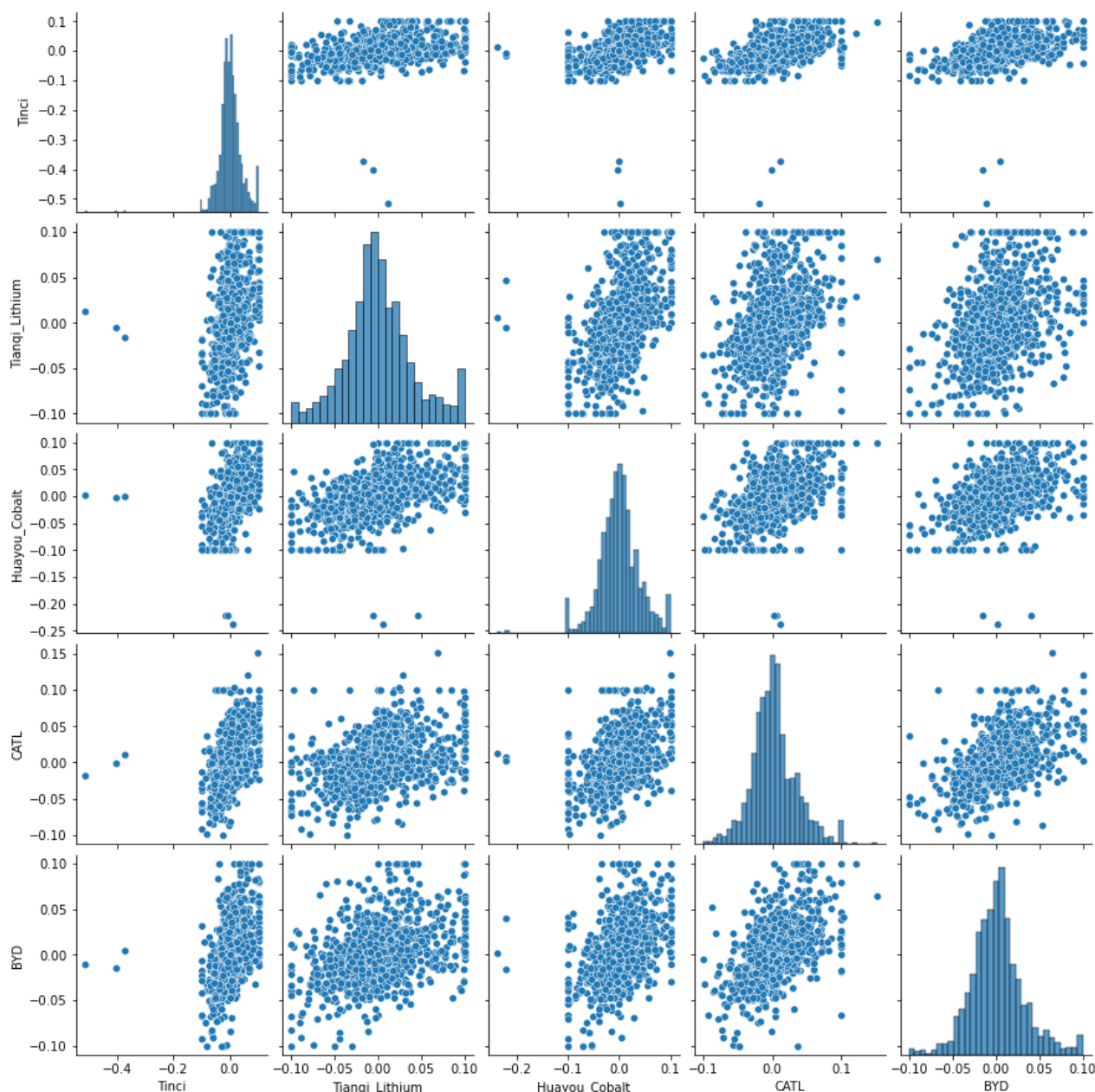


Fig.2 Pariplot

This plot demonstrates the partly positive correlation between every single pair of stocks' prices. It corroborates the consideration that these firms are Up&Down-Stream firms.

Simultaneously, build correlation matrix (see Figure 3) and draw the Kernel density estimation (see Figure 4) through Python. According to that, it is easy to see that the correlation between them is not very high so that it is suitable to construct Markowitz portfolio to diversify the risk.

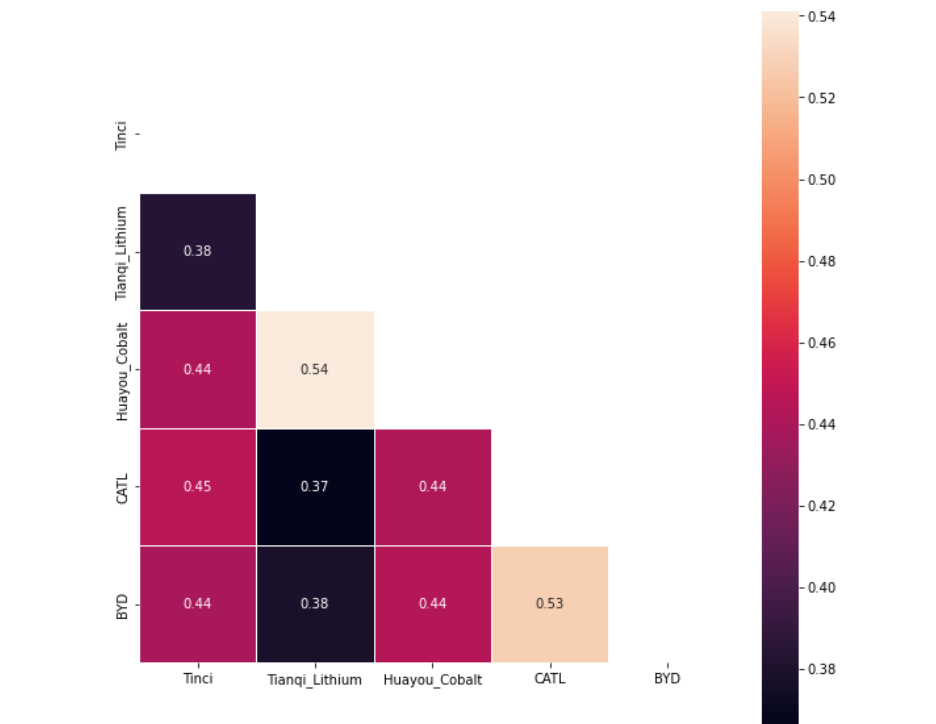


Fig.3 Correlation Matrix

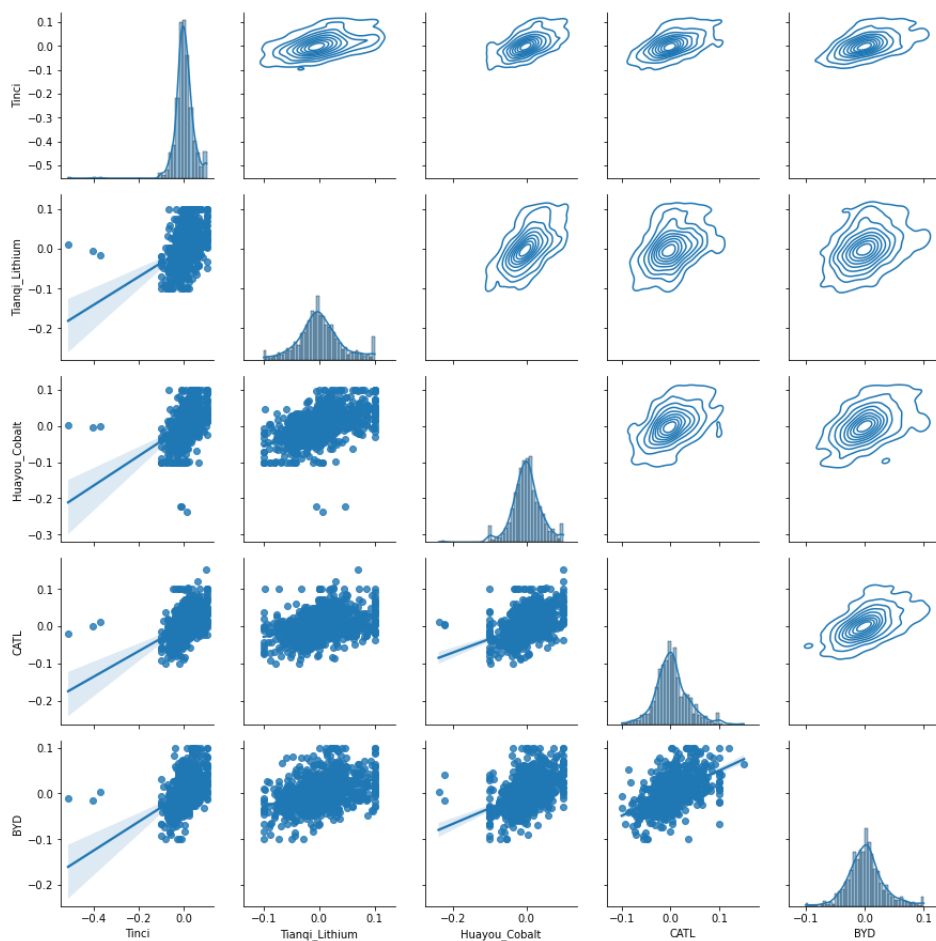


Fig.4 Kernel density estimation

Use data above to create 4000 random portfolios following the Markowitz Portfolio and find the point representing the portfolio with the highest sharp ratio.

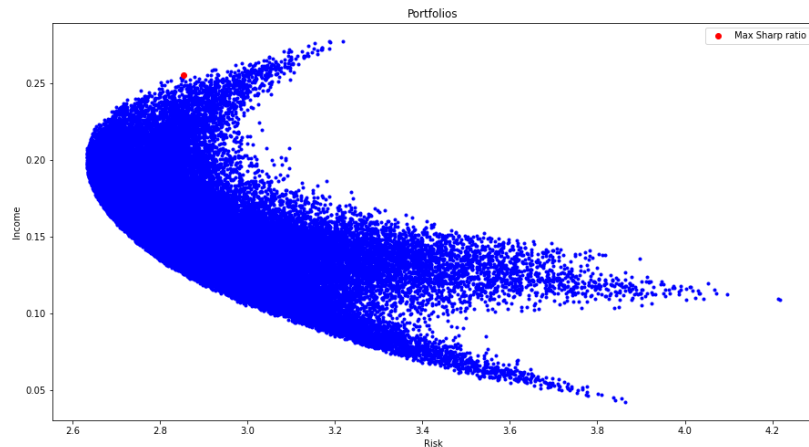


Fig.5 Plot of portfolio

From Figure 5, this plot shows the portfolio points based on every different weight of the stocks. And from the frontier of all points, choose the portfolio with highest as the optimal Markowitz Portfolio [9,10].

In Table 2, the ratio of each stock is:

Table2. Weight of the stocks

TINCI	0.008227570261304398
TIANQI LITHIUM	0.017200836734354016
HUAYOU COBALT	0.045071972118937736
CATLCATLCATL	0.6153047258045417
BYD	0.31419489508086224

Use Monte-Carlo Method to predict every stock price.

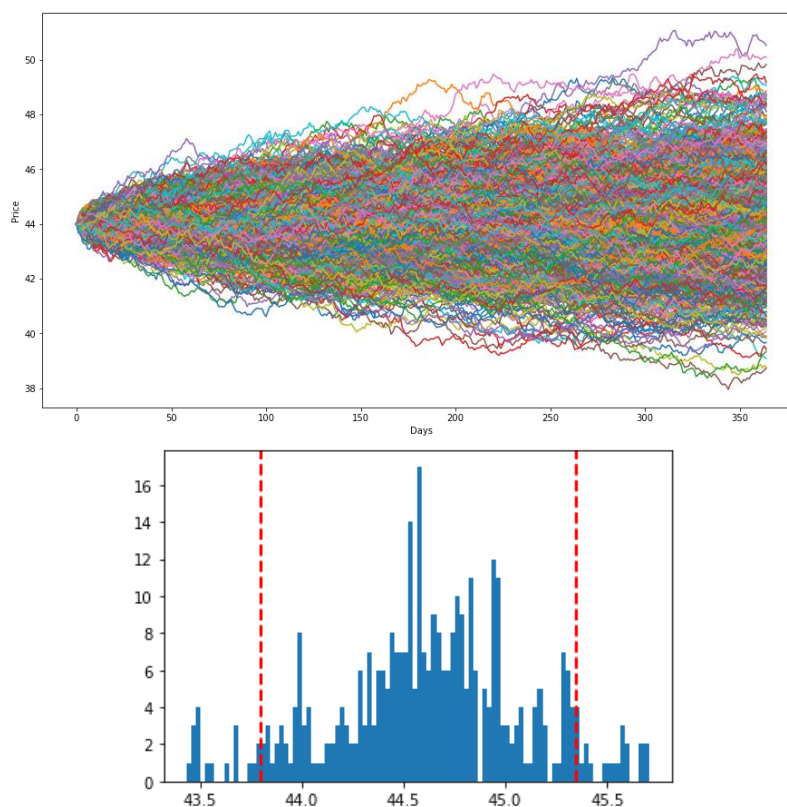


Fig.6 Monte-Carlo prediction on Tinci

From the prediction of Tinci (see Figure 6), the stock price is between 39 to 55. From the statistical analysis of the plot, the most possible prices are between the red lines. More accurately, there is a 95% possibility that the price may reach 45.35 in a year.

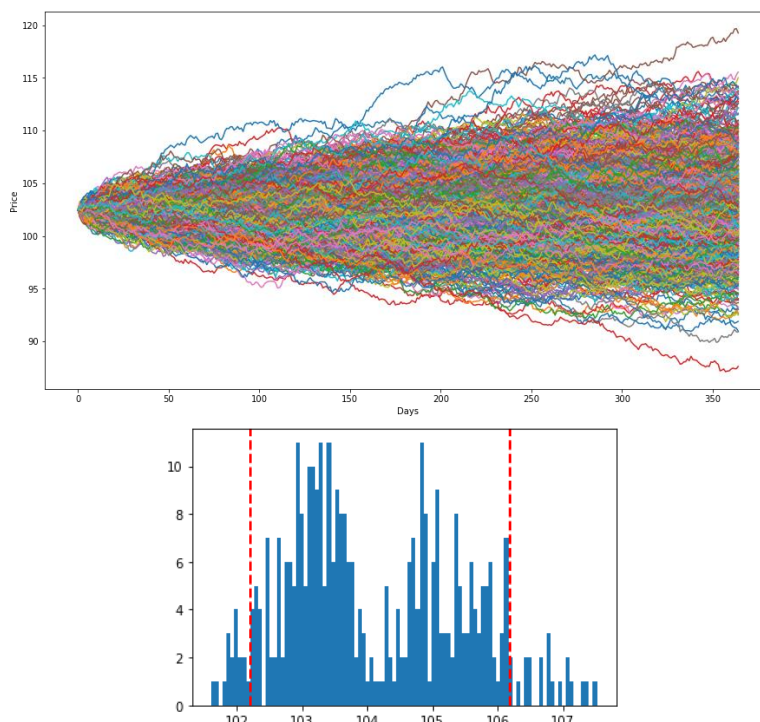


Fig.7 Monte-Carlo prediction on Tianqi Lithium

From the prediction of Tianqi Lithium (see Figure 7), the stock price is between 92 to 117. But the density of the curve with the higher price is higher than the prediction of the lower price. From the statistical analysis of the plot, the most possible prices are between the red lines. More accurately, there is a 95% possibility that the price may reach 106.20 in a year.

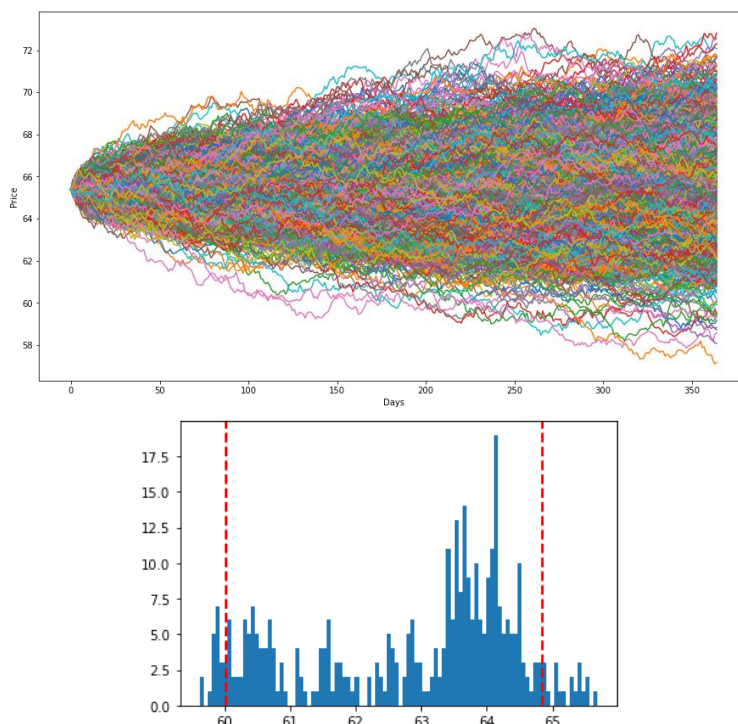


Fig.8 Monte-Carlo prediction on Huayou Cobalt

From the prediction of Huayou Cobalt (see Figure 8), the stock price is between 57.5 to 75. From the statistical analysis of the plot, the most possible prices are between the red lines. More accurately, there is a 95% possibility that the price may reach 106.20 in a year.

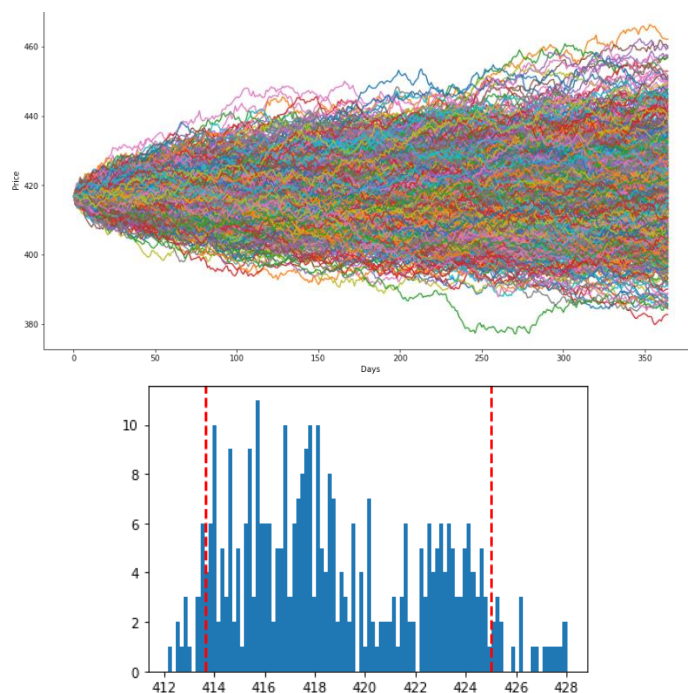


Fig.9 Monte-Carlo prediction on CATL

From the prediction of CATL (see Figure 9), the stock price is between 412 to 428. From the statistical analysis of the plot, the most possible prices are between the red lines. More accurately, there is a 95% possibility that the price may reach 106.20 in a year.

As the Downstream enterprise, the stability of Upstream enterprise stock price creates good circumstance for it to maintain its price.

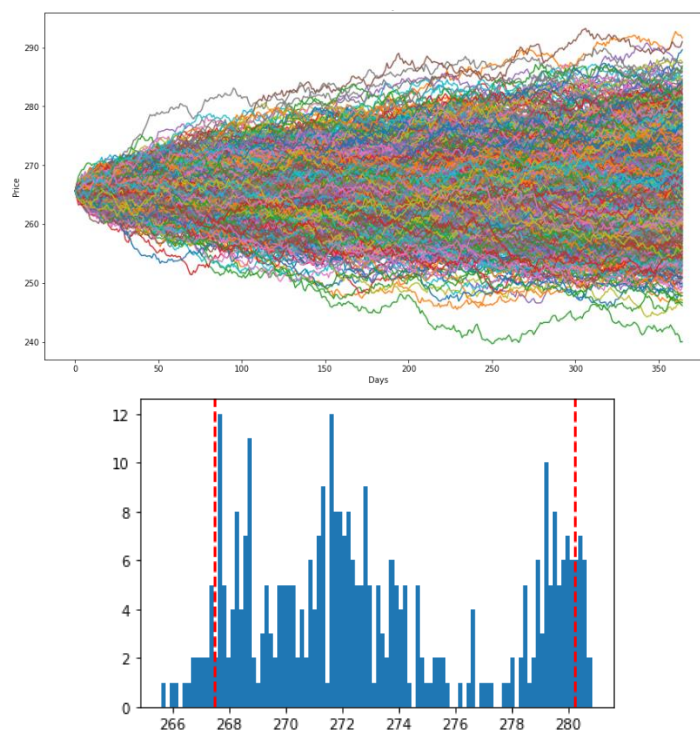


Fig.10 Monte-Carlo prediction on BYD

From the prediction of BYD (see Figure 10), the stock price is between 266 to 284. From the statistical analysis of the plot, the most possible prices are between the red lines. More accurately, there is a 95% possibility that the price may reach 280.28 in a year.

As the sale enterprise, the production enterprise's high quality lays solid foundation for it to remain its price stability.

From the analysis above, the new-energy stocks' price, the Upstream firms Tianqi Lithium may rise slightly. The selling enterprise BYD may harvest a higher stock price in one year and it accords with the trend that new-energy cars occupy a large part of the market and are becoming more popular among the world. Considering these, the downstream enterprise CATL may experience a stock price rising. Conclusively, the new-energy industry tends to be stable with a slight increase. It may show that the market of this industry hides so much financial bubble. When investing it, investors should pay more attention to the risk behind the market.

5. Conclusion

This essay combines the finance of the specific industry with the machine learning. It puts forward new suggestions and ideas in controlling risks and expends returns of the investment portfolio. To help individual investors to get higher returns and lower risks, this essay uses Markowitz portfolio and Monte-Carlo Method to construct the portfolio and predict the prices of the stock. The experiment research shows that this method is effective in expending returns and bringing the risk down.

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