

Trading by Time Series Momentum

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1 Introduction

The stock market has trends. People always like utilize the past information to aid their trading decisions. The most common strategy is to long past winners and short past losers. Although this strategy is simple, its efficiency has been validated by many studies, and the researchers calls it as time series momentum (TSMOM). However, since various stocks have distinct trends and nature, the TSMOM is shown to have different performance. In this project, we aim to explore different parameters of TSMOM and compare it with other classical momentum trading strategies: relative strength index (RSI) and moving average convergence/divergence (MACD).

2 Literature Review

The trading strategy that buy past winners and sell past losers has been highly debated. In 1992, a study examines the strategy of building stocks portfolio based on their past 6-month returns and holds them for 6 months [1]. This strategy achieved a compound excess annual return of 12.01 % on average. However, the study also notices that half of the excess returns from past winners and losers in the year following the portfolio formation date dissipate within the following 2 years. This indicates a long-term trend reversal. Two of the most powerful explanation of the early profitability is the systematic risk and delayed stock price reaction to common factors, but the study fails to find the association. Instead, they notice that the regularity of early profitability and trend reversal coincide with the time of earnings announcement date.

In 2012, a new study finds that securities that recently outperformed their peers over the past three to 12 months continue to outperform their peers on average over the next month [2]. This study formally gives such feature the name ‘Time Series Momentum’, which focuses purely on security’s own past return. Such trend is validated by running auto regressive model, where the t -statistics has a significant peak at lag 12. This paper also notes that the time series momentum partially reverse the trend, and the authors propose a theory of initial under-reaction and delayed over-reaction to explain such pattern. Most importantly, this study formally presents the TSMOM as a trading strategy with volatility adjustment. Thus, this strategy is able to have good return in both stable and extreme market condition. Finally, this study also shows that across asset classes, TSMOM exhibits positive correlation with each other, while passive long strategies exhibit zero or negative correlation.

There are also studies discounting the role of TSMOM. For example, the return of TSMOM could be attributed to volatility scaling. A study finds out that without scaling by volatility, TSMOM and a

buy-and-hold strategy offer similar cumulative returns, and their alphas are not significantly different [3]. This similarity appears in individual contract, sector, or portfolio levels.

3 Trading Strategies

3.1 TSMOM

Time series momentum is a persistent theme across many different asset classes and market. Basically, the past 12-month excess return of each assets is a positive predictor of its future return. This trend could continues for a year and then gradually reverses over longer time. For each instrument s and month t , we are interested in whether its excess return over the past k month is positive or negative. If it's positive, we can long the contract and short otherwise.

This strategy focuses on computing the time-t return based on sign of the past return from time $t - k - 1$ to $t - 1$. If the time of holding h is more than 1 month, we would continue compute the return from time $t - k - 2$ to $t - 2$ until we have $t - k - h$ to $t - h$. Thus, for each (k, h) we have a single time series of monthly return by averaging the return of all h portfolios. In this report, we focus on the properties of the 12-month time series momentum strategy with 1-month holding period($k=12$ and $h=1$), which we refer to simply as TSMOM. The TSMOM return for any instrument s at time t is therefore:

$$r_{t,t+1}^{\text{TSMOM},s} = \text{sign}(r_{t-12,t}^s) \frac{40\%}{\sigma_t^s} r_{t,t+1}^s \quad (1)$$

The sign is -1 or 1 based on whether the term is negative or positive. σ_t^2 is the annualized variance for each instrument. We set the position size to be inversely proportional to the instrument's ex ante volatility, $1/\sigma_{t-1}^s$, each month. Sizing each position in each strategy to have constant ex ante volatility is helpful for two reasons. First, it makes it easier to aggregate strategies across instruments with very different volatility levels. Second , it is helpful econometrically to have a time series with relatively stable volatility so that the strategy is not dominated by a few volatile periods. The volatility, σ^2 , can be calculated as the following:

$$\sigma_t^2 = 261 \sum (1 - \delta) \delta^i (r_{t-1-i} - \bar{r}_t)^2 \quad (2)$$

where the scalar 261 scales the variance to be annual, the weights $(1 - \delta)\delta^i$ add up to one, and \bar{r}_t is the exponentially weighted average return computed similarly. The parameter δ is chosen so that the center of mass of the weights is $\sum(1 - \delta)\delta^i = 60$ days. The volatility model is the same for all assets at all times.

After obtaining the time series momentum, the trading strategy depends on 2 factors: the number of months we lag returns to define the signal (look-back period) and the number of months we hold each portfolio after it has been formed (holding period). Compared with passive long, TSMOM strategy could achieve exponentially better return in the market from 1985 to 2009 [2].

3.2 RSI

RSI represents the Relative strength index, which is used in technical analysis as a momentum indicator. It measures the speed and magnitude of a security's recent price changes to evaluate overvalued or undervalued conditions in the price of that security, and can also used to gauge if the market is going

through a bullish or bearish trend [4]. RSI is displayed as an oscillator on a scale of (0, 100). The calculation of RSI includes tow steps.

$$RS = \frac{\text{average gain}}{\text{average loss}} \quad (3)$$

$$RSI_{\text{step one}} = 100 - \frac{100}{1 + RS}$$

In step one, we firstly find the closing price during the period. Then, we calculate the changes in closing price for each days. If the price increases, it is marked as "Gain"; if the price decreases, it is marked as "Loss". Next, we can calculate the average gain or loss during the look-back period. Periods with price losses are counted as zero in the calculations of average gain. Periods with price increases are counted as zero in the calculations of average loss. Notice that we use positive sign for average loss. We usually use 14 days period to calculate the average percentage. Here is an example:

Table 1: changes in closing price for 14 days

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14
%	-2.77	4.79	8.60	-0.18	6.02	1.23	-16.7	9.64	8.68	-0.80	4.88	-1.83	-3.96	-9.09

In this example,

$$\text{average gain} = \frac{0 + 4.79 + 8.60 + 0 + 6.02 + 1.23 + 0 + 9.64 + 8.68 + 0 + 4.88 + 0 + 0 + 0}{14} = 3.13 \quad (4)$$

$$\text{average loss} = \frac{2.77 + 0 + 0 + 0.18 + 0 + 0 + 16.7 + 0 + 0 + 0.80 + 0 + 1.83 + 3.69 + 9.09}{14} = 2.51$$

$$RS = \frac{3.13}{2.51} = 1.24$$

$$RSI_{\text{step one}} = 100 - \frac{100}{1 + 1.24} = 55.37$$

It is generally accepted that $RSI < 30$ indicates "oversold", while $RSI > 70$ indicates "overbought". In step two, we smooth the result so that the RSI only near 100 or 0 in a strongly trending market.

$$RSI_{\text{step two}} = 100 - \frac{100}{1 + \frac{\text{previous average gain}*13+\text{current gain}}{\text{previous average loss}*13+\text{current loss}}} \quad (5)$$

If the current loss for 15th day in the example is -7.97% , then,

$$RSI_{\text{step two}} = 100 - \frac{100}{1 + \frac{3.13*13+0}{2.51*13+7.97}} = 50.06 \quad (6)$$

3.3 MACD

Exponential Moving Average (EMA) is a type of moving average that measures trend direction over time by allocating greater weights to the more recent data and less weights to the more distant data [5]. The formula of EMA is expressed as:

$$EMA = k \cdot \text{Current Price} + (1 - k) \cdot \text{Previous EMA} \quad (7)$$

where k is the weighing factor/multiplier which

$$k = \frac{2}{\text{time period} + 1}$$

MACD, also known as Moving Average Convergence/Divergence, is a momentum indicator and also a type of moving average that follows the trend by subtracting two EMAs with different periods. The following formula is to calculate and construct MACD line:

$$\text{MACD Line} = \text{Fast Length EMA} - \text{Slow Length EMA} \quad (8)$$

The lengths we usually use is 12-day-period (short-term) EMA for fast length and 26-day-period (long-term) EMA for slow length, and it is the best with daily periods. In this case, the weighing factors for these two EMA are:

$$\begin{aligned} k_{12} &= \frac{2}{12 + 1} \approx 0.1538 \\ k_{26} &= \frac{2}{26 + 1} \approx 0.0741 \end{aligned} \quad (9)$$

MACD indicator can be interpreted in different types of methods, for example, crossover, divergence, rapid rise/falls, etc. The most common method is MACD Crossovers. In this method, a signal line is compared with MACD line to reveal a signal of buying and selling the stock. Generally the signal line is a 9-day-period EMA that averages out MACD line itself. The difference between MACD line and signal line is also called histogram, which is used to plot the and identify the trend.

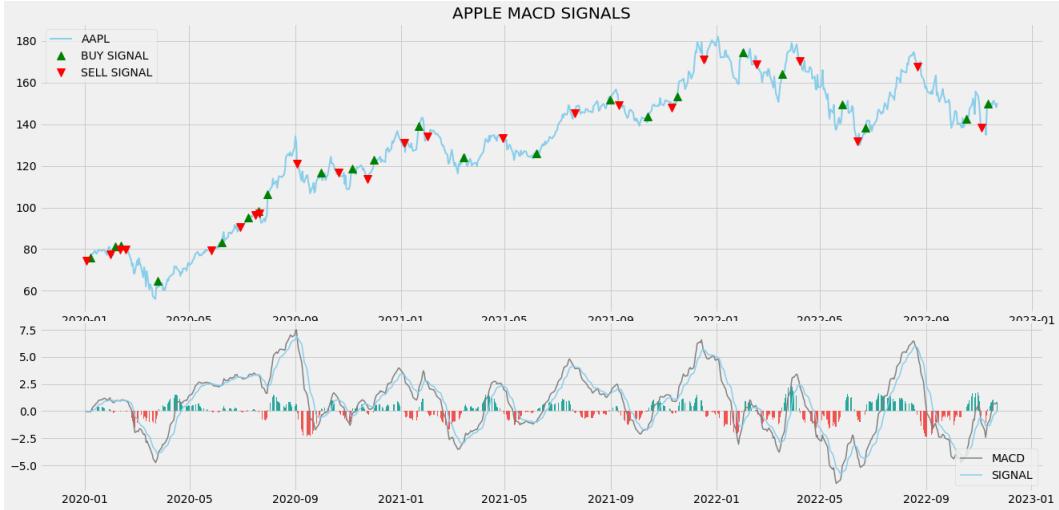


Figure 1: Apple MACD Signals

The plot above shows an example of application of MACD signals, which uses AAPL stock since January 2020. The signal of buying stock appears when MACD line crosses beyond the signal line, and the signal of selling stock appears when MACD line crosses over the signal line.

3.4 Assumptions

In relative strength investment strategies, the goal is not to buy low and sell high—the goal is to buy high and sell even higher. This strategy relies on the basic assumption that current market trends will

continue long enough into the future for investors to capitalize on them. This means that the strategy works best in stable markets with minimal disruption. Otherwise, any sudden disruption will lead to negative results. The MACD strategy mostly relies on the directional assumption. In particular, it assumes that the market would move asymmetrically, and this strategy is to measures the strength of trend, not the change of trend. While the MACD indicator measures the difference between two separate exponential moving averages, the RSI measures the difference in selected price highs and lows in the same chart.

4 Data

In order to backtest the momentum strategy, we used the prices of 10 stocks selected from S&P 500 since the beginning of 2019. These 10 stocks are stocks with largest market capitalization in their sectors. The reason we chose these stocks is because larger market capitalization can result in lower risks, and we were able to obtain more stable backtest results. The stocks and their symbols are shown as below:

Table 2: List of Companies Symbols from S&P500

Sector	Symbols	Company
Commercial Service	SPGI	S&P Global Inc.
Communications	VZ	Verizon Communications Inc.
Consumer Durables	TSLA	Tesla, Inc.
Consumer Non-Durables	PG	Procter & Gamble Company
Consumer Services	DIS	Walt Disney Company
Distribution Services	SYY	Sysco Corporation
Electronic Technology	AAPL	Apple Inc.
Energy Minerals	XOM	Exxon Mobil Corporation
Finance	BRK.B	Berkshire Hathaway Inc. New
Health Services	UNH	UnitedHealth Group Incorporated

On the other hand, we used 10 total e-mini future contracts, which are electronically-traded futures contracts, including 6 commodities futures, 2 equity indexes futures, 1 bond future, and 1 cross-currency forward pair for backtesting as well. The time period is the same as stock prices', which is from January 1, 2019 until now. The future contracts are shown as below:

Table 3: List of Future Contracts

Type	Futures	Symbol
Commodities	Corn	ZC=F
	Gold	GC=F
	Crude Oil	QM=F
	Natural Gas	QG=F
	Copper	QC=F
	Soybean Oil	ES=F
Equity Indexes	S&P 500	ZL=F
	Nasdaq 100	NQ=F
Bond	US 10 Year T-Note	ZN=F
Currency	EUR/USD	M6E=F

* Both of the data are sourced from Yahoo Finance.

5 Backtesting Results

We wanted to perform backtests on the four strategies: Simple TSMOM, TSMOM with Volatility Adjustment, RSI and MACD. We assumed that we invest \$1,000,000 total to the stocks/futures, and we split the investment with equal weight to the 10 stocks/10 futures, which means each stock/future has investment value of \$100,000.

We define the strategy by creating signals using the characteristic of the strategy: 1 for buying and -1 for selling. Also, we create the position: 1 means we long the position, which we buy or own the stock/future, and 0 means we short the position, which we sell or do not own the stock/future. We calculated the daily returns using Close/Price of the stock/future, and obtain the returns of the each strategy by returns times position. First, we concluded the summaries of annual Sharpe Ratio and Cumulative Returns. The formula of Sharpe Ratio is shown as [6], assuming risk-free rate is 0:

$$\text{Sharpe Ratio} = \frac{\text{Return of Portfolio} - \text{Risk-free Rate}}{\text{Standard Deviation of Portfolio's Excess Return}} \quad (10)$$

Also, the cumulative returns are calculated using current total portfolio return divided by the strategy return of first day/month of the time period (Jan 2019) minus 1, which is the increase/decrease percentage of the investment using strategy. Higher Sharpe Ratio and Cumulative Return will lead to better investment performances in the strategy. And we would like to see the profit of the investment gained from the strategies, and the profit percentage of the strategy in each of the stock/future and in total. The backtesting results are shown below, and strategy with the highest profit is highlighted in the table as well.

5.1 Stock Price

Table 4: Stock Price Sharpe Ratio & Cumulative Return by Strategy

	TSMOM		TSMOM with Vol.	
Symbol	Sharpe Ratio	Cum. Return	Sharpe Ratio	Cum. Return
SPGI	0.678	88%	3.448	98%
VZ	0.07	-2%	2.196	32%
TSLA	1.108	648%	2.848	98%
PG	0.07	-4%	2.052	28%
DIS	-0.002	-21%	-0.593	-51%
SYY	-0.263	-53%	-1.009	-73%
AAPL	0.015	-19%	-0.274	-21%
XOM	0.822	149%	2.792	130%
BRK-B	-0.283	-31%	-1.576	-64%
UNH	-0.26	-40%	1.153	29%

Table 5: Stock Price Sharpe Ratio & Cumulative Return **in Total** by Strategy

Strategy	Sharpe Ratio	Cumulative Return
TSMOM	0.689	69%
TSMOM with Vol.	1.745	21.02%
RSI	0.81	64%
MACD	1.27	117.41%

Table 6: Stock Price Profit & Percentage by Strategy

Symbol	TSMOM		TSMOM with Vol.		RSI		MACD	
	Profit	Profit %	Profit	Profit %	Profit	Profit %	Profit	Profit %
SPGI	110923.48	110%	70199.33	70%	63037.24	63%	91972.11	91%
VZ	-8001.02	-9%	-4776.32	-5%	-22584.03	-23%	-29390.32	-30%
TSLA	1238871.44	1238%	719223.89	719%	549050.54	549%	795074.16	795%
PG	-6992.98	-7%	31038.54	31%	28134.06	28%	16986.28	16%
DIS	-34215.99	-35%	-19465.41	-20%	-36657.19	-37%	36970.21	36%
SYY	-88389.55	-89%	-69915.2	-70%	59040.82	59%	12869.13	12%
AAPL	-73496.62	-74%	191504.73	191%	169113.23	169%	335928.41	335%
XOM	98624.34	98%	64363.18	64%	24562.85	24%	61718.58	61%
BRK-B	-38996.87	-39%	-28544.79	-29%	15666.3	15%	79014.85	79%
UNH	-10191.28	-11%	100569.19	100%	140208.64	140%	67490.44	67%
Total	1188134.95	118%	1054197.14	105.00%	989572.46	98%	1468633.85	146%

5.2 Futures

Table 7: Futures Sharpe Ratio & Cumulative Return by Strategy

Futures	TSMOM		TSMOM with Vol.	
	Sharpe Ratio	Cum. Return	Sharpe Ratio	Cum. Return
Corn	0.383	37.96%	0.015	-28.17%
Gold	0.226	18.87%	0.148	47.23%
Crude Oil	0.767	217.57%	0.174	232.21%
Natural Gas	0.087	-47.276%	0.237	154.02%
Copper	0.448	141.59%	-0.149	-239.49%
Soybean Oil	0.186	7.96%	0.3	250.95%
S&P 500	0.769	120.35%	0.058	-0.39%
Nasdaq 100	0.428	42.75%	0.206	95.67%
US 10 Year T-Note	1.149	31.61%	0.333	314.03%
EUR-USD	0.166	4.47%	0.145	42.45%

Table 8: Futures Sharpe Ratio & Cumulative Return in Total by Strategy

Strategy	Sharpe Ratio	Cumulative Return
TSMOM	0.499	73.97%
TSMOM with Vol.	0.342	90.79%
RSI	0.358	29.49%
MACD	0.4468	49.41%

Table 9: Futures Profit & Percentage by Strategy

Futures	TSMOM		TSMOM with Vol.		RSI		MACD	
	Profit	Profit %	Profit	Profit %	Profit	Profit %	Profit	Profit %
Corn	61696	61%	-10695	-11%	42477.75	42%	27615	27%
Gold	4972.52	4%	-2036.79	-3%	21328.99	21%	20897.76	20%
Crude Oil	42511.89	42%	112899.88	112%	74486.62	74%	-116892.38	-117%
Natural Gas	-146539.33	-147%	171707.27	171%	64530.58	64%	31068.87	31%
Copper	137984.05	137%	-148122.15	-149%	-11704.05	-12%	128829.52	128%
Soybean Oil	106890.59	106%	124036.28	124%	34884.68	34%	184212.15	184%
S&P 500	21384	21%	33670	33%	24492	24%	52588.4	52%
Nasdaq 100	71325.8	71%	81308.5	81%	24709.5	24%	58777.76	58%
US 10 Year T-Note	29295.21	29%	22205.48	22%	-19592.22	-20%	-177.61	-1%
EUR-USD	3691.95	3%	2589.29	2%	-9405.85	-10%	-7861.44	-8%
Total	333212.68	33%	387562.76	38%	246138.7	24%	379058.03	37%

6 Comparison

In this section, we compared these strategies by analyzing the backtesting results. We may also find the potential reasons for the differences between the strategies by visualizing the return values for each

stock/future contracts.

6.1 Stock Comparison

In the stock part, we chose 10 different companies from 10 different industries and combined them as a portfolio by equal weights. By implementing TSMOM simply, TSMOM with vol, RSI and MACD strategies, we compared their backtest results and tried to investigate the reason in details.

From the overall backtesting results in 5.1, TSLA has extremely high Sharpe Ratio and cumulative return, compared to other stocks. TSMOM with volatility adjustment improved for most of the stocks by increasing these two return measurements. On the other hand, the Sharpe Ratio of TSMOM with Vol. Strategy and MACD Strategy performed better than other two strategies, which are higher than 1. For the profit table, all the strategies perform well, which has about 100% of percentage increase of investment value of 1 million. Total investment using MACD strategy has the highest profit even when there is 1238% of profit percentage in TSLA using simple TSMOM strategy. For the stock portfolio' performance, the rank was as follows: MACD > TSMOM simple >TSMOM with VOL>RSI.

6.1.1 RSI&MACD

As the two additional indicators except for TSMOM strategy, we first compared these two strategies. For sharpe ratio, cumulative returns and total profit, MACD's performances were always better than those of RSI. But for companies who had the continuing growth trend but frequent fluctuations in a short time, the strategy returns, no matter under RSI or MACD, were lower than the normal return for most of time, which we can clearly see from the following plots:



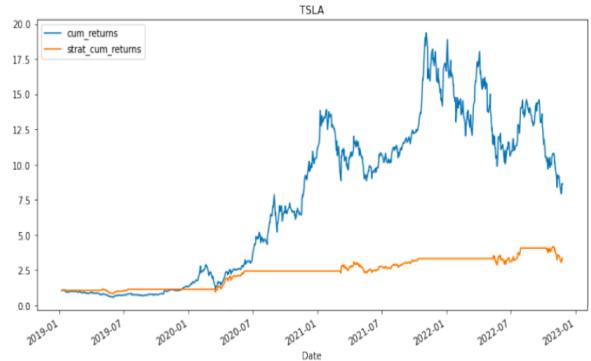
(a) MACD: PG



(b) RSI: PG



(c) MACD: TSLA



(d) RSI: TSLA

These four plots above are the strategy return V.S normal return under MACD and RSI strategies. We can clearly see that for continuing growth trend companies like PG and Tesla, the strategy return looked worse than normal returns. It may be due to the disadvantages of these two indicators.

For MACD, it is a medium and long-term indicator. When the stock price's ups and downs are particularly large in the short time, the MACD has no time to react, because the movement of the MACD is quite gentle, and there is a certain time difference compared with the movement of the market, so once the market rises and falls rapidly, the MACD will not immediately generate a signal, and the MACD will not be effective. However, this late response will be an advantage when the stock falls suddenly but rebounds immediately. For example: the short-time downs for Disney and Sysco companies.(Plots e, f)

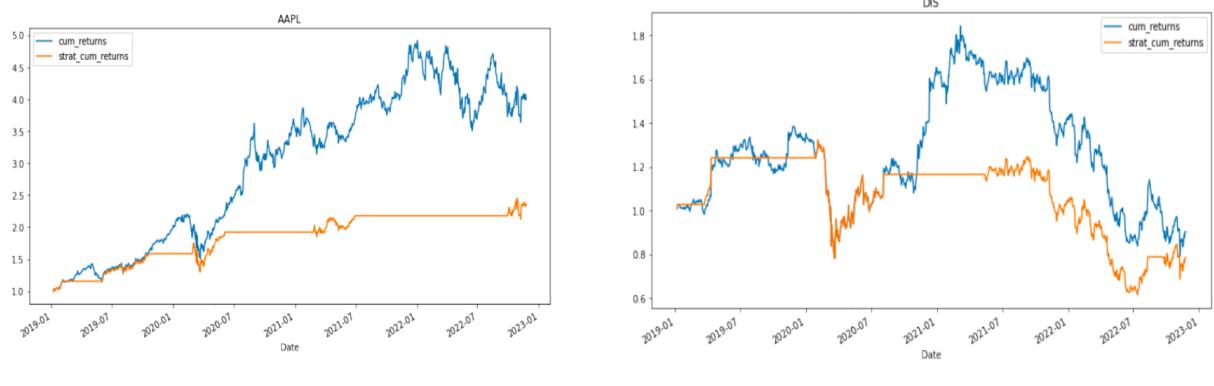


(e) MACD: Disney



(f) MACD: Sysco

For RSI, From the strategy return plots(g,h), we can see that for some ups and downs, the RSI strategy return was a flat line. This is because the sensitivity of the RSI indicators is not enough, and the response is slow. Therefore the phenomenon of missing buying and selling opportunities often occurs. From the Disney trade signal plot below, we can see that even though the RSI indicator fluctuate frequently, the buy or sell signals were rare. In this case, the buy or sell signals were set at '30' and '70' respectively. We think if we adjust these two thresholds closer such as 66.6 and 33.3 respectively, the effect would be better.



(g) RSI: Apple

(h) RSI: Disney

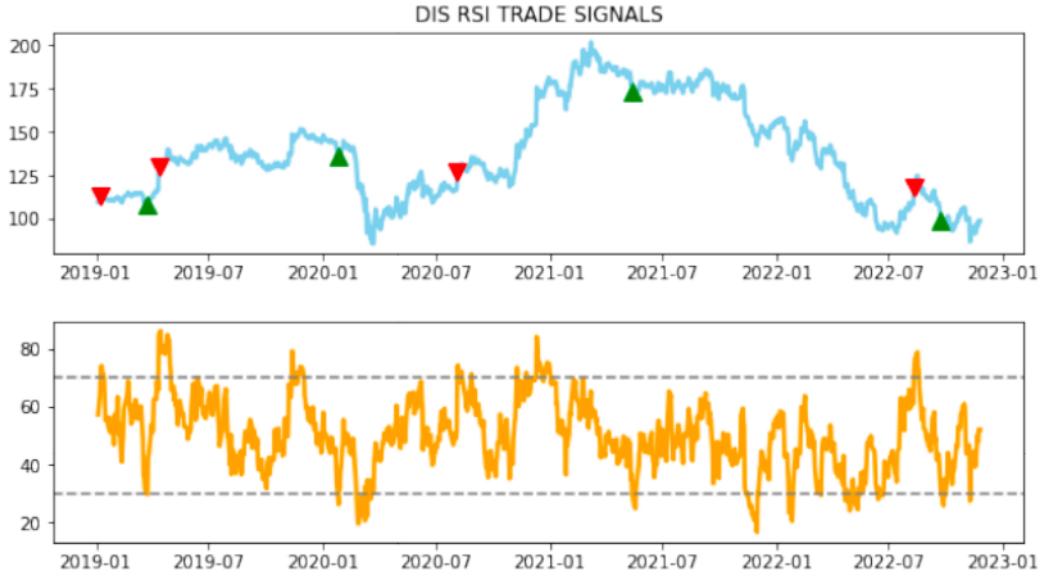
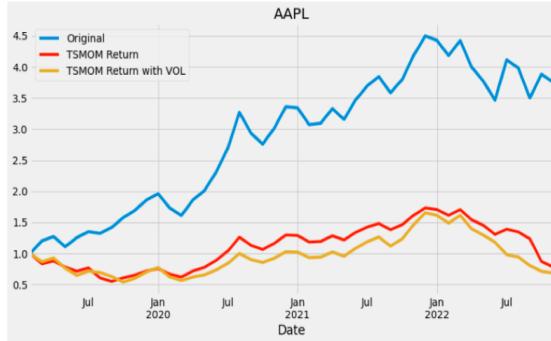


Figure 2: DISNEY RSI TRADE SIGNAL

6.1.2 TSMOM

In this part, we compared the TSMOM simple and TSMOM with volatility. We found that for some stocks who had dramatically increase within one year, like Tesla and Apple, these two TSMOM strategy returns were both not good compared with normal return. And for TSMOM with volatility, its even performed not good as TSMOM sample, which we can see from the figures below.



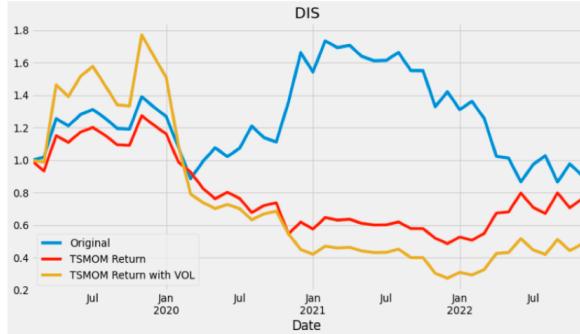
(a) TSMOM: Apple



(b) TSMOM: Tesla

This is because, the look back period for these two TSMOM strategy are both 12 months which means that they are long term indicators. For dramatically ups in the short term, TSMOM strategy will not react quickly enough. Specially for TSMOM with volatility, the return changes would be gentler since the volatility helps the time series more stable.

This late response also would be bad when the stock has a downside period. Even though TSMOM strategy return would not react immediately which would be a good downside protection in a short time, the strategy return would go downside in the long term even when the market had turned into good condition. Like the condition of Disney and Sysco corporation.



(c) TSMOM: Disney



(d) TSMOM: Sysco Corporation

In all, compared with the simple TSMOM, the TSMOM with volatility strategy could aggregate strategies across instruments with different volatility levels and increase the lower limit when the stock had the poor performance even though it reduces the upper limit at the same time. For portfolio, the overall performance under TSMOM with volatility strategy would be stable than the simple TSMOM strategy.

6.2 Future Comparison

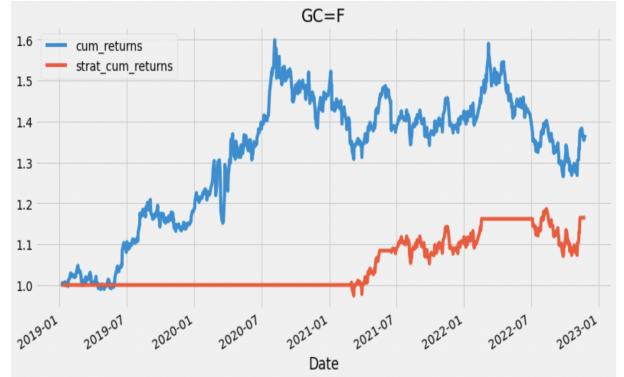
In the Future part, we chose 10 different Futures from CME featured products and combined them as a portfolio by equal weights. By implementing TSMOM simple, TSMOM with vol, RSI and MACD strategies, we compared their backtest results and tried to investigate the reason in details.

Although using strategies on futures gain profit, it is not much great compared to performances on stock price. Sharpe Ratios for TSMOM in this case becomes higher than TSMOM with volatility adjustment. However, the profit gained from using TSMOM with Vol. is still higher than simple TSMOM strategy. MACD still performs better than RSI and TSMOM. From the overall backtesting results in 5.1, for the stock portfolio' performance, the rank was as follows: TSMOM with VOL > MACD > TSMOM simple > RSI.

6.2.1 RSI&MACD

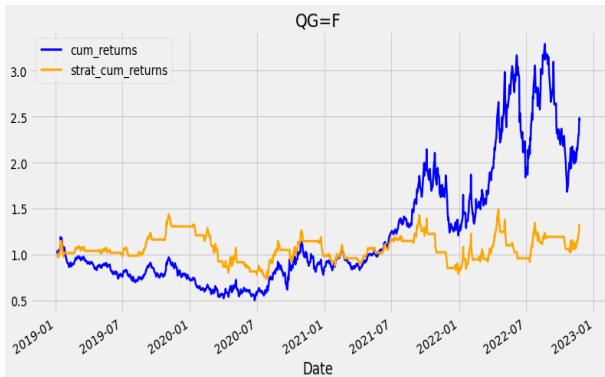


(e) RSI: Corn Future Return

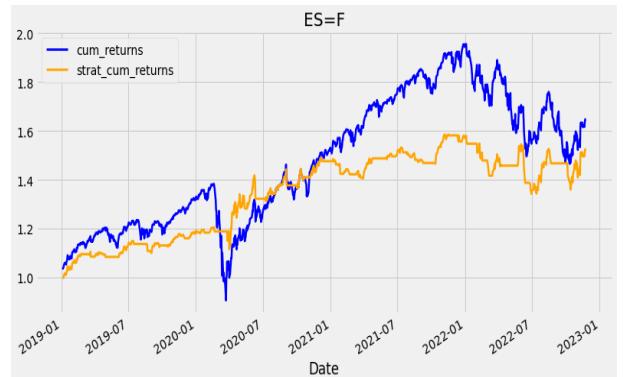


(f) RSI:Gold Future Return

By comparing 10 future's original cumulative return and their RSI cumulative return. We can find that when the original return has a dramatica increase(red line), the cumulative return of RSI strategy will be flat(blue line). Also, only when the original return have a decreasing trend, the RSI strategy can come up with a better result.



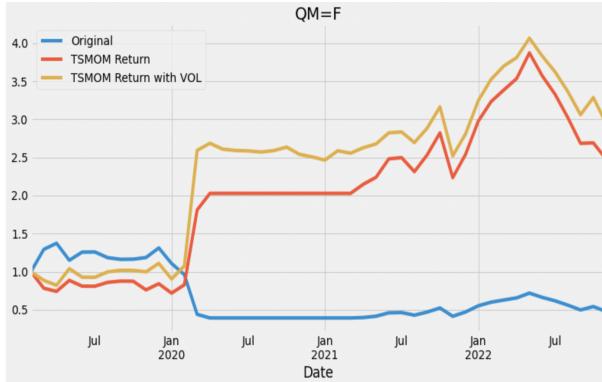
(g) MACD: Natural Gas Future Cumulative Return



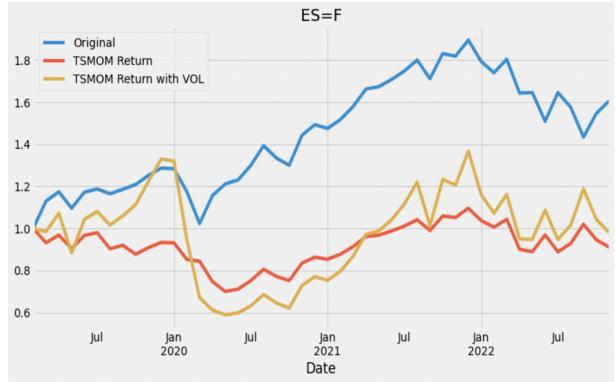
(h) MACD: S&P 500 Future Cumulative Return

In year 2020, the original cumulative return of S&P 500 dropped a lot, while the MACD's return slightly increased during the same period. Therefore, as for the MACD strategy, we also can see the similar situation with RSI. It is obviously that the cumulative return for MACD strategy is higher only when there is a decreasing trend on original return.

6.2.2 TSMOM

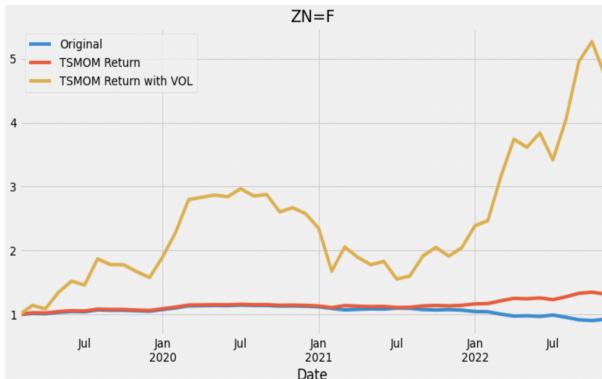


(i) TSMOM: Crude oil Future Cumulative Return

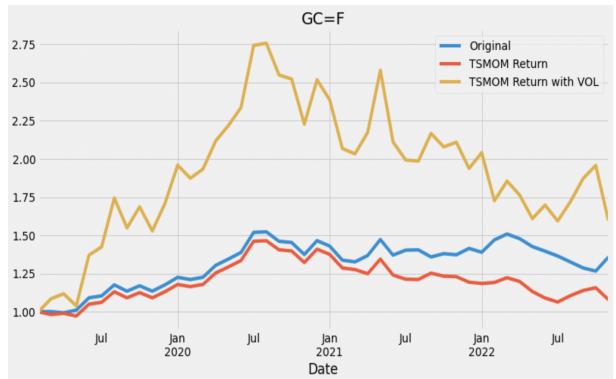


(j) TSMOM: S&P 500 Future return Cumulative Return

From the above plots, there was a huge difference between original cumulative return and TSMOM cumulative return. Therefore, we can conclude that if there is a significant drop, it will be better to use TSMOM strategy. Besides, if we think that our Future cumulative return will increase a lot, it will be better to keep the current future instead of longing or shorting them.



(k) TSMOM: 10-Year T-Note Future Cumulative Return



(l) TSMOM: Gold Future Future Cumulative Return

We also can see that when the original cumulative return was steady, which means the volatility was small, the TSMOM strategy with VOL has larger return than the others, while the return of TSMOM without VOL remained similar with original return.

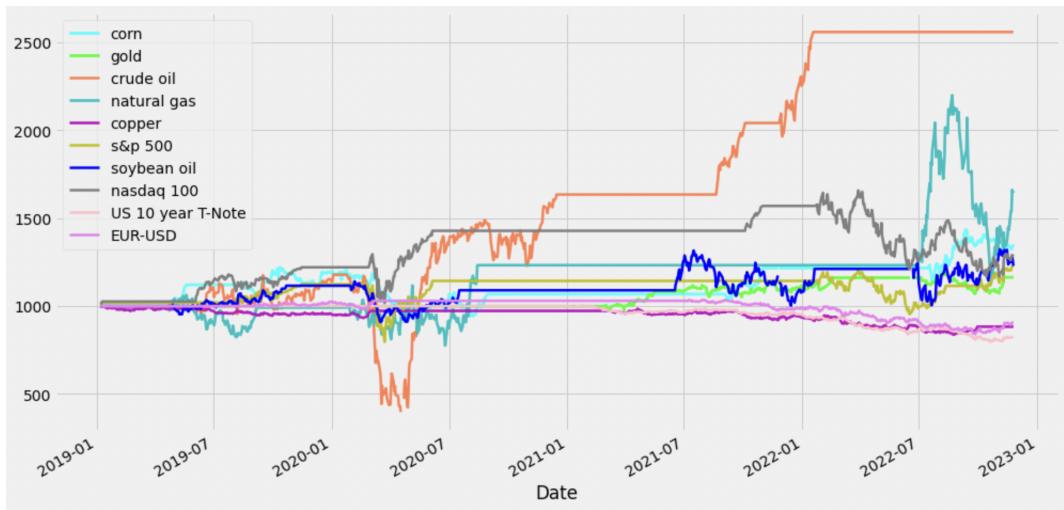


Figure 3: 10 Futures RSI Cumulative Return

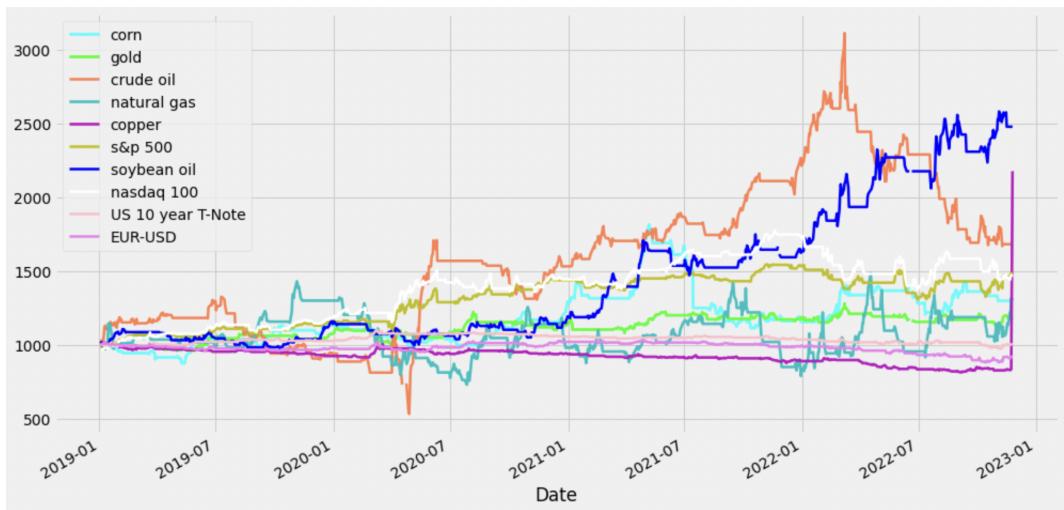


Figure 4: 10 Futures MACD Cumulative Return

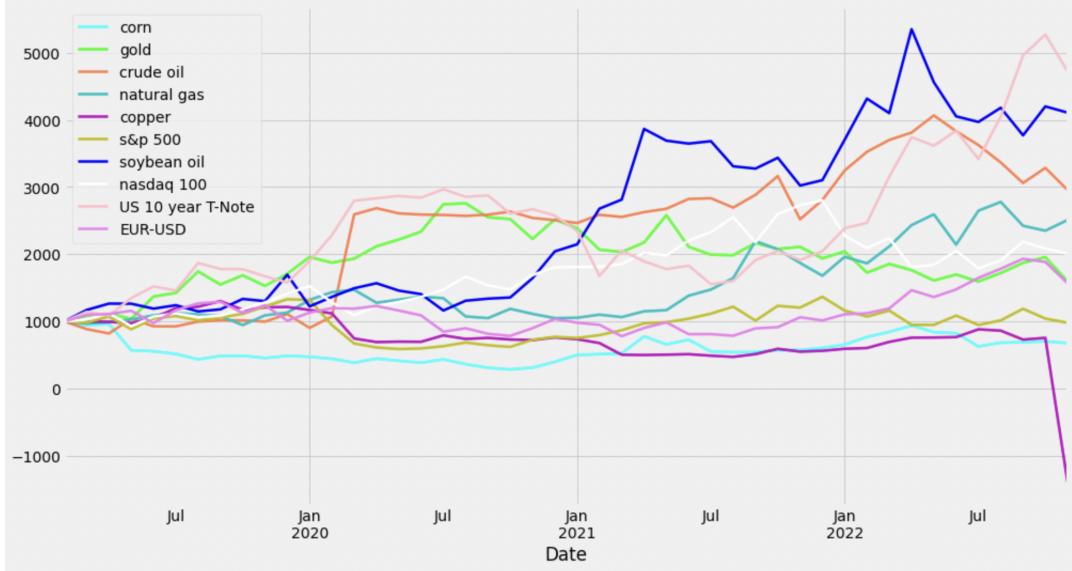


Figure 5: 10 Futures TSMOM Cumulative Return

According to the three strategy's plots, for the TSMOM strategy, we can easily see that the cumulative return of EUR-USD future significantly decreased and lose 1000 after August 2022, while the other two still have profits, especially for the MACD, the profit increased suddenly. We know that at that time, the euro has fallen below parity with the dollar, diving to its lowest level in 20 years and ending a one-to-one exchange rate with the U.S. currency. This fun fact also tell us we should not make decisions to long or short our Future only by the previous cumulative return, which may cause huge lose.

Besides, by comparing the three plots, we can find that the cumulative return of RSI strategy has relatively steady trend. It is more likely to stay same when the original return have a steadily increase, while the others have a slight increase.

7 Recommendation

Based on the previous analysis and the comparison of 10 Future plots(which can be seen in the Appendix), we know that MACD and RSI strategy works better for a decreasing trend, which means they will give us the similar signal to long or short.

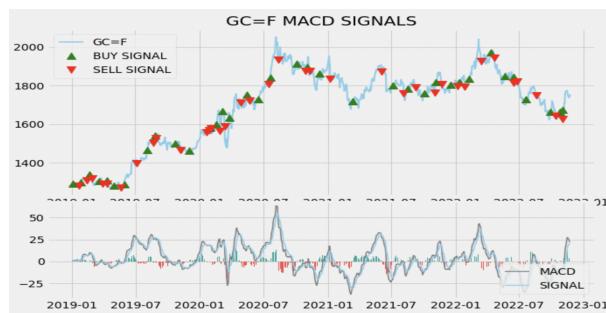
However, they all have some disadvantages. For RSI, The positive reversal only appears in bullish trends. This reversal appears when the instrument reaches a higher low and the RSI reaches a lower low. The so-called ‘lower low’ is not located in oversold territory, but tends to be between the 30 and 50 lines. On the other hand, the negative reversal only appears in bearish trends. This reversal appears when the instrument reaches a lower high and the RSI reaches a higher high. The so-called ‘higher high’ tends to be located between the 50 and 70 lines – not in overbought territory.

As for MACD, its indicator could issue what's known as a ‘false signal’. One example of this is if a bearish divergence exists on an hourly chart, with prices hitting new lows despite the fact that they are not in accordance with the indicator's reading (which wouldn't be showing a similar low).

Therefore, we recommend to forecast the future profit by combining these three factors. Here is an example about Gold Futures.



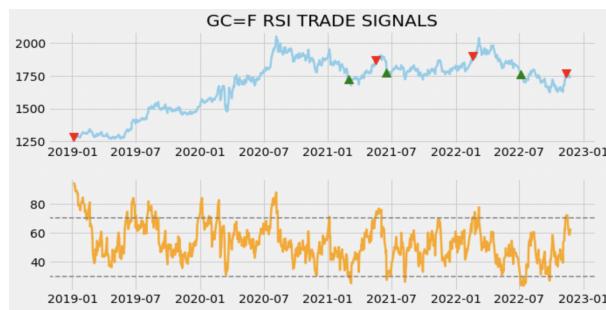
Figure 6: Gold Close Price



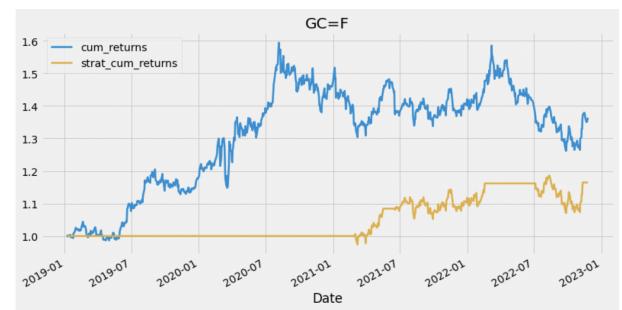
(a) Gold MACD



(b) Gold MACD Cumulative Return



(c) Gold RSI



(d) Gold RSI cumulative return

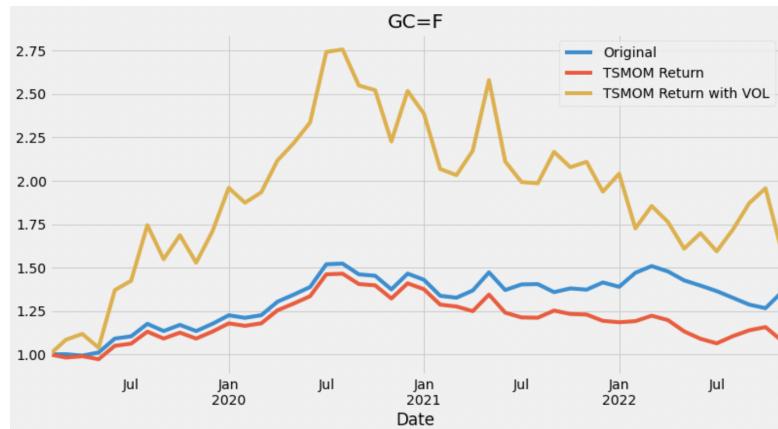


Figure 7: TSMOM: Gold Future Cumulative Return

Firstly, for the Close Price plot, there was a significantly increase from Mar. 2020 to Aug. 2020, during that time the Covid-19 pandemic continued to spread across the world and the gold future price increase a lot. This relates to the fact that the spread of the virus increases uncertainty with regard to the future of economic and financial markets, causing the demand for gold to increase and in turn pushing prices upwards, a trend which may be likely to continue until a vaccine or other treatments begin to stabilize the global economic outlook. Based on the following plots, the MACD strategy's signals change a lot while the RSI strategy prefer to keep the current Futures and the TSMOM strategy decide to long all the futures. As a result, the RSI return are less than the original return while the MACD strategy make more money than the RSI. What impressed us a lot was the TSMOM strategy, it has a dramatic increase than the original return [7].

In conclusion, RSI is a more steady strategy while TSMOM is more risky. And for the future analysis, it is perfect if we have same signal for the three strategies. However, if they have different signal, we recommend firstly check the MACD signal, if MACD have a obvious decrease trend, we can wait until RSI have a sell signal and then short the Futures. On the other hand, if we want to make more money, we can take risk to use the TSMOM strategy.

8 Dynamic weighted RSI

Among all 4 methods we mentioned before, RSI performed not good compared to others. So, we improved it by using dynamic weights. In the previous section, one of the assumption for our investment using RSI method was that every stock was equally weighted and do not changed. In the improvement, we firstly assumed the stock was invested at the equal weights for 2019. Then we reinvest based on the return of each stocks. We firstly calculated the percentage of each stock's return in the portfolio, this represented the change percentage of the weight. Then utilized the following formula to calculate the primary changed weighted.

$$\text{new weights}_{\text{step one}} = \text{previous weights} (1 + \text{weights change percentage})$$

In the above formula, if the stock made loss in the previous, the weights change percentage would be negative; if the stock made gain in the previous investment period, the weights change percentage would be positive. Noticed that the sum of weights now is not equal to 1, So, we re-scaled the weights by the step two formula:

$$\text{new weights}_{\text{step two}}^i = \frac{\text{new weights}_{\text{step one}}^i}{\sum_{i=1}^n (\text{new weights}_{\text{step one}}^i)}$$

In the above formula, i represented different companies. In this method, we need to update the weights in a valid period, but the question is that each stock have different investment period. So, we set another assumption here: the update period is set to be 1 year. This means we sell all of our stock at the end of year. If the RSI indicates that we should hold this stock until next year, we still sell it at the end of the year and buy it back at the start of the next year. Then sell it as the RSI indicates. So, for 2019, the weight is 0.1 for each stock. After calculation, the weights for the investment in 2020, 2021 and 2022 are listed:

Table 10: Weights for 2020

SPGI	VZ	TSLA	PG	DIS	SYY	AAPL	XOM	BRK-B	UNH
0.09	0.09	0.1	0.09	0.1	0.1	0.13	0.09	0.1	0.11

Table 11: Weights for 2021

SPGI	VZ	TSLA	PG	DIS	SYY	AAPL	XOM	BRK-B	UNH
0.09	0.09	0.1	0.09	0.1	0.1	0.13	0.09	0.1	0.11

Table 12: Weights for 2022

SPGI	VZ	TSLA	PG	DIS	SYY	AAPL	XOM	BRK-B	UNH
0.07	0.09	0.1	0.09	0.11	0.1	0.12	0.09	0.09	0.14

From the table, we can see that the weights did not change too much. One of the reasons is that these ten stocks are the largest company within its industrial, so their stocks are quiet competitive in this portfolio. Another reason is that we just tested 3 years data. The weight change maybe more obvious in a long period. As for the results, the new method increases the total return slightly.

For the improvement, one of the reasons is that in our case, after buying VZ company's stock in 2021 by using simple RSI method, we hold it even the stock price have already increased significantly. Our assumption of not holding stocks at the year end accidentally cut the losses by selling it at the end of 2021 and did not buy it back in 2022. As we stated before, the weights would changed more obviously in the long period. So, setting a longer investment period may have a better performance. In addition, this change will be more significantly when the stocks in the portfolio is more diversified.

9 Appendix

9.1 Contribution of Each Team Member

Xin Tan: Introduction, Literature Review, Assumptions, TSMOM Strategy, RSI Strategy, Simple TSMOM Strategy Coding

Olivia Qu: Stock Price Comparison & Coding, TSMOM Strategy with Volatility Coding, Stock Price Backtest Coding, Returns & Sharpe Coding

Iris Wu: Data, Backtest Results, MACD Strategy & Coding, Backtest Coding

Shiyue Wang: Futures Comparison & Coding and Visualization, Profit Coding, Recommendation

Wenlu Dong: RSI Strategy, RSI with different weight Coding, Optimization

9.2 Code

Code and other visualizations of the project can be found at <https://github.com/yw110-1/Time-Series-Momentum-Strategy..>

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