Changes and trends in the investment environment before and after the COVID-19 outbreak

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Abstract. The COVID-19 outbreak in 2020 has had a huge impact on the global economy and stock markets, and investors have changed their direction. In order to find some laws in the drastic stock market changes, we selected the stock market information of ten different industries, using the Markowitz model and Index model, and came up with some important data such as minimum variance, effective frontier and so on. Based on our research and the data available, we believe that investors should pay more attention to buying shares of high-tech companies and, where appropriate, sell shares of traditional energy companies and maintain continued buying of stocks of commodity companies in order to maximize returns with minimal risk.

Keywords: COVID-19, stock markets, Markowitz model and Index model, maximize returns, minimal risk.

1. Introduction

The new crown epidemic that began in 2020 has not only become the focus of attention, but also caused drastic fluctuations in the economy and financial markets. The huge impact of the COVID-19 on the world economy is mainly manifested in the following aspects. First, the economic growth rate of various economies has fallen sharply. The second is falling prices and rising unemployment. The third is the decrease in trade and cross-border investment and the price changes of bulk commodities. Fourth, the asset prices of developed economies have stopped falling and rebounded, the dollar has fallen, and the debts of various countries have expanded rapidly. In this context, investment opportunities and risks coexist, and reasonable investment becomes even more important.

In this paper, we use Markowitz model. Professor W. Sharpe then created an analysis model that can not only analyze the securities portfolio more scientifically, but also be simple and easy to implement. This model is the index model. Nowadays, as the scope and breadth of the impact of COVID-19 are getting larger and larger, people are more urgently needing their own property to be effectively invested, and the choice of using the Markowitz model and the index model for portfolio investment is undoubtedly one of the choices.

Markowitz gave out the precise definition of return for the first time, by defining return and risk as mean and variance, Markowitz introduces powerful mathematical statistical methods into the study of portfolio selection. Markowitz's main contribution is to develop a clear concept and operable theory of portfolio selection under uncertain conditions-this theory has further evolved into the basis of modern financial investment theory. Markowitz's theory is hailed as "The First Revolution of Wall Street". Later, Sharpe proposed a simplified single-index model to solve the calculation difficulties of the standard portfolio model. The single-index model is used in Western developed markets. Has been widely used. The basic idea of Sharp's single-factor model is that when the market stock price index rises, the price of a large number of stocks in the market rises; on the contrary, when the market index falls, the price of a large number of stocks tends to fall.

Markowitz’s selection model is fundamental to the foundation of the current theory of asset allocation. Since Markowitz proposed his model, numerous portfolio selection models have been developed to advance the former and portfolio theory has been improved and completed in several directions. Some models have been developed to minimize semivariance in different cases such as

Huang [1] and Markowitz [2], while other researchers like Konno and Suzuki [3], Liu et al[4] and Pornchai et al [5] added the skewness in consideration for portfolio selection. The common assumptions are that the investor has enough historical data and that the situation of asset markets in future can be correctly predicted by the historical data. Since sometimes this is not, practical problems arise. For example, when new stocks are listed in the stock market, there is no historical information for these securities. Random, fuzzy and random fuzzy optimization models proved some useful methods for investors to tackle the uncertainty. A number of researchers have shown that mean-variance efficient portfolios, based on estimates, are highly sensitive to perturbations of these estimates. Jobson et al [6] and Jobson and Korkie [7] detail these problems and suggest the use of shrinkage estimators. Some authors like Carlsson, Fuller and Majlender [8], Leon et al [9] and Vercher, Bermudez and Segura [10] use fuzzy numbers to replace uncertain returns of the securities. Tanaka and Guo [11] and Tanaka, Guo and TÄurksen [12] used possibilistic distributions to model uncertainty in returns. Arenas-Parra et al [13] introduced vague goals for return rate, risk and liquidity based on expected intervals. A measure of downside risk is incorporated by Feiring, Wong, Poon, and Chan [14] , and Konno, Shirakawa, and Yamazaki [15] who use an approximation to the lower semi-third moment in their Mean-Absolute Deviation-Skewness portfolio model. Konno and Yamazaki proposed the mean absolute deviation model as an alternative to the mean variance model claiming that it retains all the positive features of the mean variance model , not only saves computing time but also does not require the covariance matrix.

After introducing the background of the two models, the following is a comparison of the Portfolio theory and Modern investment portfolio theory. Portfolio theory refers to a portfolio composed of several securities. The return is the weighted average of the returns of these securities, but the risk is not the weighted average risk of these securities risks. The investment portfolio can reduce non-systematic risks. Modern investment portfolio theory is mainly composed of investment portfolio theory, capital asset pricing model, APT model, efficient market theory and behavioral finance theory. Their development has greatly changed the traditional investment management practices that relied mainly on basic analysis in the past, and made modern investment management increasingly systematic, scientific and combined.

2. Introduction of companies

2.1 Company background introduction

In life, people's investment choices are usually divided into several categories, and the stock market companies are usually divided into several categories. In order to enable shareholders to better invest, we explored the impact of the COVID-19 outbreak on the stock market, on shareholders, so that shareholders can better plan their portfolios. Among the companies that dominate the stock market, we've selected virous types of companies in high-tech companies, energy companies and food and beverage industries.

Among the high-tech companies, we chose Qualcomm(QCOM), Akamai(AKAM), Oracle(ORCL) and Microsoft(MSFT). By comparing the four companies, it is not difficult to see that their stock markets have moved similarly in recent years. The representative enterprises of the same high-tech enterprises, their future prospects are optimistic, they hold the unique high-tech and Internet and other technologies today more prominent importance, are the reasons why these enterprises can easily survive the COVID-19 shock and can be able to recover quickly from the stock market turmoil and raise stock prices further.

In the field of energy and chemical industry, we selected Chevron(CVX) Exxon(XOM) and Imperial(IMBBY). These three representative enterprises, from which we can find that, are unlike high-tech or Internet enterprises, energy chemical enterprises by the COVID-19 impact is very severe, and recovery is slow and difficult. I think it may have something to do with the areas in which they operate. The global economic downturn under the COVID-19 shock, the reduced demand for energy, thereby severely affecting these companies, and with the development of new energy technologies around the world, the replacement of these traditional energy sources is inevitable, leading to widespread optimism about the future prospects of these traditional energy companies.

Finally, we found several representative consumer goods companies McDonald(MCD) Coca Cola(KO) and Pepsi Cola(PEP).

TABLE 1. SOME BASIC DATA FOR SELECTED COMPANIES

Date	Annualised Average Return	Annualised Stdev	Beta	Alpha	Annualised Average Residual Return	Residual Stdev
SPX	7.81%	16.53%	1	0.00%	0.00%	0
QCOM	13.07%	33.28%	0.99	5.34%	28.98%	0.29
AKAM	28.14%	63.12%	1.18	18.95%	60.05%	0.6
ORCL	11.11%	27.82%	0.84	4.52%	24.06%	0.24
MSFT	13.15%	23.30%	0.82	6.72%	18.92%	0.19
CVX	8.79%	22.31%	0.81	2.46%	17.84%	0.18
XOM	5.37%	20.76%	0.71	-0.14%	17.18%	0.17
IMO	10.95%	30.50%	1	3.16%	25.66%	0.26
KO	7.04%	16.26%	0.46	3.47%	14.40%	0.14
PEP	7.89%	15.07%	0.44	4.47%	13.23%	0.13
MCD	13.45%	18.67%	0.56	9.07%	16.19%	0.16

The following three figures, figure 1,2 and 3 respectively show us stock prices of tech companies, energy companies and commdity companies from January 2017 to July 2021.

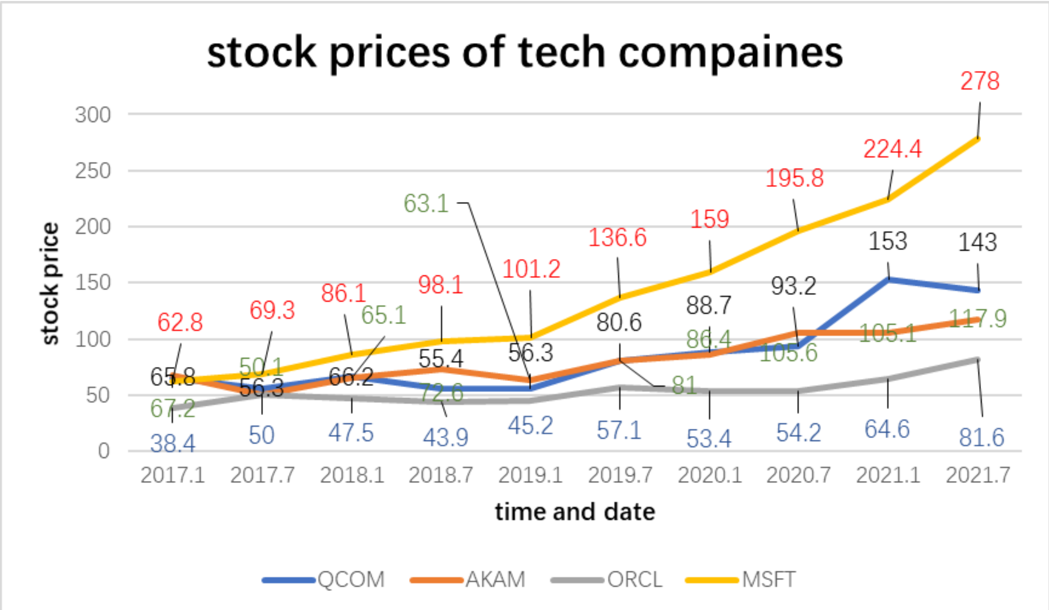

Fig. 1. Stock prices for tech companies

Source: Yahoo Finance

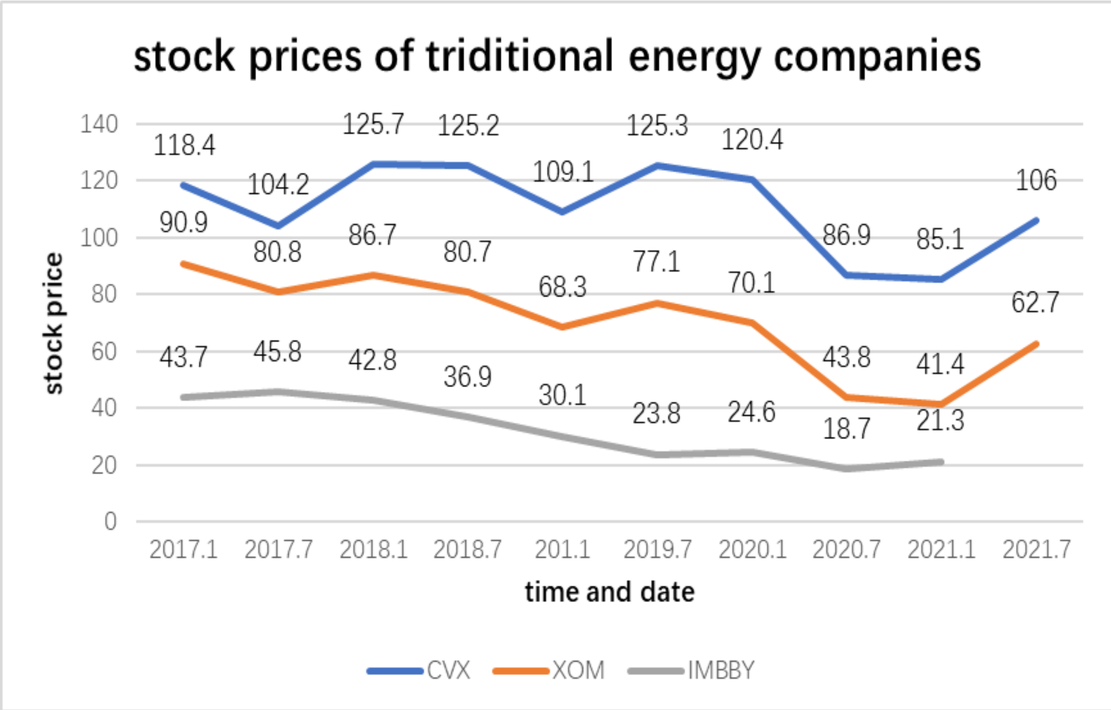

Fig. 2. Stock prices for triditional energy companies

Source: Yahoo Finance

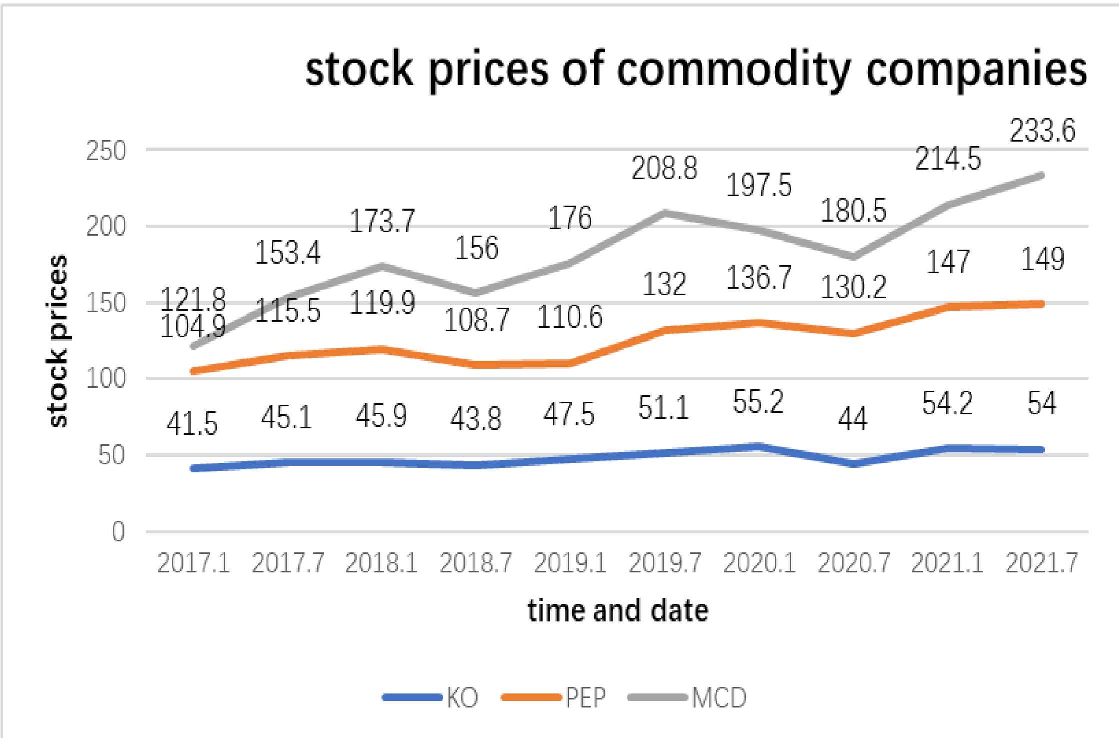

Fig. 3. Stock prices for commdity companies

Source: Yahoo Finance

TABLE 2. CORRELATION COEFFICIENT TABLE BETWEEN COMPANIES

Correlation	SPX	NVDA	CSCO	INTC	GS	USB	TDCN	ALL	PG	JNJ	CL
SPX	1.00	0.53	0.64	0.58	0.71	0.61	0.64	0.63	0.41	0.54	0.44
NVDA	0.53	1.00	0.49	0.52	0.34	0.16	0.34	0.16	0.06	0.17	0.07
CSCO	0.64	0.49	1.00	0.61	0.49	0.33	0.41	0.30	0.22	0.24	0.16
INTC	0.58	0.52	0.61	1.00	0.41	0.28	0.41	0.29	0.14	0.32	0.11
GS	0.71	0.34	0.49	0.41	1.00	0.47	0.49	0.42	0.17	0.30	0.20
USB	0.61	0.61	0.16	0.33	0.47	1.00	0.54	0.54	0.34	0.23	0.22
TDCN	0.64	0.34	0.41	0.41	0.49	0.540	1.00	0.42	0.23	0.27	0.21
ALL	0.63	0.16	0.30	0.29	0.42	0.54	0.42	1.00	0.35	0.45	0.41
PG	0.41	0.06	0.22	0.14	0.17	0.34	0.23	0.35	1.00	0.49	0.48
JNJ	0.54	0.17	0.24	0.32	0.30	0.23	0.27	0.45	0.49	1.00	0.53
CL	0.44	0.07	0.16	0.11	0.20	0.22	0.21	0.41	0.48	0.52	1.00

Through the study of the stock markets of three representative consumer goods companies, it is not difficult to find that their stock market prices are relatively stable and are obviously impacted by COVID-19, but they can also recover from the impact, which is also related to people's persistent demand for the products of these companies.

2.2 Data processing

When processing data, first, we are going to transfer those data to monthly data. Then, I need to calculate the annualized average return and annualized standard deviation by using Excess Return.

We use the same way to get all of the excess return of SPX 500 and use the average function in excel to get the average return for SPX 500. Because it is the monthly data and we need the annualized average return, I also need time 12. For standard deviation, it is much easy. We just need to put this function and select all of the company's data in excess return. Then, we get the answer.

Now, we need to calculate the Beta and Alpha. Beta and Alpha are two of the key measurements used to evaluate the performance of a stock, a fund, or an investment portfolio. Beta measures the relative volatility of an investment. Alpha measures the amount that the investment has returned compared to the market index or other broad benchmark that it is compared against.

The last is the correlation. It's a common tool for describing simple relationships without making a statement about cause and effect. We only need to use the correlation function in excel to do that.

3. Model

3.1 Markowitz Model and Index Model

Markowitz's portfolio theory not only reveals the determinants of portfolio asset risk. And more importantly, it also reveals the important conclusion that the expected return of an asset is determined by its own risk. That is, assets (single assets and combined assets) are priced by their risk, the price of a single asset is determined by its variance or standard deviation, and the price of a combined asset is determined by its covariance. For index models, in order to facilitate analysis, the single index model assumes that only one macro factor will cause stock return risks, which can be expressed by the return rate of a market index, such as the S&P 500 (S&P 500). According to the assumptions of this model, the return of any stock can be decomposed into the expected residual return of individual shares (here represented by a company-specific factor a), the return of macro-events that affect the market, and the unpredictable micro-events that only affect the company.

First of all, we use two models to draw and draw the corresponding tables and graphics respectively with no constraints.

TABLE 3. MARKOWITZ MODEL WITH NO CONSTRAINTS

minvarance fornitor		
return	stdev	sharpe
-0.40	0.76	-0.53
-0.30	0.76	-0.40
-0.20	0.57	-0.35
-0.10	0.31	-0.33
0.01	0.16	0.06
0.08	0.12	0.64
0.16	0.18	0.90
0.20	0.23	0.88
0.30	0.37	0.82
0.40	0.52	0.77

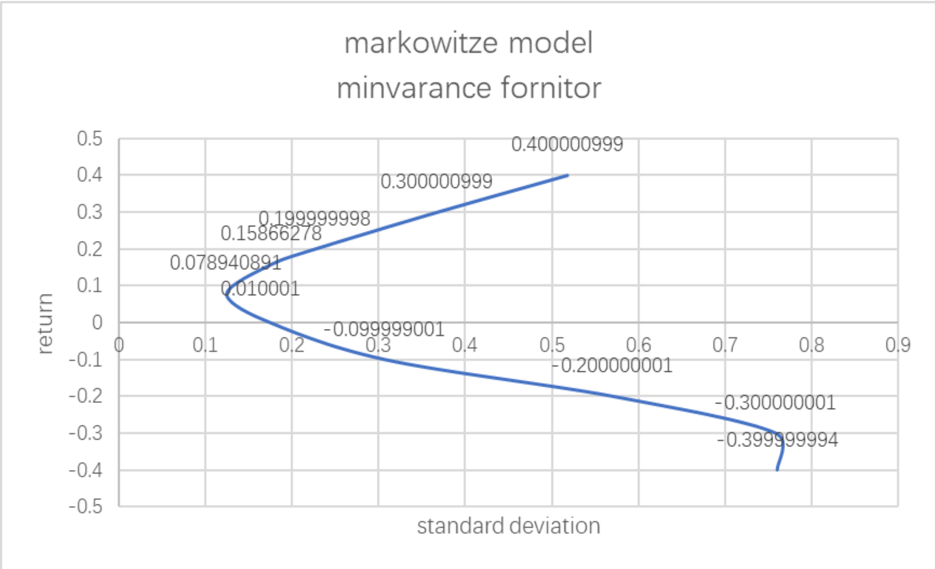

Fig 4. Markowitze model minimum variance fornitor

The figure 4 shows Markowitze model minimum variance fornitor. The horizontal coordinates of the model are stdev, the ordinates are return, the rays passing through the origin in the model are CAL lines, and the Markowitz model is to find the maximum and minimum values of return at the stdev point, and then connect the points into a curve tangent to the CAL line. The Index model is roughly the same as the Markowitz model.

Markowitz's investment model is based on the variance of return on investment and its equivalent as a measure of risk. This investment model takes the uncertainty of investment return as investment risk and measures this uncertainty by variance. And the Markowitz model holds that investors are always rational and always seek to obtain the greatest benefits under certain risks or bear the least risks at a certain level of return. The most effective portfolio of securities is determined by mean variance analysis, and the optimal distribution ratio of funds in investment objects in investment decision-making process is determined and solved under certain limited agreed conditions.

The Index model is similar to the Markowitz model and has its differences. The Markowitz model requires a large number of estimates of expected returns (risk premiums), variances, and co-variances.

The model tells nothing on how to produce those estimates. The only guess that one gets is to use the historical sample averages. But past returns may be unreliable. By comparison, The Index Model Simplifies the estimation of covariance matrix problem;

•Enhances the analysis of security expected returns (risk premiums).

•It explicitly decomposes the risk into systematic and firm-specific components; thus, exhibiting the power and limits of diversification.

TABLE 4. INDEX MODEL WITH NO CONSTRAINTS

minvarance fornitor		
return	stdev	sharpe
-0.40	0.78	-0.51
-0.30	0.62	-0.48
-0.20	0.47	-0.43
-0.10	0.32	-0.31
0.09	0.11	0.80
0.10	0.11	0.89
0.14	0.14	1.02
0.20	0.21	0.96
0.30	0.35	0.85
0.40	0.50	0.79

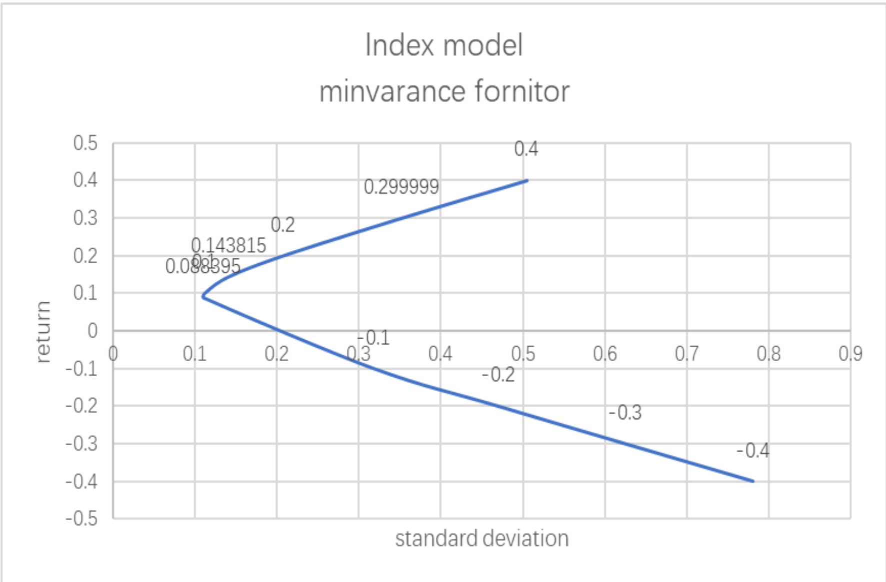

Fig. 5. Index model minimum variance frontier

The figure 5 shows Index model minimum variance frontier. To compare with the Markowitz model, we introduce the second model, the exponential model, in the next section. The index model is a different model proposed for the shortcomings of the Markowitz model. The Index model is similar to the Markowitz model and has its differences.

And when we put the Index model in Excel. Horizontal coordinates are excepted return, ordinates are risks, and can be said to be standard deviations. In the index model, however, the expected revenue is derived from Alpha plus Beta multiplying the excess return. The total risk is obtained by system risk plus the firm specific risk. So even with the same set of data, there are subtle differences between the index model and the Markowitz model. This diagram is the index model we present.

3.2 Constraints

If an investor wants to invest, he needs to be clear about effective frontiers and minimum returns. In both cases, we set different conditions when working with images and data. When we set the valid frontier image, we set the return to the maximum and limit the value of the standard deviation, so that we can get the Effective Frontier Index model. In addition to this, we have set four constraints.

Constraint 1:

This additional optimization constraint is designed to simulate the Regulation T by FINRA , which allows broker-dealers to allow their customers to have positions, 50% or more of which are funded by the customer's account equity:

$$\sum_{i=1}^{7}|w_i| \le 2\,; \tag{1}$$

In this case of restrictions, we can see that both the Markowitz model and the index model, their effective frontiers are lower than normal, and the effective frontiers of the Markowitz model have an inflection point, which indicates that when the financial links between customers and enterprises and distributors become stronger, the risk of investment will be greater, and the ratio of investment to risk will change.

Constraint 2:

This additional optimization constraint is designed to simulate some arbitrary "box" constraints on weights, which may be provided by the client:

$$|w_i| \le 1, \text{ for } \forall i\,; \tag{2}$$

In this case of restrictions, the effective frontier of the model changes downwards, indicating that the client's willingness to invest has a certain impact on the choice of portfolio, when the expected return changes, the investor's investment mind tends to change, when the expected return increases, the investor tends to become a bit presumptuous rather than completely rational, which may lead to an increase in investment risk

Constraint 3:

This additional optimization constraint is designed to simulate the typical limitations existing in the U.S. mutual fund industry: a U.S. open-ended mutual fund is not allowed to have any short positions, for details see the Investment Company Act of 1940, Section 12(a)(3)

$$w_i \ge 0, \text{ for } \forall i\,; \tag{3}$$

In the case of such restrictions, limiting investors' short positions can encourage fewer speculators in the investment market and increase market stability, so the front lines of the Markowitz and index models are not much different from the unlimited, but more stable distribution, in the case of limiting short positions.

Constraint 4:

Lastly, we would like to see if the inclusion of the broad index into our portfolio has positive or negative effect, for that we would like to consider an additional optimization constraint:

$$w_1 = 0\,. \tag{4}$$

3.3 Results

We looked at the stock market movements of three different companies in the last five years, including before and after the COVID-19 outbreak. We can get the fact that high-tech enterprises are growing rapidly and assets are expanding. While daily necessities, food companies are more stable share prices, although the outbreak has been a certain impact, but the overall stable growth. By drawing a table of correlation coefficients, we can also conclude that the share prices of the same type of company have a strong correlation. By mapping the Markowitz model and the index model, combining four different but realistic constraints, we can get effective frontiers and minimal returns by bringing data such as annual interest rates and standard deviations of several companies that investors will invest in into both models. Whether it's the Makowitz model or the index model, the changes in restrictions are similar for portfolio movements, but based on the advantages of the index model for risk-specific analysis, we can choose to favor the results produced by the index model when the portfolio is more complex. Combined with the weight distribution we calculated in maxsharp and minvarance and the stock price movements of three different companies in recent years. In the next few years, investors who want to trade lower risk for higher returns should consider increasing the proportion of daily necessities companies buying, appropriately increasing the shares of high-tech companies, and selling off traditional energy companies at the right time.

4. Graphics under constraints and related calculations

4.1 Graphics under constraints

The first is minimal variance portfolios and maxsharpe.

Table 5. Minimal variance portfolios

Markowitze model	0.10	0	0	0.08	0.02
-0.06	0.21	-0.04	0.24	0.34	0.11
Index model	-0.20	0	-0.01	0.03	0.06
0.07	0.12	0	0.32	0.39	0.20

Table 6. Maximum sharpe ratio

Markowitze model	-0.50	0.07	0.06	0.18	0.23
0.19	-0.31	0.18	0.04	0.29	0.57
Index model	-0.76	0.09	0.07	0.11	0.26
0.11	-0.01	0.07	0.23	0.35	0.48

Then, the followings are the effcient and minreturn frontier in Markowitze Model and Index Model with four different constriants.

TABLE 7. EFFCIENT AND MINRETURN FRONTIER WITH NO CONSTRIANT

Return	Stdev	Sharpe	Return	Stdev Sharpe	
Efficient frontier c2				Minreturn frontier c2	
0.09	0.13	0.72	0.05	0.13	0.42
0.13	0.15	0.88	0.03	0.15	0.17
0.18	0.20	0.90	-0.02	0.20	-0.11
0.22	0.25	0.87	-0.03	0.25	-0.24
0.25	0.30	0.84	-0.10	0.30	-0.32
0.29	0.35	0.82	-0.13	0.35	-0.37
0.32	0.40	0.80	-0.16	0.40	-0.41

TABLE 8. EFFCIENT AND MINRETURN FRONTIER WITH CONSTRIANT 1

Return	Stdev	Sharpe	Return	Stdev	Sharpe
Efficient frontier c2			Minreturn frontier c2		
0.10	0.13	0.80	-0.11	0.13	-0.90
0.09	0.15	0.59	-0.13	0.15	-0.90
0.13	0.20	0.63	-0.13	0.20	-0.88
0.10	0.25	0.38	-0.21	0.25	-0.85
0.05	0.30	0.15	-0.18	0.30	-0.59
0.01	0.35	0.03	0.05	0.35	0.13
-0.01	0.40	-0.03	0.13	0.40	0.32

TABLE 9. EFFCIENT AND MINRETURN FRONTIER WITH CONSTRIANT 2

Return	Stdev	Sharpe	Return	Stdev	Sharpe
Efficient frontier c4			Minreturn frontier c4		
0.10	0.13	0.80	-0.12	0.13	-0.9
0.13	0.15	0.88	-0.14	0.15	-0.9
0.18	0.20	0.90	-0.18	0.20	-0.9
0.22	0.25	0.87	-0.23	0.25	-0.9
0.25	0.30	0.84	-0.27	0.30	-0.9
0.28	0.35	0.80	-0.31	0.35	-0.9
0.30	0.40	0.77	-0.36	0.40	-0.9

TABLE 10. EFFCIENT AND MINRETURN FRONTIER WITH CONSTRIANT 3

Return	Stdev	Sharpe	Return	Stdev	Sharpe
Efficient frontier c4			Minreturn frontier c4		
0.10	0.13	0.79	0.03	0.13	0.26
0.13	0.15	0.85	0.04	0.15	0.26
0.16	0.20	0.79	0.05	0.20	0.26
0.18	0.25	0.71	0.06	0.25	0.26
0.19	0.30	0.64	0.08	0.30	0.26
0.13	0.35	0.38	0.09	0.35	0.26
0.14	0.40	0.36	0.10	0.40	0.26

TABLE 11. EFFCIENT AND MINRETURN FRONTIER WITH CONSTRIANT 4

Return	Stdev	Sharpe	Return	Stdev	Sharpe
Efficient frontier c1			Minreturn frontier c1		
0.10	0.13	0.79	0.06	0.13	0.46
0.13	0.15	0.86	0.03	0.15	0.23
0.17	0.20	0.86.	-0.01	0.20	-0.04
0.21	0.25	0.82	-0.01	0.20	-0.04
0.24	0.30	0.79	-0.04	0.25	-0.17
0.27	0.35	0.77	-0.07	0.30	-0.25
0.30	0.40	0.75	-0.10	0.35	-0.30
0.36	0.50	0.72	-0.14	0.40	-0.34

TABLE 12. EFFCIENT AND MINRETURN FRONTIER WITH NO CONSTRIANT

Return	Stdev	Sharpe	Return	Stdev	Sharpe
Efficient	frontier			Minreturn frontier	
0.13	0.13		0.12	0.13	0.93
0.15	0.15	1.02	0.14	0.15	0.93
0.20	0.20	1.02.1.02	0.19	0.20	0.93
0.25	0.25	1.02.1.02	0.23	0.25	0.93
0.31	0.30	1.02 1.02	0.28	0.30	0.93
0.36	0.35		0.32	0.35	0.93
0.41	0.40		0.37	0.40	0.93

TABLE 13. EFFCIENT AND MINRETURN FRONTIER WITH CONSTRIANT 1

Return	Stdev	Sharpe	Return	Stdev	Sharpe
Efficient	frontier c1			Minreturn frontier c1	
0.13	0.13	1.01	-0.13	0.13	-1.01
0.15	0.15	1.00	-0.15	0.15	-1.00
0.19	0.20	0.96	-0.19	0.20	-0.96
0.23	0.25	0.93	-0.23	0.25	-0.93
0.26	0.31	0.84	-0.27	0.30	-0.90
0.27	0.31	0.88	-0.29	0.35	-0.83
0.27	0.31	0.87	-0.23	0.40	-0.57

TABLE 14. EFFCIENT AND MINRETURN FRONTIER WITH CONSTRIANT 2

Return	Stdev	Sharpe	Return	Stdev	Sharpe
Efficient	frontier c2			Minreturn frontier c2	
0.13	0.13	1.02	-0.13	0.13	-1.02
0.15	0.15	1.02	-0.15	0.15	-1.02
0.20	0.20	1.02	-0.20	0.20	-1.02
0.25	0.25	1.01	-0.25	0.25	-1.01
0.30	0.30	1.00	-0.30	0.30	-1.00
0.35	0.35	0.99	-0.35	0.35	-0.99
0.39	0.40	0.98	-0.39	0.40	-0.98

TABLE15. EFFCIENT AND MINRETURN FRONTIER WITH CONSTRIANT 3

Return	Stdev	Sharpe	Return	Stdev	Sharpe
Efficient	frontier c3			Minreturn frontier c3	
0.12	0.13	0.91	0.05	0.13	0.36
0.14	0.15	0.91	0.05	0.15	0.36
0.18	0.20	0.91	0.07	0.20	0.36
0.23	0.25	0.91	0.09	0.25	0.36
0.27	0.30	0.91	0.10	0.30	0.36
0.32	0.35	0.91	0.13	0.35	0.36
0.37	0.40	0.91	0.14	0.40	0.36

TABLE 16. EFFCIENT AND MINRETURN FRONTIER WITH CONSTRIANT 4

Return	Stdev	Sharpe	Return	Stdev Sharpe	
Efficient frontier c4				Minreturn frontier c4	
0.12	0.13	0.93	0.01	0.13	0.06
0.14	0.15	0.93	-0.14	0.15	-0.3
0.19	0.20	0.93	-0.19	0.20	-0.3
0.23	0.25	0.93	-0.23	0.25	-0.3
0.28	0.30	0.93	-0.28	0.30	-0.3
0.32	0.35	0.93	-0.32	0.35	-0.3
0.37	0.40	0.93	-0.37	0.40	-0.3

Followings are images presented by the two differnt models.

For Markowitze Model:

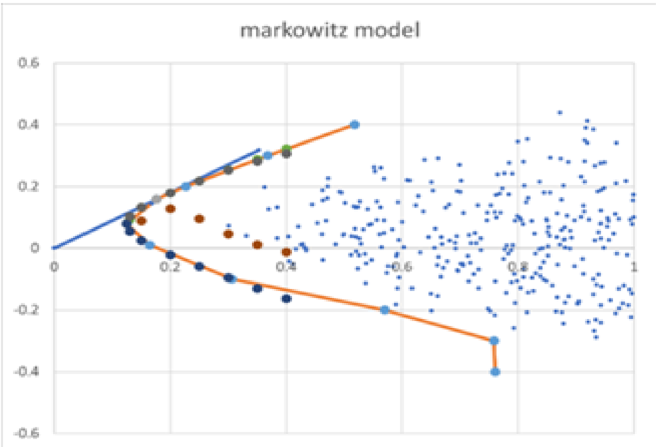

Fig 6. Markowitze model efficient frontier under constraint 1

As shown as figure 6, the effective frontier presented by the image are significantly lower than when there are no constraints.

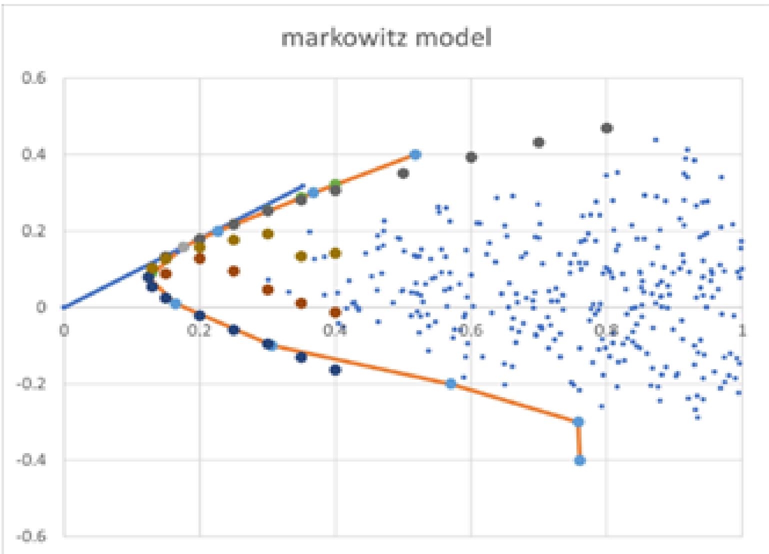

Fig 7. Markowitze model efficient frontier under constraint 2

As for figure 7, the effective frontier also declined, but by less than constraint1.

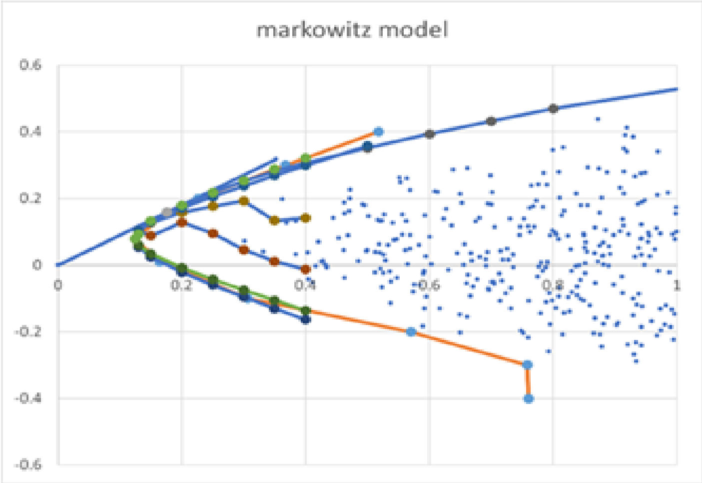

Fig 8. Markowitze model efficient frontier under constraint 3

The figure 8 shows that the effective frontier has decreased only slightly compared to the no constraints, and there has been no significant change.

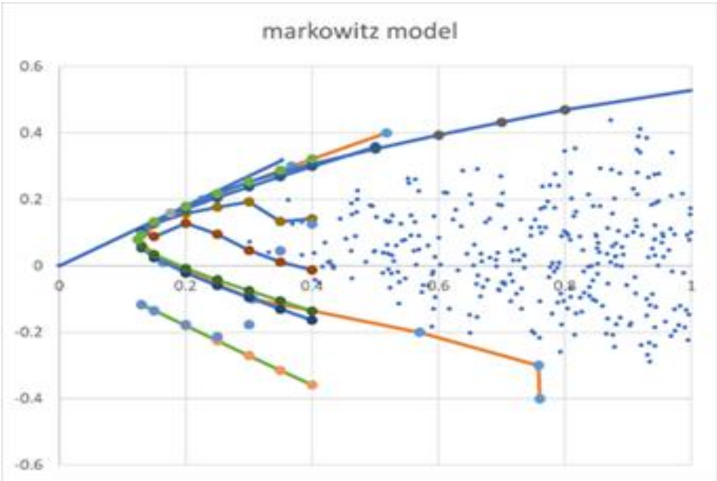

Fig 9. Markowitze model efficient frontier under constraint 4

In the figure 9, there has also been no significant change in the effective frontier.

For Index Model:

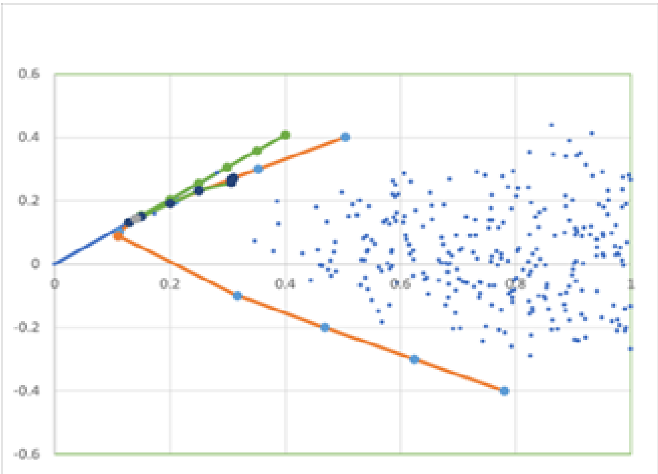

Fig 10. Index model efficient frontier under constraint 1

As shown as figure 10, the change in the effective frontier is not obvious.

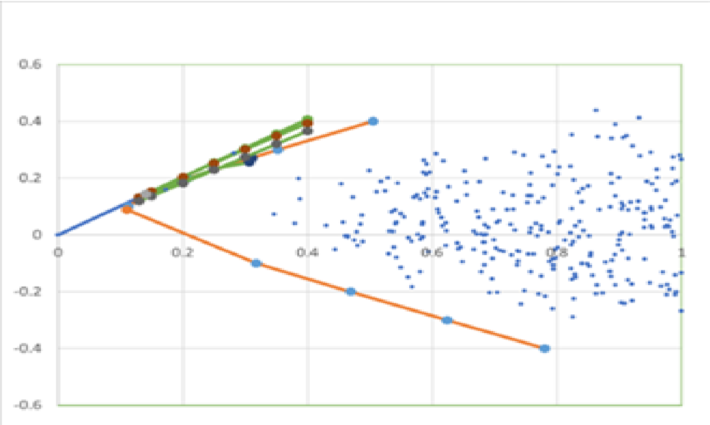

Fig 11. Index model efficient frontier under constraint 2

As for figure 11, the effective frontier is lower than when there are no constraints, but still not by much.

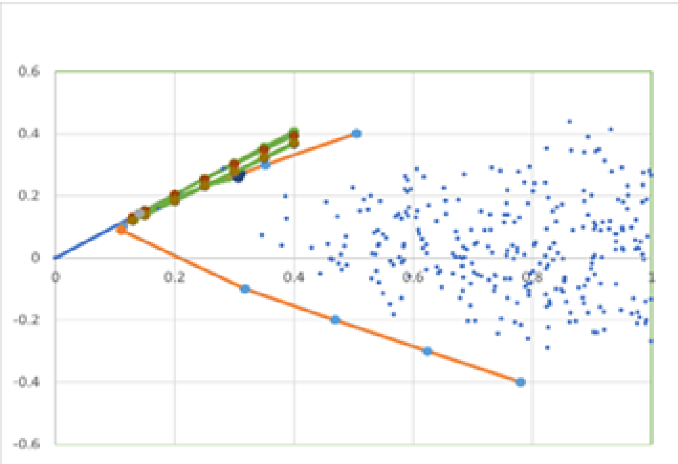

Fig 12. Index model efficient frontier under constraint 3

The figure 12 shows that the change in the effective frontier is much the same as in constraint 2.

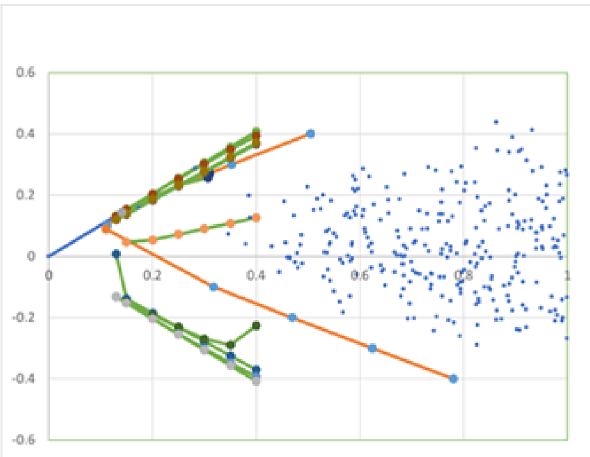

Fig 13. Index model efficient frontier under constraint 4

In the figure 13, the effective frontier is reduced compared to the no constraints situation, and the magnitude is the largest of the four constraints.

5. Conclusion

The COVID-19 outbreak in 2020 has caused tremendous volatility in the world's major economies and stock markets, and stock market conditions have changed. In order to provide a valuable reference for investors in the post-epidemic era, we have presented our views to you through an article.

By selecting ten companies in three different areas, we put ten companies into a portfolio, selected their stock market ups and downs before and after the outbreak, brought specific data into the Markowitz and index models, and derived the portfolio's minvarance and maxsharpe, as well as the effective frontier and minimum yield curve of the portfolio. The aim is to get a better, reference-oriented investment weight range, which presents a reference weight range for investors. Through research, we have come to the conclusion that in the next few years, investors who want to exchange lower risks for higher returns should consider increasing the purchase ratio of daily necessities companies, appropriately increasing their holdings of high-tech companies, and dumping traditional energy companies in a timely manner. . This conclusion has been rigorously calculated and proven. It not only gives reasonable investment advice under the new crown epidemic from a scientific point of view, but also gives people a certain understanding of the existing market industry. When making personal investments in the future, Will avoid detours.

Through the stock price movements before and after the outbreak of three different companies and the weight distribution of the minimum variance and maximum Sharpe points we seek, as well as the effective frontier trend, we believe that in the post-epidemic era investors can choose to appropriately increase the purchase of high-tech enterprise stocks, continue to buy the stock of commodity companies, and see the timely selling of energy companies stocks can enable investors to take on smaller investment risks in the case of greater returns.

However, there are some limitation in our paper. The ten companies we selected do not represent all industries, and our portfolio has certain limitations. Our data processing is accurate to one in 100,000, and the accuracy is not at its highest. The number of data combinations used in the model we built is not sufficient to fully simulate the movement and distribution of the Markowitz model and the Index model, with some errors.

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