Momentum: A New Look on the Old World

Haoran Zhang*
Master of Finance, Quantitative, Washington University of St. Louis, St. Louis, Missouri, U.S.
henryzhang.9793@yahoo.com

Zihe Tang
Bachelor of Applied Mathematics, University of California, Los Angeles, California, U.S.
lillytangzihe0915@foxmail.com

Luwei Sun
Bachelor of Computing Mathematics, City University of Hong Kong, Hong Kong, China
lw27596677@gmail.com

ABSTRACT

With the rapid growth of the stock market, many researchers examined the profitability and market efficiency of various trading strategies with the idea of Momentum Investing. This study optimizes the Moving Average Convergence-Divergence (MACD) oscillator and tests its performance under different trading strategies. The research simulates the trading process of 40 U.S. industry portfolios from 1926 to 2021 using different MACD oscillators constructed by the Exponential Moving Average (EMA) indicators of different decay parameters. To acquire the optimal MACD oscillator, the study performs the OLS linear regression analysis on each industry's stimulated excess returns and excess industry portfolio returns and uses the corresponding regression coefficients (alpha and beta) as the assessment criteria of the performance. To further optimize the model, the study improves the traditional trading strategy, the simple-crossover operation, to the n-day holding strategy, which aims to weaken the influence of false signals. The result shows that MACD strategies generally have positive alpha, hinting that investor can utilize this indicator to diversify portfolios and hedge their risks.

CCS CONCEPTS

• **Computing methodologies** → Machine learning; Machine learning approaches; Instance-based learning.

KEYWORDS

Momentum, MACD, EMA, Random Forest, Signal Line, Divergence Series, OLS, Alpha

ACM Reference Format:
Haoran Zhang, Zihe Tang, and Luwei Sun. 2022. Momentum: A New Look on the Old World. In *2022 6th International Conference on E-Business and Internet (ICEBI 2022), October 14–16, 2022, Singapore, Singapore.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3572647.3572684

1 INTRODUCTION

The idea of Momentum Investing assumes that the investors can utilize the continuance of the market's existing trends to enter or exit the market at the proper time. Various momentum indicators generated by different techniques function to evaluate the directions and possibilities of the existing market trends. Applying Momentum on the market, investors aim to buy the stock when the trend of the price starts to go upward and to sell the stock when it achieves the peak.

The debate about whether Momentum Investing is effective has continued for a long time. Opponents of the idea such as Professor Eugene Fama, who proposed the Efficient Market Hypothesis (EMH) in 1960, believe that higher returns only come from higher systemic risks, but the high turnover of momentum makes its risk change too fast and violently to make any potential excess returns [1]. However, given that the emergence of research proved the effectiveness of momentum in different markets, many supporters also believe in momentum's rationality to bring success. As Hedge Funds Manager Dr. Cliff Asness concludes, "[m]omentum's success could be from some irrational behavior and investor biases showing up in prices (2016)." Under such a background where momentum investing is controversial, this research tries to take a closer look at specifically one of the momentum indicators, and tests its performance as well as analyzes its risks over the actual historical data.

In practice, the Moving Average Convergence-Divergence (MACD) oscillator is one of the most commonly used indicators. First applied by Dr. Gerald Appel in 1979, the MACD indicator demonstrates a stock price's trend-following momentum by comparing the difference between two Exponential Moving Averages (EMA) with different weighted factors. Such a difference of two EMAs is known as the MACD series, and a Signal series is further computed by taking a third EMA of this MACD series. Comparing the difference between the MACD series and the Signal series, MACD indicators generate hints on the opportunities of entering or exiting the market. Different from other popular indicators, MACD is a more complex and varied one as it contains three different parameters that can be controlled, and thus any different combinations may lead to totally different results.

Given its popularity, MACD has been studied by various scholars in recent years. Some researchers tend to study the indicator via a single stock, while others test MACD over a whole market. This study differs in that its experimental method is somewhere in between. Using historical returns of 40 industries in the U.S. market, the research weights each industry's stocks into a corresponding industry single portfolio in two methods, equal weighted and value weighted, and performs MACD by industry. While the claim that momentum indicators only work over a short period emerged, this research aims to comprehensively consider and analyze the performance of the MACD indicators over a very long time from 1926

*Haoran Zhang,email: henryzhang.9793@yahoo.com

ICEBI 2022, October 14–16, 2022, Singapore, Singapore

ACM ISBN 978-1-4503-9864-0/22/10…$15.00
https://doi.org/10.1145/3572647.3572684

to 2021. The study compares different combinations of decay parameters to achieve the best MACD oscillators for each industry portfolio.

Another characteristic of this paper is that the research directly uses the decay factors as the MACD controlling parameters, while the majority of existing research used periods of days. (The periods of days and decay factor can be converted to each other, see Appendix1.) The research goes through all possible combinations of three decay factors in the range of [0,0.2], with a different level of 0.02. After obtaining the most optimal parameter choices of each industry's MACD indicator, the research then conducts the simulated trading process under different MACD strategies as well as the buy and hold strategy. In the end, the study analyzes different returns and the alpha coefficient under each strategy to understand the MACD indicator's efficiency as well as risk.

2 LITERATURE REVIEW

There are enormous studies about MACD to verify the efficiency of the parameter settings and optimize the trading rules in various markets. Chong and Ng (2008) focused on the 12 and 26-day EMAs, which are the most used short and long-period EMAs. They found that this MACD (12,26,0) model outperformed the buy-and-hold strategy based on the 60-year data of the London stock exchange [2]. Chong et al. (2014) later took more profound research in the MACD model. They checked different time frames of MACD (12,26,0), MACD (12,26,9), and MACD (8,17,9) models to market data of five OECD countries, such as Italy, Canada, Germany, United States, and Japan, from 1976 to 2002. They generated significant abnormal returns by applying a modified MACD model in the Milan Comit General and the S&P/TSX Composite Index [3].

Many researchers adopted the effectiveness of the MACD with the indicator (12,26,9). The current studies tested the efficiency of this MACD in different markets and different periods. Nor and Wickremasinghe (2014) checked this model based on the Australian All Ordinaries Index (XOA) data in 18 years, from 1st January 1996 to 30th June 2014. Their study indicated that the Australian market could also use momentum trading to generate an abnormal return [4].

Furthermore, current academic researchers aimed to optimize the trading strategies by modifying the trading signal. Kang (2021) introduced newly developed models to lessen the probability of false trade signals interference. They applied 19,456 different MACD models to Japan's Nikkei 225 futures throughout 2011–2019, therefore found the performance resulting from these improved strategies is far more significant for non-optimized models [5].

As shown from the above studies, most past researchers adopted the traditional parameter and used the simple signal as the trading criteria when they prove the effectiveness of the MACD indicators, which missed the potential improvement in the model. For the researchers who optimized both the parameter and trading strategy, such as Kang (2021), their researches chose a relatively short range of years, nearly one decade, thus bringing forth market particularity which made their conclusion less representative.

MACD indicator is often studied alongside other common momentum indicators. Mingyuan and Xiaotian studied the MACD indicator with RSI and KDJ indicators. By combining the three strategies, they were able to generate fairly accurate prediction for the SH and SZ market [6]. Yogesh also combined MACD with RSI and proved that the combination is more effective than both the buy and hold strategy as well as using a single indicator [7]. Steven went as far as testing six different indicators, MACD, AROON, Relative Strength Index, Accumulation Distribution Line, Stochastic Oscillator, and On-Balance Volume. His "findings with respect to return efficiency were mixed but improved significantly when volume conditions were combined with the trend and momentum indicators" [8].

There are also studies that focus on new approaches. Such as the one done by Ziba in 2013. In her paper "Technical analysis of Forex by MACD Indicator", Ziba discussed the effectiveness of MACD under different currency exchange systems. EURUSD was found to be the market where MACD performed the best [9].

3 DATA ACQUISITION AND PREPROCESSING

The research calculates the MACD models and simulates the trading process based on the historical daily returns of 49 industry portfolios from 1926 to 2021 and the corresponding daily risk-free rate, which are sourced from Kenneth R. French's Data Library [10].

Specifically, this research chooses the 49 Industry Portfolios daily returns with dividends included. The original data includes all daily returns from 07/01/1926 to 05/28/2021, calculated based on equal weighted and value weighted industry portfolios, respectively. The research removes the 9 industries of Candy and Soda, Healthcare, Rubber and Plastic Products, Fabricated Products, Defense, Precious Metals, Personal Services, Computer Software, and Business Supplies, as they have missing data in the early years.

Next, the research obtains the daily risk-free rate over the same period of years sourced from French's Data Library, and subtracts it from each daily return to get the excess returns for each portfolio.

Formula for the Excess Return:

$$Excess\ Return = Weighted\ Return - Risk\ Free \tag{1}$$

Lastly, starting with an initial price of $1 on day one, the research calculates the daily portfolio price.

Formula for the Price:

$$Price_{Today} = Price_{Yesterday} \cdot (1 + Excess\ Return) \tag{2}$$

4 METHODOLOGY

4.1 Overall analysis

The research focuses on using the combination of Exponential Moving Average(EMA) indicators with different decay parameters to obtain varied Moving Average Convergence Divergence(MACD) oscillators, and setting up corresponding trading strategies under different MACD signals. The study then tests each strategy's performance by simulating trading processes using historical portfolio data of 40 industries in the U.S. market from 07/01/1926 to 05/28/2021. In comparing each strategy's result, the research conducts the OLS linear regression analysis on each industry's simulated excess returns to the excess market return, and evaluates the corresponding regression coefficients (alpha and beta).

4.2 Momentum investing models

4.2.1 Exponential Moving Average (EMA). EMA is an arithmetic moving average of data over a period of time that weights higher for the most recent data. Each EMA is calculated with a unique decay factor K as the weighting parameter on the latest data. Thus, the higher the decay factor is, the higher the most recent data is weighted. In this research, EMA is calculated by using the daily closing price of the assets, and the most recent data is the closing price of the day.

Formula for the EMA:

$$EMA_{Today} = K \cdot Price_{Todday} + (1 - K) \cdot EMA_{Yesterday} \quad (3)$$

where K is the decay factor.

In this study, for each EMA series with a decay parameter K, the initial value of EMA will be that of the EMA of the$(2/K - 1) + 1$ day. This value is calculated by using the arithmetic mean of previous $(2/K - 1)$ days values.

The 1st day EMA of an n period EMA series:

$$\begin{aligned} EMA_{1st\ day} &= K \cdot Price_{1^{st}\ day} \\ &+ (1 - K) \cdot \sum_{i=1}^{\frac{2}{K}-1} Price_{i^{th}\ day} \div (2/K - 1) \end{aligned} \quad (4)$$

Such an arithmetic mean of a period of values is also known as the Simple Moving Average (SMA). See APPENDIX.

4.2.2 Moving Average Convergence-Divergence (MACD). A MACD oscillator indicates the trend of a stock's price. In this research, denoted as MACD (a, b, c), each MACD indicator uses the decay factors (of EMA) a, b, c as input parameters and includes three series as follows:

- The MACD Series (Line): The difference between a fast EMA with a relatively large decay factor a, and a slow EMA with a relatively small decay factor b.
- The Signal Series (Line): EMA of the above MACD series with a larger decay factor c.
- The Divergence Series (Line): Difference between the above MACD Series and Signal Series.

Formulas for MACD (a, b, c):

$$MACD\ Series = EMA_a\ (Price) - EMA_b\ (Price) \quad (5)$$

$$Signal\ Series = EMA_c(MACD\ Series \quad (6)$$

$$Divergence\ Series = MACD\ Series - Signal\ Series \quad (7)$$

where $b < a < c$ are the different EMA decay factors?

The trading signals are generated by interpreting the behavior of the Divergence Series. To obtain the optimal MACD indicator that leads to the maximum alphas in stimulating trading progress for each industry, this research goes over all possible parameters combinations from 0 to 0.2, with a difference of 0.01 each time.

4.3 Trading strategies

4.3.1 The Buy and Hold Strategy. This is the most classical trading strategy. Within a period of time, investors buy the portfolio at the beginning and sell it at the end, without conducting any other operations. This research utilizes such a trading method to compare and test the performance of the MACD indicator strategies.

4.3.2 The Simple-Crossover operation. This strategy compares the values between the Divergence Series, viewing Divergence Series positive as the time to enter the market and vice versa. Since the MACD indicator is calculated by the stock's closing price of a day, investors can only react to the signals on the next trading day. That is to say, long the portfolios on the next day whenever the Divergence Series goes positive, and short the portfolios on the next day whenever the Divergence Series goes negative.

This study finds the best MACD parameters of each industry by comparing the alphas of simulated transactions under this strategy.

*4.3.3 The **n**-day Holding Strategy (**n**=1).* Instead of immediately reacting to the MACD signals, this strategy waits for another $n$days to evaluate the confidence of the signals. A potential trading signal still appears when the Divergence Series changes its sign, but it can only be viewed as valid if the Divergence Series has maintained this trend after the following n days. The investor will take the corresponding positions the next day. Otherwise, the investor will maintain its previous positions until a valid signal appears. This research takes n=1 as the holding period.

4.4 The Capital Asset Pricing Model (CAPM) and Ordinary Least Square (OLS)

CAPM measures the relationship between the excess return on the market$(R_m - R_f)$and the excess return of the asset $(R_p - R_f)$, which in this study is the excess return of each strategy.

Formula for CAPM:

$$R_p - R_f = \alpha_p + \beta_p \cdot \left(R_m - R_f\right) \quad (8)$$

where $R_m$is the return of the market, $R_f$is the risk free rate.

This research uses a derivation of the CAPM formula:

$$R_p - R_f = \alpha_p + \beta_p \cdot \left(R_{ip} - R_f\right) \quad (9)$$

where $R_{ip}$is the return of the industry portfolio, $R_f$is still the risk free rate.

In this research, after acquiring the simulated trading return under different strategies for each industry, the study calculates the corresponding α_p with respect to the excess return of said industry's portfolio by using OLS. Also, α_p is denoted as zero if it is insignificant.

4.5 Random Forest Model

Random forest is a commonly practiced method in machine learning for finding the optimal value of a certain variable. The process starts with a simulation of a certain objective function over different sets of variables. A single set of variables is then selected based on a certain criterion, for example, picking the parameter that generated the highest objective function value. This research uses random forest to select the set of MACD parameters that generates the largest alpha relative to the excess return of industry portfolios. Such a set of parameters will be called the optimal parameters for said industry.

5 EXPERIMENT & RESULTS

5.1 The Buy and Hold Strategy

Using a starting holding of one dollar, the final holding for each industry portfolio is calculated.

5.2 The Simple Crossover strategy

Similar to the Buy and Hold strategy, this research conducts the Simple Cross Over strategy using a starting holding of one dollar. Firstly, using the generally accepted parameters (in days) of (12,26,9) which is equivalent to parameters (in decay factor) of (2/13,2/27,0.2), the final holding, as well of the alpha and beta for the strategy are calculated for each industry. A zero value in both the alpha and beta rows represent a non-statistically significant alpha for that industry.

While using equal weighted returns, Agriculture, Construction and Real Estate had non-statistically significant alphas. All other 37 industries have a significant positive alpha, which suggests value in this strategy. Something that is of interest is the fact that out of these 37 industries, 36 have negative betas, the exception being Coal. This suggests that this strategy is net-short. Hypothesis such as "MACD indicators work only for shorting" could be further investigated.

While using value-based returns, 6 industries have non-statistically significant alphas, with Medical Equipment, Communication, and Business Service joining the aforementioned 3. Similar pattern could be recognized as all the other 34 industries have significant positive alpha, while all but one industry has negative betas, this time, with the exception of Recreation.

Secondly, the random forest model is run for this strategy. Decay factors ranging from 0.01 to 0.2, with an interval of 0.01 were tested. Restrictions are put in place such that the third decay factor is always the largest and the second is always the smallest of the three. A set of optimized parameters are found for each industry, along with the respective final holding price, alpha and beta for that specific strategy.

Results based on equal weighted returns gave every industry except Agriculture a significant positive alpha, and all 39 of these industries have negative betas. An interesting observation can be made for the pattern of the optimized parameters. The second parameter is almost always close to 0 (the lower limit of possible parameters) while the third parameter is almost always close to 0.2 (the upper limit of possible parameters).

Results based on value-based returns gave all 40 industries significant positive alphas as well as negative betas. 26 industries can obtain more final returns under this strategy, but the extent of their excess returns is very random. The other 14 industries have less profit compared to the returns from buy and hold strategy.

5.3 The n-Day Holding Strategy

As optimized parameters for each industry under the simple crossover strategy are acquired, the research conducts the n-day holding strategy by using the same MACD parameters.

39 industries perform much worse in returns under this strategy, with the only exception of Coal, most of the alpha are insignificant, with the only exception of Recreation that also performs worse in having a negative alpha. All these results illustrate that the strategy of waiting for another n days to react is not a good idea, or at least cannot further improve the given results of those optimized parameters.

While the 34 industries perform much worse, the 6 industries of Food Products, Household, Chemicals, Communication, Business Services, and Measuring and Control Equipment give a better final return under this strategy. However, when consider about the alphas and betas, 5 of these industries result with negative or insignificant alphas, with the only exception of Chemicals that has a much smaller alpha. Thus, the overall performance of the n-day holding strategy is not optimal.

The insight behind the result may come from the fact that MACD is a lagging indicator, which performs well only when the investors can react to its signals quickly. As the market varies in seconds, waiting for another n day to take action makes the indicator far more accurate from the actual market trends.

6 CONCLUSION

Interesting in whether the momentum investing is scientifically reasonable, this research looks into one of the most popular momentum indicators, MACD, optimizes its parameters, and tests its performance under different strategies on 40 industries portfolios in the U.S. market from 1926 to 2021. The results indicate that it is uncertain whether the rapid trading strategies based on this factor can obtain more final returns than a buy and hold strategy, and, in some cases, when applying non-optimal strategy such as the n-day holding strategy, MACD can perform much poorly as the indicator cannot reflect the real market conditions in a timely manner. However, the alpha of MACD's simple crossover strategy is positive for nearly all industries, leading to another hint for investors that they can hedge their risk by applying such a momentum indicator in diversifying portfolios.

APPENDIX

1. Conversion of EMA Period of Days and the Decay Factor

The period of days $(n)$of the EMA is calculated by 1 divided by K:

$$n = 1/\ K \cdot\ \alpha - 1 \tag{10}$$

where α is a factor to make sure that the result of the calculation is always an integer.

2. Simple Moving Average

SMA is a moving average that is equally weighted for every data over the period.

Formula for SMA:

$$SMA_{n\ days} = \begin{pmatrix} Price_{\ 1^{st}\ day} + Price_{\ 2^{nd}\ day} \\ +\ldots + Price_{\ n^{th}\ day} \end{pmatrix} \div n \tag{11}$$

REFERENCES

[1] Asness, C., (2016). Fama on Momentum [online]. AQR Capital Management. Available from: https://www.aqr.com/Insights/Perspectives/Fama-on-Momentum

[2] Chong, T. and Ng, W., (2008). Technical analysis and the London stock exchange: testing the MACD and RSI rules using the FT30. Applied Economics Letters, 15(14), pp.1111-1114.

[3] Chong, T., Ng, W. and Liew, V., (2014). Revisiting the Performance of MACD and RSI Oscillators. Journal of Risk and Financial Management, 7(1), pp.1-12.

[4] Nor, S. and Wickremasinghe, G., (2014). The profitability of MACD and RSI trading rules in the Australian stock market. Investment Management and Financial Innovations, 11(4), pp.194-199.
[5] Kang, B., (2021). Improving MACD Technical Analysis by Optimizing Parameters and Modifying Trading Rules: Evidence from the Japanese Nikkei 225 Futures Market. Journal of Risk and Financial Management, 14(1), p.37.
[6] Mingyuan W. and Xiaotian D., (2015). Technical analysis of three stock oscillators testing MACD, RSI and KDJ rules in SH & SZ stock markets.
[7] Yogesh M., (2015). Optimization of Macd and Rsi Indicators: An Empirical Study of Indian Equity Market for Profitable Investment Decisions.
[8] Steven G., (2015). The Viability of Six Popular Technical Analysis Trading Rules in Determining Effective Buy and Sell Signals: MACD, AROON, RSI, SO, OBV, and ADL.
[9] Ziba, H. L., (2013). Technical analysis of Forex by MACD Indicator.
[10] French, K. R., (2021). 49 Industries Portfolio [daily] [Data Set]. Kenneth R. French - Data Library. [Accessed 27 July 2021]. Available from: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html