Quantitative trading strategy Report:

Mean reverting strategy

By

Shiyu Jiang / Jason

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Group No.3

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Abstract

The development of quantitative trading strategies is going as fast as technology

improves. There are lots of complex strategies. As a beginner, our group chooses a simple and executable strategy during the project.

We go through several understandable strategies and then choose to realize the mean-reverting strategy. Our group members separate the strategy into several steps and make the logic clear, then we use python to program it and get the result of figures and back-testing.

Besides, we analyze the data that we got after running the python back-testing program and try to change the parameters to make the results more beautiful. During the process, a deeper understanding of how to implement a quantitative trading strategy is received.

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Introduction

Quantitative trading strategies are only a few decades old. The development of programming and the speed of computer speed the process up. It was discovered that computers could make money on their own in the market simply by completing a sequence of code and applying unique logic and trading techniques. Computers have many advantages that human beings do not, such as fast speed, resolute execution of orders, and so on. As a result, quantitative trading strategies have quickly taken over parts of the trading market, but have always held most people back because of their high mathematical and programming barriers.

The project's goal is to construct a complete strategy and using a programming language to realize it and get the returns. In this case, members will get a basic overview of the logic of strategy and a direct understanding of back-testing results. At the same time, let members be able to exert the knowledge of mathematics and programming in the real world.

As for our group, we decide to implement a strategy that follows the logic of mean-reverting. We suppose the price will go up and down but always near the value of the mean, so the strategy will have a chance to short high and long low. The strategy is to bet that when prices deviate from the mean, there is a greater chance that they will revert rather than continue to deviate. This paper will analyze all the details and show the final results.

Literature review

This paper focuses on the mean regression strategy, so we focus on the strategy and its related aspects. We know that in the case of market turbulence, mean regression strategy can play a more efficient role. However, when the market price has momentum, the strategy does not seem to perform well. After the completion of the mean regression strategy, whether we can judge the market state and integrate with the momentum strategy is the focus of our next step.

Firstly, some researches have already proved that the mean reverting strategy does make a good sense. According to Bali, Demirtas and Levy in 2008, their paper shows that "when the market level declines substantially, mean reversion tends to cause it to have a significantly positive drift so that the market is pulled strongly back to some long run average level over time." However, we can also realize that the market will not always has a reversion or the trend is not obvious. In this case, momentum strategy would be better, so Wu and Balvers in 2006 proved another theory. They constructed a strategy that combines momentum and mean reversion and it typically yielded excess returns of around 1.1-1.7% per month and generally outperform pure momentum and pure mean reversion strategies. Therefore, Serban in 2010 mentioned about one method that can confirm mean reversion and momentum. He adopted the Jegadeesh and Titman (1993) strategy to the deviations from UIP (uncovered interest parity theory). Although it can only apply to forward foreign exchange contract, it still give some enlightenments here.

Overall, the literature points out cons and pros of mean reversion strategy and

how to improve. It also introduces some methods to combine mean reversion and momentum which give some extra information about further research.

Methods

This kind of mean-reverting strategy will follow a simple rule to realize buying and selling instruction. It will set several parameters according to what the original data gives us, and they are simple moving average (SMA), a difference of close price and SMA, and position which is used to set a signal for trade. After operations above, the next procedure is back testing. Some indicators such as sharp ratio, drawdown, volatility, and yield rate will be calculated, and besides, the data will be transferred into figures to be more vivid.

I.   Strategy and Procedure

The strategy will assume that the value of the market has the nature of reverting, which means their prices will always back to the normal standard when they are offset too much compared to the average prices. According to this thought, we construct an easy rule, setting a parameter as the threshold, when the price out of the scope, the trade will be triggered. Sell where prices are high and buy where prices are low. In short, we bet the possibility of the appearance of reverting prices is higher when the price is out of our setting scope. In this case, there are some chances to make profits.

II.   Data and Parameter

In the first place, HS300 from 2008 to 2015 will be treated as the experimental data. All the results will base on HS300's daily close prices. The mean of the close prices of the last five trading days will be calculated as the simple moving average.

As for the threshold, we directly set a suitable value according to the figure 1.1, just make sure there are enough opportunities here for the trade happens. Also, I will talk about several options for the threshold to choose from later.

At last, to estimate the efficacy of the strategy, we will choose several back-testing parameters, and they are maximum drawback, maximum drawback duration, volatility, sharp ratio, and annual yield rate.

III.   Analysis and Reporting

Generally speaking, the strategy is not a successful one, since the back-testing results are not satisfying. Especially as for the sharp ratio, normally the value should around 1 and 2. But according to ours, it is negative though it is very close to zero. Our professor's recommendation here about the situation is that the set parameter of risk-free interest rate is too high (4%) which makes the yield too low. In this case, it is advisable to make the change, and I also realize that strategic positions are all closed on the same day, so we can ignore the risk-free rate. When I set the risk-free interest rate as zero, everything goes normal and I realize my calculation of the sharp ratio is wrong which also has a severe influence on the result.

As for the value of SMA, there can have some discussions here. We choose the value of the average of five days, but to make the data more accurate or suitable to the

situation, we can use ten-days SMA, even fifteen-days SMA. More days are calculated, a stronger relationship related to history, so it all up to the strategy maker's preference for historical data.

Next, talking about the choices of the value chosen for the threshold, we have considered about three standards at the beginning of the project. They are the standard deviations, the percentage of the SMA, and the number set directly. For the standard deviation, it will be a good choice since it describes the extent of the deviation of the historical prices, so we can take the standard deviation of values of the past several days as a threshold. The number of days can also be chosen with reference to the discussion in the previous paragraph. For the percentage, for instance, I can set 80% of the SMA and 120% of the SMA as the thresholds.

On the whole, we find that the yield of this strategy is very low. Due to time and capacity constraints, we only consider how to complete the whole strategy, without carefully selecting the parameters described above. Moreover, in the setting of the opening signal, there may be a better method. Judging from the results, we have missed a large part of arbitrage opportunities.

At last, some words for the back-testing data. Although we have the results of most of the important parameters, we need to perfect them. To improve the results, we can also calculate the benchmark data and compare it with the strategy. Besides, we can not only get those data, but also need to make them more efficient and satisfactory, which will be covered in the next section.

IV.   Improvement and Further Plan

For reasons of time, this strategy is only the most basic understanding about the

mean reversion. The literature has given us a general direction, which is to combine mean reversion strategy and momentum strategy, and apply some mathematical methods to solve it. The lack of mathematical knowledge application is also a weakness of this strategy, and maybe the reason why the yield is unsatisfied. So that's the next step we need to think about.

Besides, I hope to make the back-testing data more perfect and the data visualization more beautiful.

Result and discussion

The following are the results and discussions of the strategy result according to the data we collected. The data analysis of some parameters of the strategy, followed by consolidated tables and figures can give a further demonstration of the data.

I.   Visualization of Strategy's Data

1.1 How to set the signal of trading
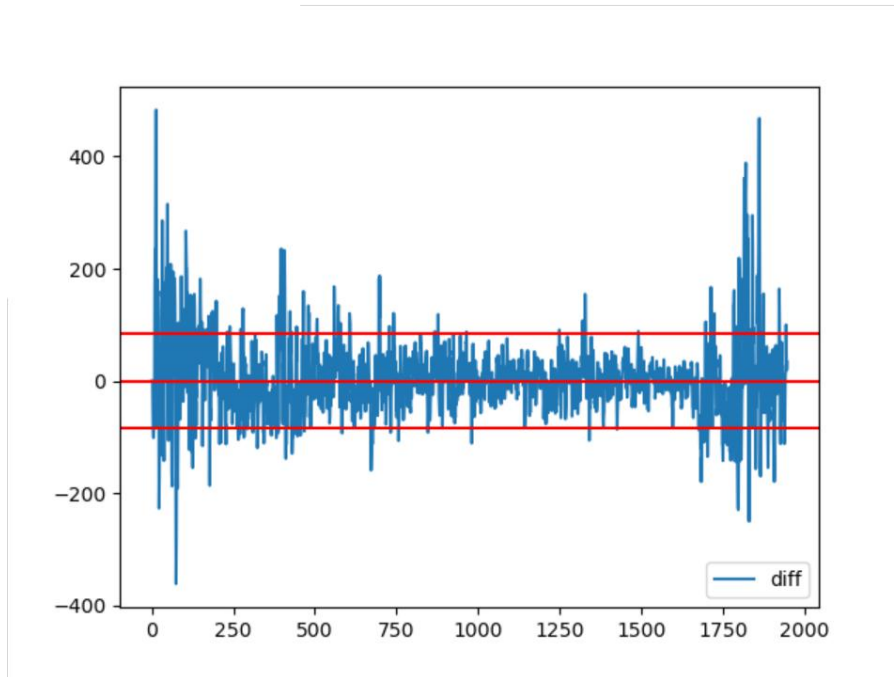
Figure 1.1 – **Difference and the line of threshold**

This figure would give us a further understanding of the threshold and make it visualized. The upper and down red lines represent the two thresholds lines which calculated against the value of difference, which is the red line in the middle. In this case, it is clear to figure out the time when the traders should make purchases. Also, according to this figure, the approximate threshold can be set and then using the results of back-testing to set an accurate value.

1.2 Trend of daily close prices

Figure 1.2 – **Curve for daily close price of HS300**

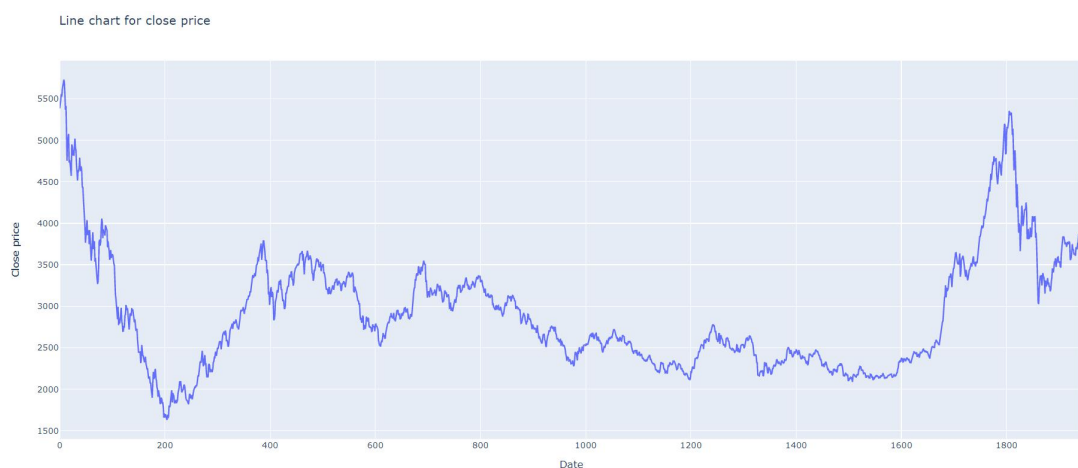There is the curve of the daily close price of the HS300 index. It is also a auxiliary figure, which assist us to judge the trend of the price and to double check if the yield is right. From what the result got, the conclusion is that the difference is much varied at the head and tail part than the middle part. It is also corresponding to the figure 1.1. It shows that the market pattern at the head and tail is volatile, there will be more arbitrage opportunities.

1.3 The outcomes of all the parameters and data calculated during the computing

	A	Date	Oprice	MaxPrice	MinPrice	CPrice	SMA	std	diff	position	yield_Rate	strategy_re	return_cum	strategy_cu	index	Cumulative	drawdown	Max_dra
2	0	20080102	5349.763	5404.928	5283.448	5385.103	0	0	0	0					0			0
3	1	20080103	5381.147	5422.673	5315.948	5422.034	0	0	0	0	0.006858	-0.00016	1.006858	1	1	1		0
4	2	20080104	5430.63	5499.085	5422.456	5483.65	0	0	0	0	0.011364	-0.00016	1.0183	1	2	2		0
5	3	20080107	5480.442	5569.152	5455.501	5556.593	0	0	0	0	0.013302	-0.00016	1.031845	1	3	3		0
6	4	20080108	5575.95	5630.624	5485.234	5528.054	5475.087	63.92777	-52.9672	0	-0.00514	-0.00016	1.026546	1	4	4		0
7	5	20080109	5507.116	5614.678	5490.305	5613.758	5520.818	64.9766	-92.9402	0	0.015503	-0.00016	1.042461	1	5	5		0
8	6	20080110	5631.645	5707.667	5602.594	5672.154	5570.842	65.9427	-101.312	1	0.010402	-0.00016	1.053305	1	6	6		0
9	7	20080111	5688.563	5702.572	5629.638	5699.147	5613.941	65.29046	-85.2058	1	0.004759	0.0046	1.058317	1.004759	7	7.004759		0
10	8	20080114	5717.525	5756.919	5679.287	5731.757	5648.974	71.79064	-82.783	1	0.005722	0.005563	1.064373	1.010508	8	8.015267		0
11	9	20080115	5743.431	5754.107	5652.04	5696.45	5682.653	39.32013	-13.7968	0	-0.00616	-0.00632	1.057816	1.004283	9	9.01955		0
12	10	20080116	5642.566	5642.566	5498.39	5505.717	5661.045	79.94456	155.328	0	-0.03348	-0.00016	1.022398	1.004283	10	10.02383		0
13	11	20080117	5445.803	5533.65	5226.639	5365.624	5599.739	141.643	234.115	-1	-0.02545	-0.00016	0.996383	1.004283	11	11.02812		0
14	12	20080118	5358.183	5419.57	5307.496	5414.468	5542.803	147.3422	128.3352	-1	0.009103	-0.00926	1.005453	0.995141	12	12.02326		0
15	13	20080121	5424.64	5434.349	5122.463	5145.734	5425.599	179.9025	279.8646	-1	-0.04963	0.049474	0.95555	1.044533	13	13.06779		0
16	14	20080122	5015.428	5032.245	4708.388	4753.868	5237.082	269.0702	483.2142	-1	-0.07615	0.075995	0.882781	1.124078	14	14.19187		0
17	15	20080123	4787.171	4976.272	4751.499	4975.111	5130.961	245.825	155.85	-1	0.04654	-0.0467	0.923866	1.071763	15	15.26363		0
18	16	20080124	5034.533	5079.796	4926.374	5027.213	5063.279	216.7681	36.0658	-1	0.010473	-0.01063	0.933541	1.060539	16	16.32417		0
19	17	20080125	5022.896	5121.408	4966.519	5077.429	4995.871	133.4836	-81.558	0	0.009989	-0.01015	0.942866	1.049946	17	17.37412		0
20	18	20080128	5038.507	5038.507	4711.277	4731.883	4913.101	142.8745	181.2178	0	-0.06806	-0.00016	0.878699	1.049946	18	18.42406		0
21	19	20080129	4742.901	4845.658	4688.728	4762.083	4914.744	141.0698	152.6608	-1	0.006382	-0.00016	0.884307	1.049946	19	19.47401		0

com_Result

Table 1 – **Outcomes of all results of calculations**

Those outcomes will be recorded as a form of excel. It allows us to check the middle values during the calculation if there are something wrong and inaccurate. Programmer would have a chance to see the mistakes and quickly repair them.

II.   Back Testing

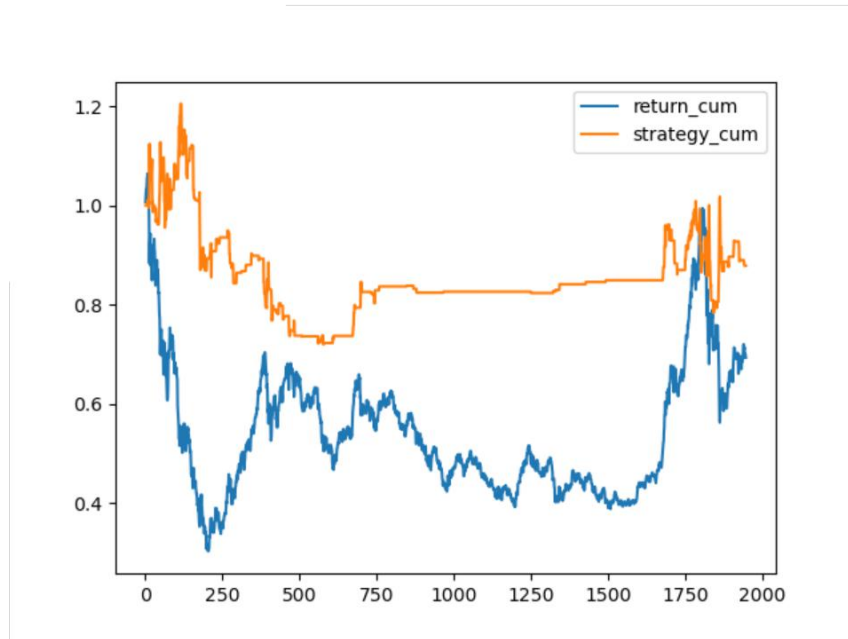2.1 Comparison between cumulative benchmark return and strategy return

Figure 2.1 – **cumulative yield rate curve**

The two curves clearly show the different cumulative yield rate trends of the benchmark and strategy. From the figure, we can see that the performance of the strategy outperforms the benchmark during most periods of time. But at the tail, it not shows very well and was exceeded by benchmark once. Also, the result is bad, since their return is only near 1% which means it even cannot exceed the risk-free interest rate, it is something that we need consider about next.

2.2 Trend of cumulative strategy yield rate

<center>Figure 2.2 – **Curve for cumulative strategy yield rate**</center>

This figure shows the curve for the cumulative strategy yield rate, which figure 2.1 has already shown. However, it makes some differences, since it is plotted by the library called Plotly. By using this tool in python, we can zoom in and out the figure to carefully consider a particular period of time. The operation is hard to show in the paper, but it does is very convenient and has a concise interface.

2.3 Daily yield rate of the strategy
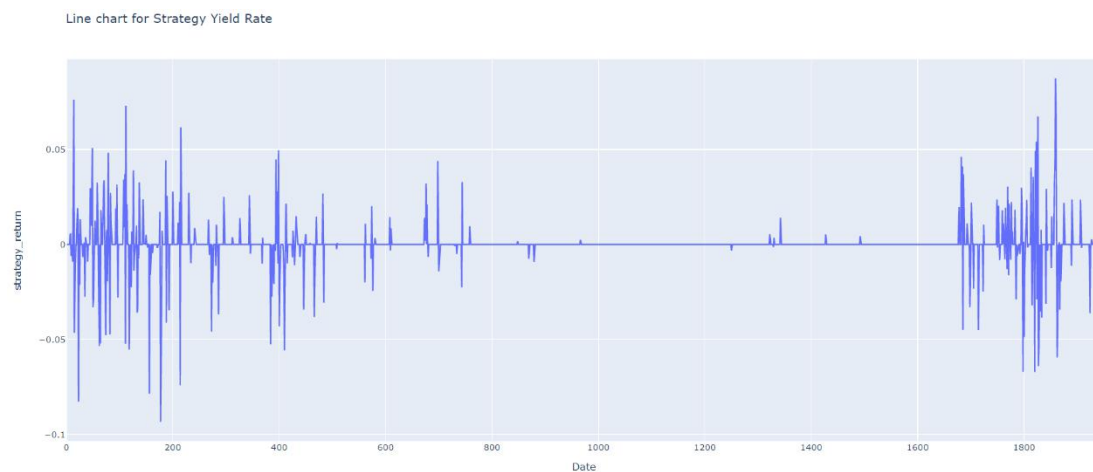
<center>Figure 2.3 – **Curve for daily strategy yield rate**</center>

The figure shows a curve for the daily strategy yield rate. Similarly, it is also plotted by the Plotly library. From the figure, we can clearly find out that the positive and negative yield mostly happens at the beginning and the end. There almost no trade activities in the middle, that is why the yield rate is so low. Besides, the non-trade situation is also shown in other figures indirectly. It is a problem that is needed to figure out.

2.4 Back testing data

Maximum Drawdown	872.86%
Maximum Drawdown Duration	1755 days
Annulized Volatility	0.329781
Daily Volatility	0.020774
Sharpe Ratio	-0.01527
Annual Yield	0.113718
Benchmark volatility	?
Benchmark annual yield	?

Table 2 – **Back testing data**

At last, it is a table that shows all the back-testing data. Most of them are not very good. The most important reason is that there is a long period of time that has no trade activities. It causes a large drawdown and an extremely long drawdown duration. The value of volatility is nearly normal. As for the sharp ratio, I have talked it before, because of the miscalculation of the formula and the exorbitant risk-free interest rate, its value is inaccurate. The annual yield rate is 0.113 which is correct and also needs improvement. Finally, some parameters of the benchmark, it still waits for the finish.

Conclusion

This part I will briefly talk about some feelings and what I have learned from the project.

First of all, I am grateful that professor and TA make me as the group leader. During the cooperation with my group members, though we are from difference places and difference majors, we overcame most of the difficulties to make our strategy complete. From my side, I accumulated some experiences about how to

assign tasks and communicate with group members by different ways.

Besides, back to the project itself, through the lessons the professor taught us, I have learned a lot of knowledges of this field. I learn python myself and never apply it to solve real problems. This is my first time of using python to finish a large project and run it completely and successfully, which enhances my confidence largely. Also, through searching for the Internet and checking all related information about the strategies, I have constructed a basic outline of being a quantitative trader.

Finally, it is a pity that we cannot finish the project in Beijing, since we can have more communication and exchange about studying and the understanding of strategies. But I also learn a lot from the answers to the questions that our class members put out and the presentation the other groups shown at the last day. All in all, I am satisfied with my own effort toward this project.

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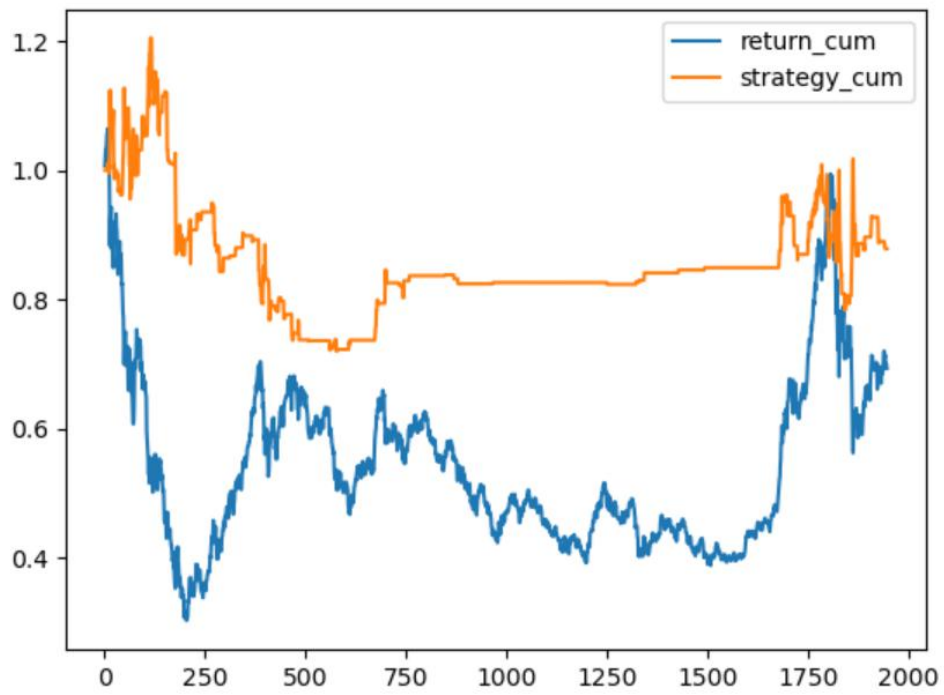https://doi.org/10.1016/j.jbankfin.2007.05.013

Jegadeesh, N., Titman, S. (1993). Returns to buying winners and selling losers: Implications for stock market efficiency. *The Journal of Finance*. 48(1993). 65-91. DOI: 10.1111/j.1540-6261.1993.tb04702.x

Appendices
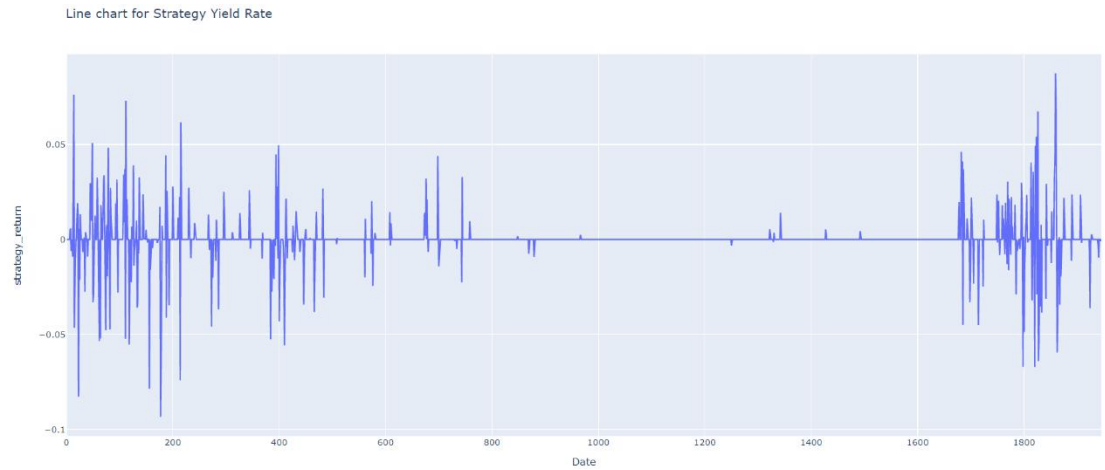
Appendix 1: Figures and tables of data and results.
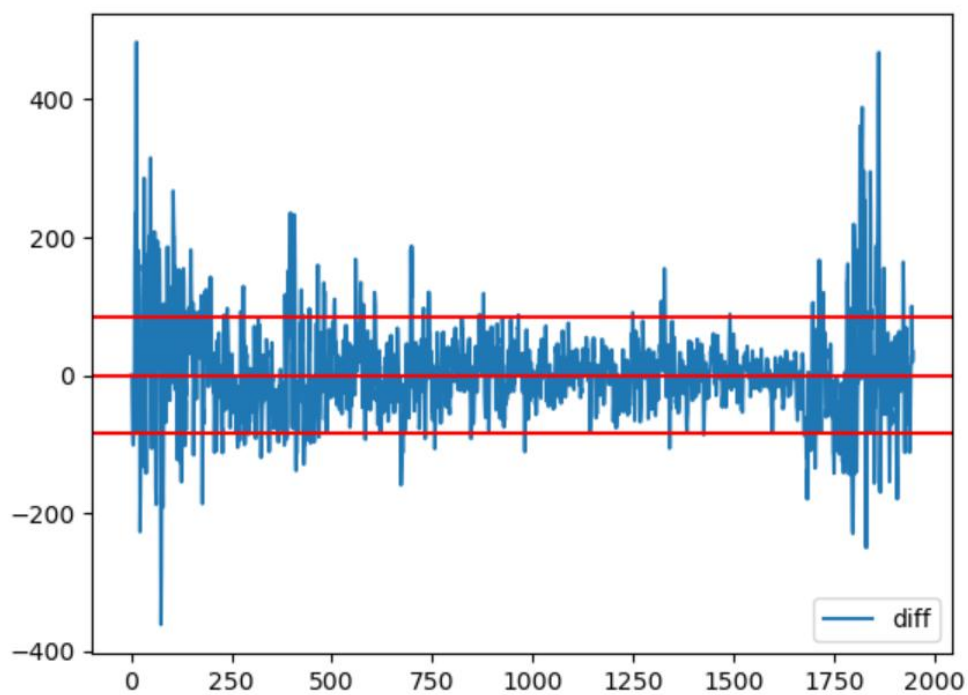
Line chart for close price

Line chart for Cumulative Strategy Yield Rate

Line chart for Strategy Yield Rate

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1		Date	Oprice	MaxPrice	MinPrice	CPrice	SMA	std	diff	position	yield_Rate	strategy_re	return_cum	strategy_cu	index	Cumulative	drawdown	Max_dra
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19	17	20080125	5022.896	5121.408	4966.519	5077.429	4995.871	133.4836	-81.558	0	0.009989	-0.01015	0.942866	1.049946	17	17.37412	0	
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21	19	20080129	4742.901	4845.658	4688.728	4762.083	4914.744	141.0698	152.6608	-1	0.006382	-0.00016	0.884307	1.049946	19	19.47401	0	

com_Result

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Annual Yield	0.113718
Benchmark volatility	?
Benchmark annual yield	?

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