Portfolio Construction and Performance in 2022 based on Index Model

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Abstract. Investment has always been a course of knowledge, data and information. Different investors follow different investing strategies and develop different investment portfolios. Traditional investment portfolios seek for stability by diversifying the risks to products from a wide range of industries. However, in recent years, the rise of investment in Information Technology industry encouraged more aggressive investments and correspondingly the portfolio constructions should be more aggressive. This study will investigate the performances of the stocks of the leading companies in the IT industry and train the Index Model and test its projections. It finally arrives at the conclusion that though the price trends of different stocks in the IT industry differ a lot and are fluctuating a lot, the Index Model is applicable to the data from 2020-2021 and is proved to work through year 2022. Therefore, with sufficient admit to potential limitations and risks in the future, a more aggressive way to invest in the IT industry is somehow developed. These results shed light on guiding further construction of portfolio.

Keywords: Portfolio Construction; Index model; stability; effective frontier.

1. Introduction

Given the current backgrounds and recent global events, investing in the Information Technology sector is actually riskier than ever [1-3]. This is because the IT companies are always unlikely to complete their latest projects with the most advanced technologies within the current fiscal year and usually are projected to complete all the projects in the current plan in the next 3 years [3, 4]. However, global incidents like the COVID pandemic also brings opportunities for growth of the Information Technology sector and it's projected that the stock market of the Information Technology industry will arrive at its peak in 2025 [5, 6].

Therefore, the most decisive factor of successful investments in this industry would be the portfolio selection and when considering the portfolio construction one should not only consider the economic aspects of the companies but also news about their latest technological innovations [7, 8]. This analysis will mainly focus on the economic aspects of the industry, so will attempt to construct the most stable portfolio (the least risky) and the portfolio with the maximal returns which are the Minimum Variance Portfolio and the Maximum Sharpe Ratio Portfolio [9]. In general the Maximum Sharpe Portfolio is more of investors' interests. According to CMS, the portfolio selection standards of stocks in IT industry include: the company has sound and viable project plans and the investor is only accepting positive returns based on data analysis [10]. According to Liberated Stock Trader, the Berkshire Hathaway Stock Portfolio is one of the top traditional portfolios in 2022 but it bears risks that it relies heavily on the traditional economics and though it's stable its return rates are relatively low. This analysis is going to focus on new economics and aggressive investments, seeking for relatively high beta values and this is possible to be achieved in the Information Technology Industry [9].

In this study, the portfolio selected and to be studied in this analysis will include 5 stocks that are within the Information Technology sector of the S&P 500 Index, and they are: Activision Blizzard (ATVI), Apple (AAPL), Intel Corporation (INTC), NVIDIA (NVDA) and Microsoft (MSFT). The standard S&P 500 Index will be introduced as the benchmark in this portfolio analysis. This selection has fundamental implication because the five companies chosen are market leaders in the Information Technology sector and the trends in their stock prices to some degree reflect the climates of the whole industry [9]. Studying the recent performances of these stocks will offer some insights into the

impacts and potential impacts the COVID pandemic brought to the development of th Information Technology sector, especially the economic aspects [11]. The rest part of the paper will be organized as follows. The second section of the essay will introduce the source and extraction of data and how they are aggregated and processed to become eligible parameters to be inputted into the Index Model. The third section will introduce how the model is set up and presents diagrams that show the training results of the model. The fourth section will assert possible drawbacks and limitation of the implications of the model and the fifth section is conclusion.

2. Data & Method

2.1 Data

Since the purpose of this analysis is to investigate the performance and train model based on the data of the portfolio in the past year, considering the current date, a satisfactory time range could be reasonably determined: from 11/01/2020 to 10/31/2021. Thereafter, data of the five stocks as well as the SPX index (which is a stock market index tracking the stock performance of 500 large companies listed on exchanges in the United States and will the benchmark for analysis in this essay) could be extracted online for further use. The data source for this essay is Investing.com where the historical data of stocks are available. Because the time ranges are selected identically, there's no need to clean the data to make sue their dates column are aligned. Fig. 1 shows scatter diagrams of the daily price changes of each stock. Accordingly, the stock price of Apple, NVIDIA, Intel and Microsoft are generally rising through the year 2020-2021 whereas the stock price of Activision Blizzard is fluctuating very gently and is lower at the end of the selected time period.



Fig. 1 Price changes of different underlying assets.

After the daily prices of the five stocks and the benchmark are well processed and aggregated, the annual federal funds rate FEDL01 will be introduced to the worksheet and the resulted excess daily return rate and residual daily return rate could be computed by deducting the average daily FEDL01 rate and deducting the daily benchmark change rate in sequence. Then this data will be used to set up the input table that will be later used to train the model. Table. 1 includes Annualized Average Revenue, Beta, Annualized Alpha and Annualized Standard Deviation for each stock and index.

Table 1. Summary of the descriptions for different stocks.

	SPX	ATVI	AAPL	INTC	NVDA	MSFT
AAR	-0.333	0.053	0.347	0.143	0.786	0.513
A SD	0.127	0.276	0.255	0.326	0.397	0.213
Sharpe	-2.622	0.191	1.358	0.439	1.979	2.406
beta	1.000	0.035	-0.048	-0.109	-0.289	-0.123
Annualized alpha	0.000	0.064	0.331	0.107	0.689	0.471
Annualized Residual std	0.000	0.302	0.255	0.326	0.396	0.214

There are 3 kinds of constraint will be applied to the portfolio:

- The sum of the absolute weights of all stocks and index is smaller than or equal to 2, s.t. $\sum_1^6 |w_i| <= 2$ where w_i is the weight of the product s_i.
- The absolute values of all weights of stocks and index is smaller than or equal to 1, s.t. $|w_i| <= 1$ where w_i is the weight of the product s_i.
- All weights are non-negative s.t. $|w_i| >= 0$ where w_i is the weight of the product s_i.

2.2 Models

The model to train is the Index Model. It represents the nominal data in the probabilistic form. The degree of certainty that a characteristic belongs to a nominal class is expressed as interval or ratio-scaled values. Mathematically the Index Model constructed on a portfolio of n stocks $\{s_1, s_2, s_3 \dots s_n\}$ is represented by $r_i - r_f = \alpha_i + \beta_i(r_m - r_f) + \epsilon_i$ where r_i is the return of s_i and r_f is the risk free rate which is the rate of FEDL01 in this case, α_i and β_i are the Annualized Alpha and Beta values of the stock s_i respectively, r_m is the excess return to s_i and ϵ_i is the residual return rate of s_i. As mentioned in the previous section, after the data is processed, one obtains an input table for the Index Model and one constructs solvers to find the Minimum Variance Point and Maximum Sharpe Point under each constraint. In setting variables of the Excel Solver, one controls the sum of the weights of stocks in the portfolio to be 1 and the SPX index and the weights of first four stocks as independent variables and the last stock as a dependent variable. Applying the three constraints to the model, the Minimum Variance Points and the Maximum Sharpe Ratio Points under each constraint will be calculated respectively and the Capital Allocation Line (CAL) will be calculated and plotted based on the former results. It will be a straight line that passes through the origin and has a positive slope and all the possible outcomes of the portfolio would fall on the right side of the CAL. To ascertain that the calculated CAL is correct, one way is to randomly generate a large amount of portfolio outcomes and check if all the points fall on the right of the CAL. In this analysis the number of randomly generated plots is 5000.

3. Results & Discussion

3.1 Model Training

Table. 2 is tabular data of the Minimum Variance Portfolio and the Maximum Sharpe Portfolio calculated by the Excel Solver complying to the three constraints mentioned in the previous section. The Minimum Variance Portfolio is calculated by using the Solver to solve the Minimization Linear Program of minimizing the target cell (StD) by changing the values of the weight of each stock; whereas the Maximum Sharpe Portfolio is calculated by using the Solver to solve the Maximization Linear Program of maximizing the target cell (Sharpe) by changing the values of the weight of each stock. Thereafter, the Capital Allocation Line, the random data plots and a point representation of each of the portfolios are shown in the Fig. 2.

Table 2. Summary of the models.

	SPX	ATVI	AAPL	INTC	NVDA	MSFT	**Return**	**StD**	**Sharpe**
C1 MinVar	0.496	0.076	0.116	0.075	0.059	0.177	2.71%	8.49%	31.95%
C1 MaxSharpe	-0.500	0.069	0.349	0.094	0.293	0.694	89.07%	22.92%	388.58%
C2 MinVar	0.496	0.076	0.116	0.075	0.059	0.177	2.71%	8.49%	31.95%
C2 MaxSharpe	-1.000	0.091	0.468	0.120	0.391	0.930	130.08%	32.48%	400.45%
C3 MinVar	0.496	0.076	0.116	0.075	0.059	0.177	2.71%	8.49%	31.95%
C3 MaxSharpe	0.000	0.026	0.228	0.056	0.212	0.479	50.02%	14.68%	340.64%

Then, this study applies each constraint to the Solver Table to calculate the Minimum Variance Curve under each constraint. The algorithm runs in this way: in each step fixing the value of the return

rate of the portfolio, keeping the weights of the stocks in the portfolio as variables and executing a Solver to calculate the Minimum Variance Point (mainly interested in the corresponding Std of each solution) under the constraints and repetitively execute this process and make a sufficiently small increment to the fixed return rate in each step (in the setting of this case analysis, the value range of return rate is from -30% to 70% with a stepping of 0.002). Subsequently, one applies the three constraints individually to the Solver Table to calculate the Efficient Frontier under each constraint. The algorithm is as following: in each step fixing the standard deviation (Std) of the portfolio while keeping the weights of the stocks in the portfolio as variables, and constructing a single Solver in each step to calculate a series of Maximum Return Point (mainly interested in the Return Rate of the solution in each step) and repeating this process to obtain a curve (in the case of our selected data the range of standard deviation is from 0.1 to 0.6 with a stepping of 0.002). The Minimum Variance Curves and the Efficient Frontiers are drawn below corresponding to the calculation results obtained by Solver Tables. Fig. 3 follows that all our randomly generated portfolio points are to the right side of the CAL as CAL is the most efficient situation. This study also checks that the randomly generated plots are almost all to the right of the Efficient Frontiers and Minimum Variance Curves. This proves the construction of the Index Model is successful so the model is well-trained. This model is trained based on data from 2020/11/01 to 2021/10/31 and thereafter it could be applied to the data from 2021/11/01 to 2022/10/31 to examine the implication of the model and whether the expectations based on the model are correct.

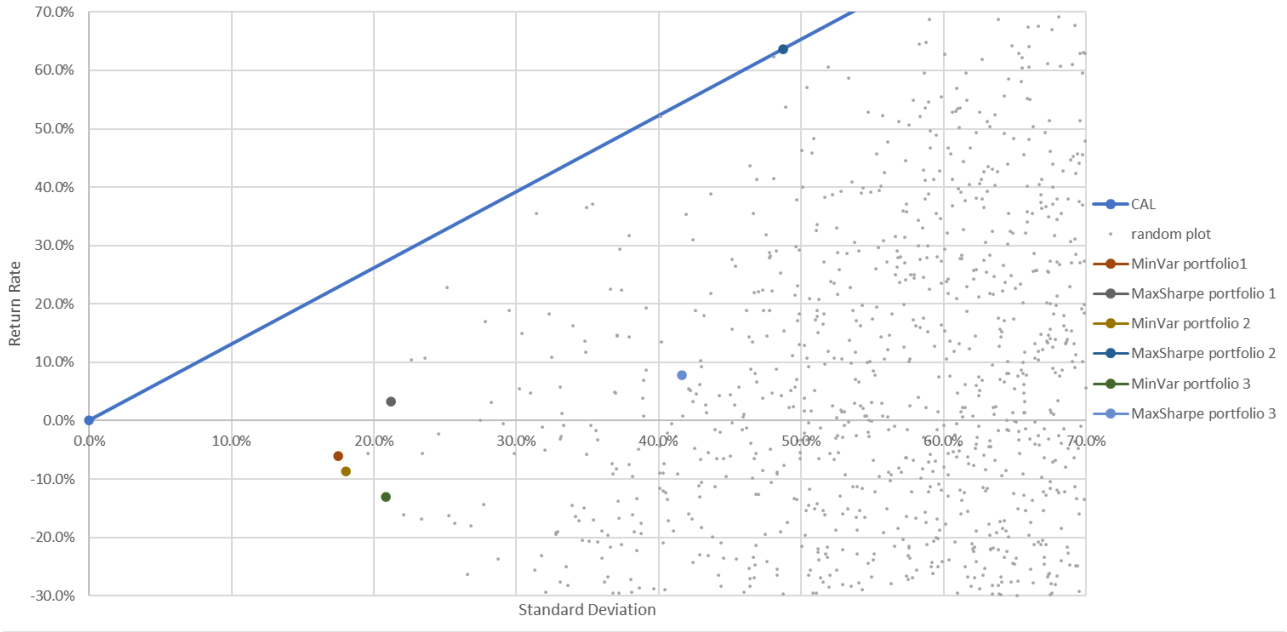


Fig. 2 Capital Allocation Line and random data.

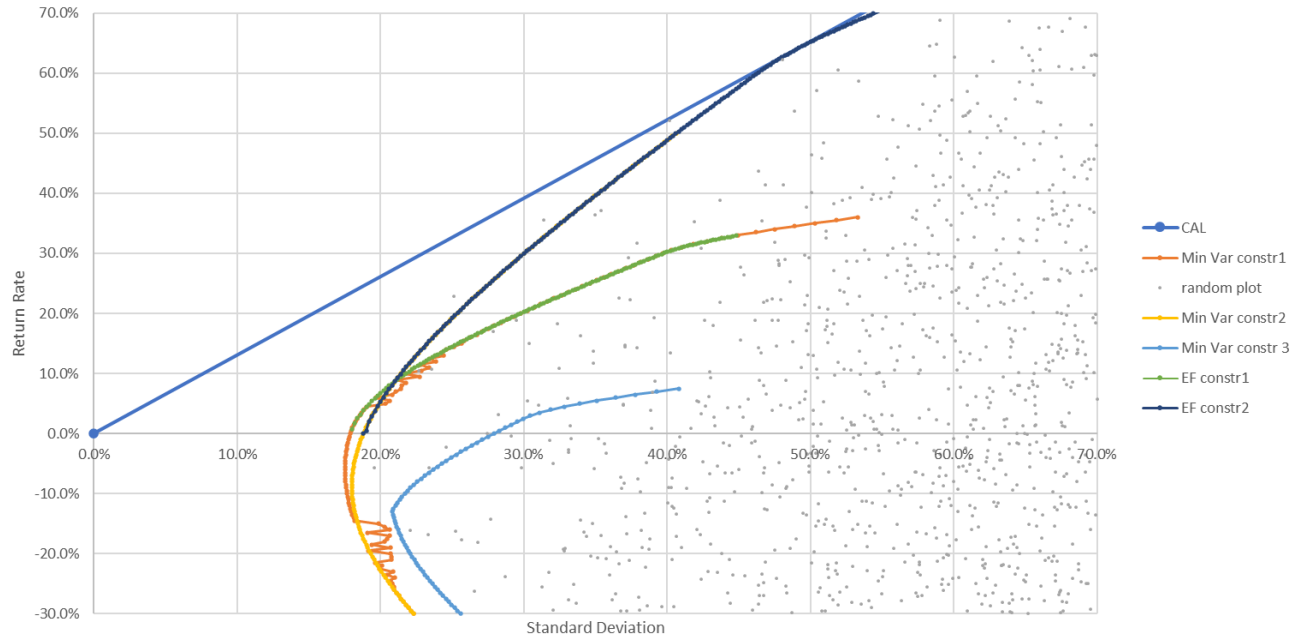


Fig. 3 Effective Frontiers, capital Allocation Line and random data.

3.2 Model Evaluation During 2022

Fig. 4 shows the daily percentage change of the stock prices. The Fig. 1 and Fig. 4 reveal that the prices of Microsoft, NVIDIA and Intel Corporation fell in 2022 and the prices of Apple and Activision Blizzard and increased slightly through 2022. As analyzed in the previous section, the Minimum Variance Portfolio and the Max Sharpe Portfolio are calculated under each constraint. To evaluate the correctness of the model based on the data through 2022, one can assume each portfolio under each constraint is executed on the starting day of the financial year from 2021/11/01 to 2022/10/31 and investigate what would the outcomes of these portfolios be 1 year after they're executed. The starting price and the ending price of the 5 stocks and SPX within the time range of 2021/11/01 to 2022/10/31 are shown in the Table. 3.

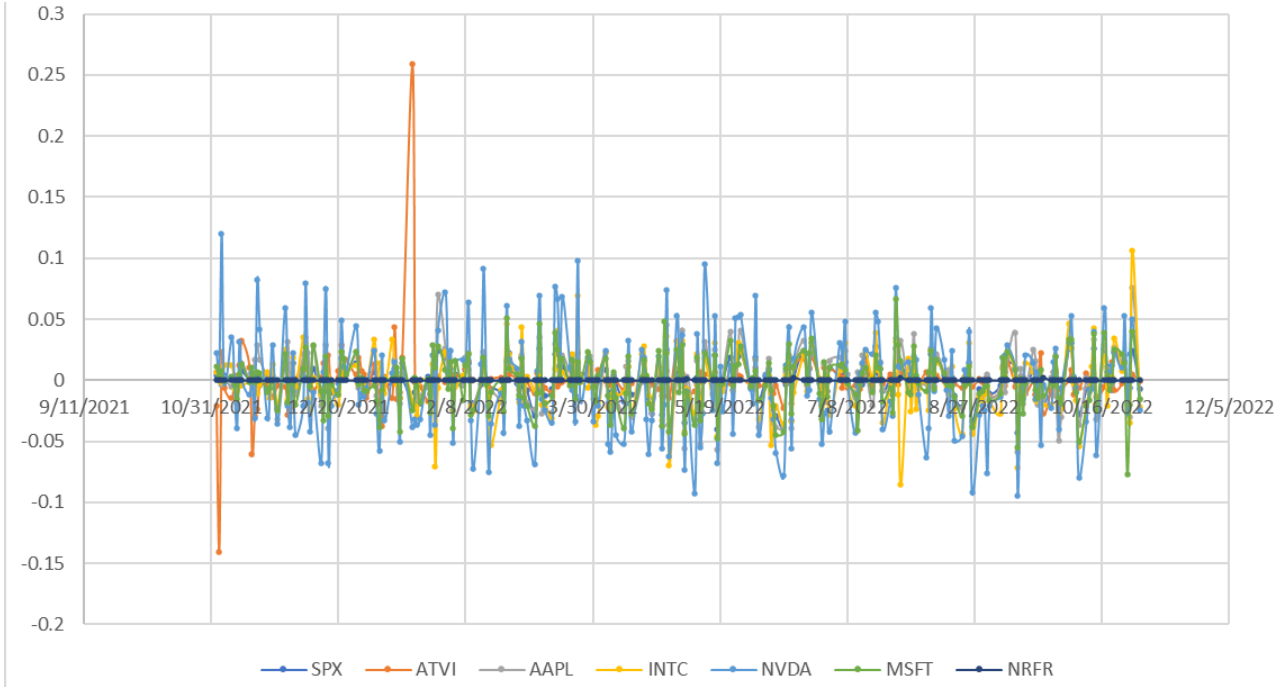


Fig. 4 Returns of different underlying assets.

Table 3. Summary of underlying assets.

	Starting Price $	Ending Price $	Price Difference $	Percentage Difference $
SPX	4613.67	3871.98	-741.69	-16.0759%
ATVI	79.35	72.78	-6.57	-8.27977%
AAPL	148.96	153.36	4.4	2.95381%
INTC	49.55	28.43	-21.12	-42.623612%
NVDA	258.27	134.97	-123.3	-47.740736%
MSFT	329.37	232.13	-97.24	-29.5230%

Table 4. Summary of return rates of different models.

	Return Rate
MinVar1	-6.99776%
MaxSharpe1	1.6%
MinVar2	-9.43328%
MaxSharpe2	0.531512%
MinVar3	-14.2662%
MaxSharpe3	2.95381%

Now, one recalls the Minimum Variance Portfolio and the Maximum Sharpe Portfolio calculated before, the weights of investments in the portfolios (seen from Table. 2). Then, one applies the price change of each stock and index through 2022 to the calculated portfolios, a table of return rates of all the portfolios is obtained as given in Table. 4. To evaluate the applicability of the Index Model trained, one compares the return rates calculated by executing the Minimum Variance and Max Sharpe portfolios obtained from the 2020-2021 data at the start of 2021-2022 data with the return rates of 2020-2021. It's clear in the table above that the return rate of each portfolio through 2021-2022 is similar to the return rate of each portfolio trained in the model of 2020-2021, and all of the three Max Sharpe portfolios under the three constraints respectively generate positive returns. Therefore, the projections of the model are proved reliable as the testing results with the 2021-2022 data showed. In a nutshell, the model training is at least successful an applicable within short term (as 1 year range is already tested and guaranteed).

3.3 Implications

As mentioned in the previous section 3.2, the Index Model trained by 2020-2021 data performed well and gave good estimations about the future stock market circumstances through 2021 to 2022. If the data through 2022 is also introduced to the model, the model should be more unbiased and the trend of data and the corresponding predictions of the model should be more balanced and generalized. Therefore, a combination of data in two years could be used to make better projections about the prospects of the five stocks and SPX in our portfolio after entering 2023.

4. Limitaions & Prospects

The data used in this model analysis consists only of daily data within the past year and the amount of data(number of financial days) for each stock is only 252. Therefore, the selection of the data set may result in non-Gaussian effect such that the inflation may have contribute to the data in the model but is not expected to be detectable. In addition, since the size of the data sample is quite limited, the data used to train the model may be insufficient so the trained model is unstable and the projected predictions based on the model is unstable and is likely to have relatively large errors. Moreover, it's always been a contentious question about whether more data is better for projections of model as especially in recent years considering the impact of the COVID pandemic, the performances of the stock market have been fluctuating capriciously. So it's possible that only using the data of the previous year would be the best strategy in some cases (just like the Index Model trained in this

analysis). Furthermore, different models perform differently when they are applied to stock markets in different countries, in this study the stock market is the United States stock market and the sector of the stocks is the Information Technology sector and the Index Model may not be the most proper model to use which further undermines the credibility of the results. Lastly, some of the calculation processes during the setup of the model are rounded (e.g. computing annualized indicators based on daily data) which generates natural errors.

5. Conclusion

In summary, this paper investigates the portfolio performances of Information Technology sector during 2022 based on index models. According to the analysis, the portfolio performances well at least in some extents. Since the investment portfolio studied in this analysis include only 5 stocks in the Information Technology sector and the studied data sample was quite limited, though the trained Index Model showed satisfying performance when making estimations of the most stable portfolios and the highest return portfolios in the next year, it can't be denied that this may be a case of coincidence, and the Index Model may not be able to perform as well as in this analysis in the future. Therefore, during such a time period that's full of economic turbulence due to the COVID pandemic and global political uncertainties, the best strategy in investment is probably not relying heavily on models, but diversifying the risky investment as much as possible. Overall, these results offer a guideline for constructing portfolio based on index model.

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