QF444800: Advanced Investment Science

Final Project Topic:On Performance Evaluation for Trading Strategies:
A Mean-Variance Approach

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1 Abstract

Recently, algorithm trading strategies have sprung up. They consist of statistical and machine learning. In this project, we aim to develop a method to measure a stock's trading strategies' portfolio with mean-variance analysis. Use this standard measure to check whether a consensus trading strategy for the same industry. However, we find there is no definite fund allocation for each. We use the past five years' data to find the best union of parameters. We take them into our model to find the best fund allocation for different strategies and get the minimum variance portfolio. Then, we compare forward trading with the weights and trading without them. There is a general phenomenon. If we regard the weights as the amount of longing position, it can generally improve the Sharpe ratio, return, and volatility.

2 Introduction and Motivations

Harry Markowitz(1952)'s seminal work[1] argued for taking standard deviation as a measure of volatility. In addition,the concept of efficient portfolio. Investors generally not only regard expected returns as desirable things but also regard the variance of return as undesirable things. Investment in the stock market is a common scenario for making capital gains. However, one of the investors' concerns is to choose the right timing for taking a long or short positions.To the end, it is often the case that extracting information from stock prices, financial statements, and news are valuable. Thus, some financial experts developed technical indicators.[3][8][10]

2.1 Simple Moving Average

Merrill Lynch, Richard Donchain, and another engineer, J.M. Hurst[2], invented the moving averages(MA). Many studies have uncovered evidence that technical trading rules MA have the predictive ability in the USA, the UK, and South Asia[3]. Even in Taiwan, this rule could also make profits[4]. After judging the overall trend of the stock market, the next step is to find the best entry opportunity. The easiest way is to find the intersection of moving averages of different periods. The faster-moving average is considered a shorter period, and n is smaller. When the faster-moving average crosses over the slower from the bottom, considered a buying signal; however, when the faster-moving average crosses below the slower one from the top, this would be a selling signal.

$$SMA(N) = \sum_{i=1}^{n} ClosePrice(i)/N \tag{1}$$

2.2 Exponential Moving Average

An exponential moving average (EMA) is an exponential type of MA, an exponentially increasing weighted moving average as more recent time. The more recent data is, the heavier the exponentially weighted is; however, the older price data is also calculated with a weighted value. If the stock price remains above the EMA level, investors take a long position; if the price falls below the level of the EMA, the investors would short positions until the price crosses to the upside of the EMA.

$$EMA(N, ClosePrice) = 2 * ClosePrice/(N + 1) + (N - 1) * EMA(N - 1)/(N + 1) \quad (2)$$

2.3 Moving Average Convergence / Divergence

Moving Average Convergence / Divergence (MACD) was proposed by Gerald Appel[11]. MACD is an exponentially smoothed moving average. By calculating the degree of dispersion (DIF) between the two EMA values of the stock price or index change at the close price of the market for a short-term period and a long-term period to determine the timing for buying and selling. If DIF minus MACD is from negative(positive) to positive(negative), investors would long(short) positions. Gabriel Dan I.Anghel collects more than one thousand companys' data to prove the MACD rule can be beneficial for getting abnormal returns from some companies in the world.

$$MACD = [EMA(12) - EMA(26, ClosePrice) \quad (3)$$

$$MACDSIGNAL = EMA(9, MACD) \quad (4)$$

$$MACDHIST = MACD - MACDSIGNAL \quad (5)$$

3 Results

First, use the past five years' historical stock data to train the best set of parameters. Second, backtest these parameters to find the minimum volatility for these trading strategies. Third, use the portfolio's weights of each trading strategy to examine whether it is better to use these weights as trading's fund allocation. We assumed that the best fund allocation depends on the stock industry. However, there is no direct relation between fund allocation and the stock industry.

3.1 Trading Strategy

If the signal cross over another from the bottom, we buy the value of weight*10000.If the signal cross over another from the above, we close this position. The pseudo code about when to buy and sell are in Algorithm 1.

3.2 Find the best set of parameters.

We use the past five years, from 2012 to 2016, as our training data. Use these to find out the set of the best parameter to achieve a minimum variance portfolio.

Algorithm 1 Trading Signal
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entrysize>0when the signal from below to crossanother ; entrysize<0 when the signal from above to cross another

if *entrysize1>0* **then**

   long position (value = $SMA's\ weight * 10000$)

else if *entrysize1<0* **then**

   close position

end if

if *entrysize2>0* **then**

   long position (value = $EMA's\ weight * 10000$)

else if *entrysize2<0* **then**

   close position

end if

if *entrysize3>0* **then**

   long position (value = $MACD's\ weight * 10000$)

else if *entrysize3<0* **then**

   close position

end if

代碼	產業	EPS	SMA_n1	SMA_n2	EMA_n1	EMA_n2	MACD_n1	MACD_n2	MACD_n3
2454	半導體業	70.56	65	45	45	55	25	30	15
4966	半導體業	66.29	55	40	85	60	35	40	30
2609	航運業	48.73	10	60	5	85	45	65	55
2615	航運業	45.57	85	70	5	20	5	40	30

Graph1: The parameters for each stock and strategy

Algorithm 2 Find the optimal parameters for strategy

Require: $f(x) : profit function\ x_0 : initial solution\ s : step size$

Ensure: optimal n_1^*, n_2^*

  initial $n_1 = 0$ $n_2 = 0$

  repeat

    compute profit function $f(x, n_1', n_2') = back\ testing's\ profits$

  until *find the maximum profits*

3.3 Find fund allocation's weights.

Introduce the Modern Portfolio Theory into the experiment. Use trading strategies instead of assets. As we know that the trading volume is affected by our trading signals, there must be relationships between them. Let the equity change, time series data, as the correlation evaluation of the strategies. Then, find the strategy portfolio which can reach the minimum volatility. More than that, we discover that the allocation wouldn't be different only depending on the industry. That overturns our assumption.

代碼	產業	EPS	SMA	EMA	MACD	E[r]	Volatility
2454	半導體業	70.56	0.2744	0.5704	0.1552	0.51	0.34
4966	半導體業	66.29	0.0638	0.6086	0.3277	0.96	0.54
2609	航運業	48.73	0.1776	0.71	0.1123	0.14	0.33
2615	航運業	45.57	0.3928	0.3834	0.2237	0.59	0.42

Graph2: The fund allocation of each stock.

4   Empirical Studies

Use the best setting to do forward testing. Take the data from 2017 to 2022 to examine whether the weights measured above can help us to improve our strategy's performance on return and volatility. Through the following Graph3 and Graph4, we could find that this method can get more return and less volatility.

	2454.TW	4469.TWO	2609.TW	2615.TW
Start	2017-01-03 00:00:00	2017-01-03 00:00:00	2017-01-03 00:00:00	2017-01-03 00:00:00
End	2017-12-29 00:00:00	2017-12-29 00:00:00	2017-12-29 00:00:00	2017-12-29 00:00:00
Duration	360	360	360	360
Exposure Time [%]	32.9218107	48.55967078	24.69135802	48.97119342
Equity Final [$]	10466.97354	9253.490267	9384.992755	10482.75637
Equity Peak [$]	11508.60034	11986.10042	12224.92736	11256.35954
Return [%]	4.669735386	-7.465097332	-6.15007245	4.8275637
Buy & Hold Return [%]	39.06044446	90.39162744	10.97762009	17.92794219
Return (Ann.) [%]	4.846814968	-7.73061398	-6.370441274	5.010770253
Volatility (Ann.) [%]	18.00092447	26.12692405	17.45903645	19.7315254
Sharpe Ratio	0.269253669	0	0	0.253947434

Graph3: The strategy performance without portfolio weights.

	2454.TW	4469.TWO	2609.TW	2615.TW
Start	2017-01-03 00:00:00	2017-01-03 00:00:00	2017-01-03 00:00:00	2017-01-03 00:00:00
End	2021-12-30 00:00:00	2021-12-30 00:00:00	2021-12-30 00:00:00	2021-12-30 00:00:00
Duration	1822	1822	1822	1822
Exposure Time [%]	48.15119145	47.2473295	52.91700904	57.02547247
Equity Final [$]	11954.08767	10413.61233	63883.53182	120131.164
Equity Peak [$]	13233.00867	10875.22765	123297.9198	125163.164
Return [%]	19.54087671	4.136123269	538.8353182	1101.31164
Buy & Hold Return [%]	535.7061559	644.6079417	1067.677568	1383.104463
Return (Ann.) [%]	3.765040914	0.842745837	46.8145541	67.32490441
Volatility (Ann.) [%]	9.138166039	12.7967249	67.7166568	62.79630319
Sharpe Ratio	0.412012749	0.065856369	0.691329967	1.07211573

Graph4: The strategy performance with portfolio weights.

4.1 Time Robustness

Split the time from five years, 2017 to 2021, into per year. We pick the trade performance in 2017 and 2018 to claim that the weight can improve our profits. We find that setting the weight as trade value can improve the Sharpe ratio, return, and volatility, even in different timeframes.

	2454.TW	4469.TWO	2609.TW	2615.TW
Start	2017-01-03 00:00:00	2017-01-03 00:00:00	2017-01-03 00:00:00	2017-01-03 00:00:00
End	2017-12-29 00:00:00	2017-12-29 00:00:00	2017-12-29 00:00:00	2017-12-29 00:00:00
Duration	360	360	360	360
Exposure Time [%]	32.9218107	48.55967078	24.69135802	48.97119342
Equity Final [$]	10466.9745	9253.496501	9384.992755	10482.75033
Equity Peak [$]	11508.60034	11986.1031	12224.92736	11256.35353
Return [%]	4.669745031	-7.465034994	-6.15007245	4.827503272
Buy & Hold Return [%]	39.06043312	90.39164909	10.97762009	17.92793379
Return (Ann.) [%]	4.846824987	-7.730549519	-6.370441274	5.010707478
Volatility (Ann.) [%]	18.00092738	26.12696052	17.45903645	19.73152238
Sharpe Ratio	0.269254182	0	0	0.253944292

Graph5: The strategy performance without portfolio weights.

	2454.TW	4469.TWO	2609.TW	2615.TW
Start	2017-01-03 00:00:00	2017-01-03 00:00:00	2017-01-03 00:00:00	2017-01-03 00:00:00
End	2017-12-29 00:00:00	2017-12-29 00:00:00	2017-12-29 00:00:00	2017-12-29 00:00:00
Duration	360	360	360	360
Exposure Time [%]	32.9218107	48.55967078	24.69135802	48.97119342
Equity Final [$]	10655.4318	9746.19713	9398.948398	10474.65544
Equity Peak [$]	10938.7324	10875.22693	12235.00331	11245.55277
Return [%]	6.554317968	-2.5380287	-6.010516021	4.746554383
Buy & Hold Return [%]	39.06043312	90.39162744	10.97762009	17.92794219
Return (Ann.) [%]	6.805152321	-2.630782489	-6.226051943	4.926614973
Volatility (Ann.) [%]	5.705683655	11.31638883	17.23139213	19.33294622
Sharpe Ratio	1.192697095	0	0	0.254830015

Graph6: The strategy performance with portfolio weights.

	2454.TW	4469.TWO	2609.TW	2615.TW
Start	2018-01-02 00:00:00	2018-01-02 00:00:00	2018-01-02 00:00:00	2018-01-02 00:00:00
End	2018-12-28 00:00:00	2018-12-28 00:00:00	2018-12-28 00:00:00	2018-12-28 00:00:00
Duration	360	360	360	360
Exposure Time [%]	33.06122449	35.10204082	20	45.30612245
Equity Final [$]	7021.80748	7852.425846	9881.139226	9693.61809
Equity Peak [$]	10065.74717	10893.39652	10626.27905	10061.47054
Return [%]	-29.7819252	-21.47574154	-1.188607741	-3.063819104
Buy & Hold Return [%]	-18.40636628	-23.52385224	-29.03225434	-17.24157146
Return (Ann.) [%]	-30.48768627	-22.01627902	-1.222359565	-3.149963585
Volatility (Ann.) [%]	13.43544427	21.82081905	12.70004631	8.687380979
Sharpe Ratio	0	0	0	0

Graph7: The strategy performance without portfolio weights.

	2454.TW	4469.TWO	2609.TW	2615.TW
Start	2018-01-02 00:00:00	2018-01-02 00:00:00	2018-01-02 00:00:00	2018-01-02 00:00:00
End	2018-12-28 00:00:00	2018-12-28 00:00:00	2018-12-28 00:00:00	2018-12-28 00:00:00
Duration	360	360	360	360
Exposure Time [%]	33.06122449	35.10204082	20	45.30612245
Equity Final [$]	9445.523534	9057.63114	9856.369649	9697.401163
Equity Peak [$]	10009.6687	10365.48067	10597.54948	10065.25431
Return [%]	-5.544764656	-9.423688603	-1.436303507	-3.02598837
Buy & Hold Return [%]	-18.40636628	-23.52384917	-29.03225434	-17.24158702
Return (Ann.) [%]	-5.698585554	-9.67947003	-1.4770362	-3.111086337
Volatility (Ann.) [%]	2.826427388	10.06853567	11.94683023	8.309266011
Sharpe Ratio	0	0	0	0

Graph8: The strategy performance with portfolio weights.

4.2 Financial Expansion Robustness

Due to COVID-19, the global stock market is bear from 2020 to 2021. However, Taiwan's stock market is a bull market. Thus, we pick these two years to examine whether considering the weight into our trade can get better profits. However, we discovered optimization strategy we offer couldn't create more profits in an expanding market.

	2454.TW	4469.TWO	2609.TW	2615.TW
Start	2020-01-02 00:00:00	2020-01-02 00:00:00	2020-01-02 00:00:00	2020-01-02 00:00:00
End	2021-12-30 00:00:00	2021-12-30 00:00:00	2021-12-30 00:00:00	2021-12-30 00:00:00
Duration	728	728	728	728
Exposure Time [%]	40.57377049	33.40163934	65.16393443	59.83606557
Equity Final [$]	13106.11428	11347.35173	144561.8158	130094.4652
Equity Peak [$]	21022.42347	13467.16245	276904.3198	135568.4652
Return [%]	31.06114282	13.47351732	1345.618158	1200.944652
Buy & Hold Return [%]	185.5004721	263.0422757	1562.087864	1131.017362
Return (Ann.) [%]	14.99071589	6.744908313	297.2318559	276.1802131
Volatility (Ann.) [%]	30.72310895	27.88979049	288.718277	224.3814961
Sharpe Ratio	0.487929653	0.241841484	1.029487496	1.230851108

Graph9: The strategy performance without portfolio weights.

	2454.TW	4469.TWO	2609.TW	2615.TW
Start	2020-01-02 00:00:00	2020-01-02 00:00:00	2020-01-02 00:00:00	2020-01-02 00:00:00
End	2021-12-30 00:00:00	2021-12-30 00:00:00	2021-12-30 00:00:00	2021-12-30 00:00:00
Duration	728	728	728	728
Exposure Time [%]	40.57377049	33.40163934	65.16393443	59.83606557
Equity Final [$]	10267.10102	10711.65894	140642.9721	122358.1266
Equity Peak [$]	11086.01037	11126.56501	271497.4561	127483.6266
Return [%]	2.671010236	7.116589423	1306.429721	1123.581266
Buy & Hold Return [%]	185.5004721	263.042314	1562.087864	1131.017362
Return (Ann.) [%]	1.370499642	3.613852792	291.6342133	264.4571341
Volatility (Ann.) [%]	6.32980268	9.971228075	280.7512925	209.6622091
Sharpe Ratio	0.216515382	0.362428054	1.038763565	1.261348601

Graph10: The strategy performance with portfolio weights.

5 Discussions

Before starting this project, we assume that fund allocation is related to the industry. However, we discover that fund allocation is more relevant to itself. From the above experiments, we can find that if we use the weight to buy positions, the profits we get will be greater; however, when the market is on an up trend, the weight strategy would not be feasible. In this project, we only do long positions and close them. In the future, we can short positions, discuss the other algorithm trading strategies, and use the moving window approach to training and testing.

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