MA61061 Optimization Method in Finance

Integration of Mean–Variance Model and Stochastic Indicator for Portfolio Optimization

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Abstract

The mean–variance model proposed by Harry Markowitz is widely used for portfolio optimization. It helps the investors to allocate their capital to a number of assets, however, it does not guide the investors when to buy or sell these assets. In contrast, technical indexes are widely used to help the investors to decide when to buy/sell an asset. In this paper, we integrate the mean–variance model with a commonly used technical index, called stochastic indicator or KD index, to derive three investment strategies. Preliminary performance study is conducted to compare these investment strategies against the mean–variance model during the uptrend, downtrend and correction periods.

Methodology

Preliminaries

1) **Mean Variance Model -** Mean-variance analysis is the process of weighing risk, expressed as variance, against expected return. Investors use mean-variance analysis to make investment decisions. Investors weigh how much risk they are willing to take on in exchange for different levels of reward. Mean-variance analysis allows investors to find the biggest reward at a given level of risk or the least risk at a given level of return.
2) **KD Index -** A stochastic oscillator is a momentum indicator comparing a particular closing price of a security to a range of its prices over a certain period of time. The sensitivity of the oscillator to market movements is reducible by adjusting that time period or by taking a moving average of the result. It is used to generate overbought and oversold trading signals, utilizing a 0-100 bounded range of values.

Mean–variance optimized portfolios help the investors to allocate their wealth on a number of assets to achieve the goal of diversification. A mean–variance optimized portfolio, however, does not provide enough agility to the investors on the timing of buying and selling an asset. It is assumed that there is no buying and selling within each period except at the beginning or the end of a period. In practice, an investor may want to buy/sell an asset anytime with response to the dynamic market conditions. Consequently, using the mean–variance optimized portfolios alone may not be agile enough to meet the investors' needs. Technical analysis is a popular technique to decide the timing of buying and selling an asset. Here, the stochastic indicator (also called KD index) from technical analysis is integrated with a mean–variance optimized portfolio to derive three new investment strategies. On one hand, the mean–variance optimized portfolio is responsible for asset allocation. On the other hand, the KD index helps to determine the timing of buying and selling an asset. Overall, the resulting investment strategies provide more agility to the investors than the mean–variance optimized portfolio.

There are three strategies proposed in the paper to guide the investor when to buy and sell the shares. Three strategies are:

1) Conservative Strategy
2) Moderate Strategy
3) Aggressive Strategy

Conservative Strategy

Simply uses the mean-variance model to derive the optimized portfolio, but uses the KD index to decide when to buy an asset. Steps are shown below:

1) Solve the mean-variance model to yield the optimized portfolio **w** = (w_1, w_2, ... , w_n)
2) For each asset *i*;
3) If KD index == *Buy* => buy asset *i* with wealth w_i
4) Else => invest wealth w_i *to risk-free asset*

Moderate Strategy

Relies on both the mean-variance optimized portfolio and the KD index's buying signal to choose assets for investment, but allocates equal weight to each chosen asset. Steps are shown below:

1) Solve the mean-variance model to yield the optimized portfolio **w** = (w_1, w_2, ... , w_n)
2) B = *phi*
3) For each asset *i* satisfying $w_i > 0$
4) If KD index shows a buying signal, then add *i* to B
5) For each asset *i* in B
6) Buy asset *i* with wealth 1/|B|

Aggressive Strategy

Simply relies on the KD index's buying signal to choose assets for investment, but allocates equaled weight to each chosen asset. Steps are shown below:

1) B = *phi*
2) For each asset *i*
3) If KD index shows a buying signal, then add *i* to B
4) For each asset *i* in B
5) Buy asset *i* with wealth 1/|B|

Implementation with your data

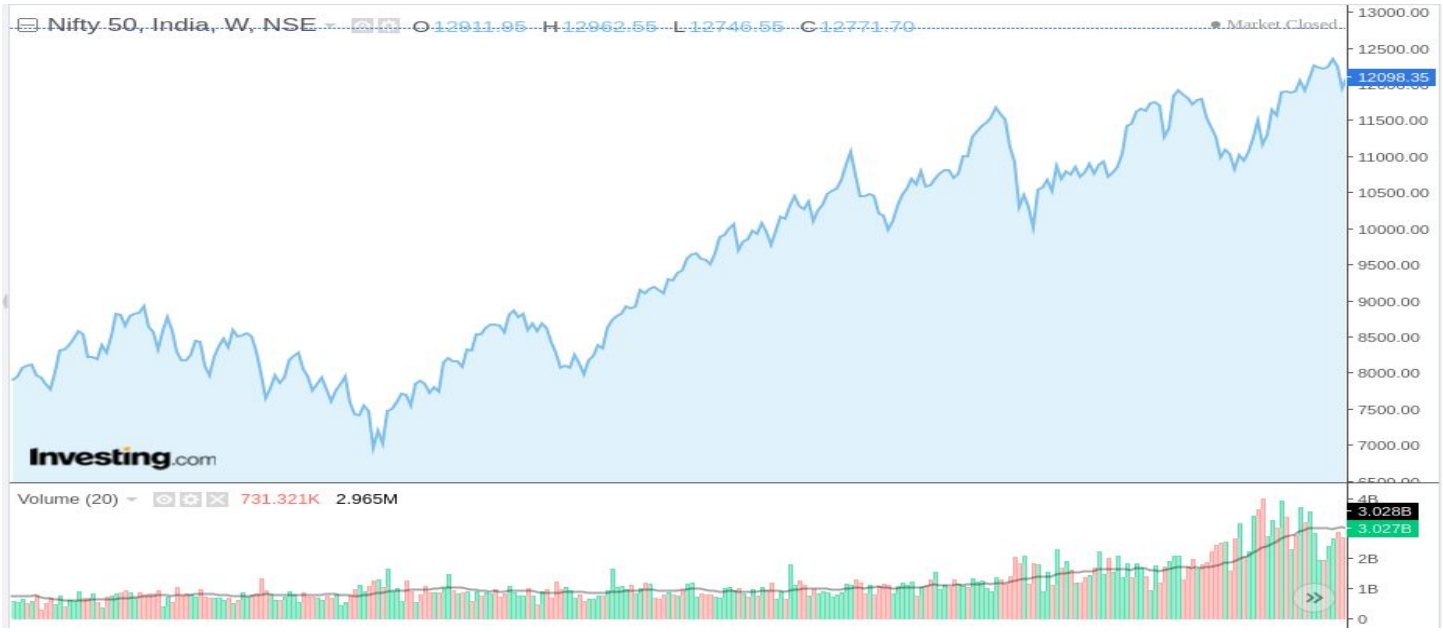
The shown three strategies are implemented in python using various libraries. The data used is historical data of 5 years of the following companies.

ASIANPAINT.NS, BAJFINANCE.NS, CIPLA.NS, HINDALCO.NS, HINDUNILVR.NS, ICICIBANK.NS, INFY.NS, ITC.NS, KOTAKBANK.NS, LT.NS, MARUTI.NS, M&M.NS, NESTLEIND.NS, RELIANCE.NS, SBIN.NS, SUNPHARMA.NS, TCS.NS, TECHM.NS, TITAN.NS, WIPRO.NS

The experiment is conducted using a moving window approach. In each window, the last month is used as test data, and the rest as training data. The training data is used both to calculate KD index to generate buying signal, and to construct the mean-variance model to yield the optimized portfolio. The resulting portfolio and the buying signal are then used to execute trades on the test data to gather the returns of each investment strategy.

The data span from Jan 2015 to Jan 2020. The period from Jan 2015 to Feb 2016 is considered for downtrend. The period from March 2016 to July 2016 is considered as a correction. The period from August 2017 to Jan 2020 (before covid) as uptrend. (Using Graph 1)

The results of the experiments are shown in the tables below. Table 1 reflects the return for the downtrend period. Table 2 reflects the return for the correction period. Table 3 reflects on the returns of the uptrend period.



Graph 1: Movement of NIFTY50 over the last 5 years.

Table 1: Average monthly return during the downtrend period

Strategy	Average monthly return	Standard deviation
Conservative	- 0.0005	0.00200
Moderate	- 0.0025	0.00560
Aggressive	- 0.0025	0.00560
Mean-Variance Model	- 0.0319	0.06723

Table 2: Average monthly return during the correction period

Strategy	Average monthly return	Standard deviation
Conservative	0.0017	0.00254
Moderate	0.0069	0.01980
Aggressive	0.0033	0.02456
Mean-Variance Model	0.0008	0.02144

Table 3: Average monthly return during the uptrend period

Strategy	Average monthly return	Standard deviation
Conservative	0.0009	0.00123
Moderate	0.0234	0.05320
Aggressive	0.0309	0.04921
Mean-Variance Model	0.0013	0.01009

Conclusion

Compared to the mean–variance model, the three proposed strategies show promising performance in terms of monthly return. The mean–variance model only outperforms the conservative strategy during the uptrend period. During downtrend and correction periods, all three strategies perform better than the mean–variance model. The conservative strategy performs the best and the worst for the downtrend period and the uptrend period, respectively. The aggressive strategy performs the best for the uptrend period, and the moderate strategy performs the best for the correction period.

Further, various other technical indicators can be combined with present strategies to bring an improvement. Different strategies can be used according to the market behaviors to achieve an effective combination of strategies to get a promising return. Studying with more datasets is needed to strengthen the results of this study and prove the hypothesis of the combination of strategies.