Project of Artificial Intelligence in Finance_Final V.pdf

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Project of Artificial Intelligence in Finance

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Abstract

Referring to the requirements of the Quantopian platform contest, we have written seven strategies after studying the platform's tutorials, including strategies based on RSI, controlling leverage, pairs trading, differential trend motion, designed-factor, turtle trading, and momentum effect. We analyze the principles and results of the strategies above to see which strategy performed best.

I. Introduction

Quantopian is a place for learning quant finance. The advantage of this platform is that it has a packaged library to facilitate writing quantitative strategies, provide data, and have a ready-made backtest framework.

For example, the Pipeline API is a powerful analysis tool.Specifically, after a variety of data are processed and analyzed in a unified manner through the pipeline, we can output the results we want.

As another example, one of the libraries provided by the platform, the quantopian.optimize library, is convenient for users to choose their own investment portfolios and calculate weights according to the constraints set by them, so they can be easily used in subsequent strategies.

Our strategies including:

Strategy based on Relative Strength Index, a technical indicator basing on the theory of supply-demand balance to measure stock's or market's intrinsic strength or weakness.

Control leverage strategy which is doing momentum strategy while keep account leverage limited to 2.5x.

Pairs trading involves a long-short position when the spread is substantially away from its mean value, betting that the mispricing is likely to correct itself.

Differential trend motion strategy uses OLS to estimate the moving average of differencial price and creates the supported line and restricted line to do the trading.

Assets with high designed-factor values are considered high-value ones and then determine the portfolio.

Turtle trading, a well known trend following strategy that was originally taught by Richard Dennis. The basic strategy is to buy futures on a 20-day high (breakout) and sell on a 20-day low.

Momentum effect, refering to assets with higher returns in the past, which will still obtain higher returns in the future, and assets with lower returns in the past will still receive lower returns in the future.

The following are the principles, results, and analysis of our strategies.

II. Trading Strategies

1. RSI Strategy

1.1 RSI trading strategy:

1.1.1 The main idea of our trading strategy:

For the first 240 min (bar_length=240), we put in data in the bar. At any time t after the first bar, we can input the bar data collected from the former bar to RSI and make predictions on t+1 (forcast_length=1), and then, we can decide which position we should take(long or short), based on the forecast price and the price at t. At t we can also decide how many stocks we should long or short at t based on the forecast price, the price at t and our the transaction fee. When the time comes to t+1, we can decide whether we should close the position based on the real price at t+1.

We also set many parameters, there meaning can be listed as follow:

Table 1. Parameters

parameter	meaning
bar_length	The length of input data. We put the data in the bar_length to the "generate_bar" function in the auxiliary.
forcast_length	The length of data which is generated from the output of the RSI model. It is the output of the last"generate_bar" function in the auxiliary.

1.2 Mathematical models analysis of Relative Strength Index(RSI)

Following are the three models mainly considered by our group, in this part, we do the modeling analysis and justify why we prefer RSI Model.

1.3 RSI Model

1.3.1Model introduction

Relative Strength Index(RSI) is a technical indicator basing on the theory of supply- demand balance to measure stock's or market's intrinsic strength or weakness. It calculates the percentage of upward change over total change in some trading period basing on everyday closing price.

$$\frac{\text{average of upward change in n days}}{\text{average of upward change in n days+average of downward change in n days}} \times 100.$$

The formula is:

The RSI formula provides smoothed moving average to ignore some irregular fluctuation. The range is [0, 100]. 50 level is the mid-line to divide uptrend and downtrend. 30 and 70 levels are marked as high and low levels. Usually, 20 and 80 levels are seemed as extremely high and low levels indicating strong momentum. 50 is the point when the long and short signal balance.

Usually, these are the long signal:

1. When the index is above 50 but not too high(about 85) , it means that the stocks' gain is greater than the loss.

2. When the index drop into the extremely low region(like less than 15). Which means the stock is in oversold region.

3. Bottom divergence condition: This condition always happens when the RSI is below 20. When the stock price has been falling all the way, while the RSI formed a trend of going higher.

The short signal is similar but exactly the opposite.

1.3.2Our RSI strategy

Calculation of RSI indicator:

If the closing price of n minutes is higher than n-1 minutes, set:

the n minute increase= closing price of n minutes-(n-1) minute closing price otherwise we set:

n minute decrease= (n-1) minute closing price-n minute closing price Then, we set:

RS = n minute increase/ n minute decrease

RSI = 100-100 / (1 + RS)

bar_length:240 min

(we set this because we tried many bars, among those this performs best)

long signal:

For data in a bars, if they have:

1. 50 <RSI <80(when the market is optimistic and is expected to go up)

2. RSI <15(when price is too low and is expected to go up)

3. Let f1 be the number of close(i)<close(i-1) for every i in this 240 minutes, g1 be the number of RSI(i)<RSI(i-1) for every i in the 240 minutes, if f1>35 while g1<25.

(Bottom divergence condition)

Then we long 1 stock at next bar unless the current cash balance is less than 30,000.

Pattern for short signal:

For three sequential bars (each bar is 15 minutes long), if they have:

1. 20 <RSI <50

2. RSI> 85

3. Let f2 be the number of close (i)> close (i-1) for every i in this 45 minutes, g2 be the number of RSI (i)> RSI (i-1) for every i in this 45 minutes, if f2> 35 while g2 <25. then we short 1 stock at next bar.

1.3.3Performance

Initial Investment: $0.5 million; time horizon: January 1, 2015 - January 1, 2020

The cumulative return is 34.45% and drawdown is -38.24%.

Figure 1: Performance of RSI strategy

2. Turtle Trading Strategy

2.1 Introduction of Turtle Trading Strategy

Turtle trading is a well known trend following strategy that was originally taught by Richard Dennis. The basic strategy is to buy futures on a 20-day high (breakout) and sell on a 20-day low.

The turtle strategy is essentially a trend tracking model, which uses the DonchianChennel breakthrough method to determine the entry and exit signals. The DonchianChennel was invented by Richard Donchian and consists of 3 different curves. The indicator uses the highest price and the lowest price in the period (n) to show the market price volatility. When the channel is narrow, it means that the market volatility is small. Broad means that the market is volatile.

Basic method: when the price breaks the upper rail, it is a buy signal; conversely, when the price breaks the lower rail, it is a sell signal.

The calculation method of this indicator is: upper line = Max (highest price, n) lower line = Min (lowest price, n) midline = (upper line + lower line) / 2

In addition to the basic entry conditions, the Turtle Trading Law also needs to decide: fund management (position control), stop loss conditions, position addition and subtraction management, exit criteria, etc.

Fund management: The core idea of fund management is to determine the variable parameter N by observing the true volatility (TR) within a certain period, and use N to control positions, increase or decrease positions, take profit and stop loss levels.

About N value: N value is the core of position management. N value is very similar to the average true volatility ATR of technical indicators.

True amplitude: is the largest of the following three values

1. The volatility of the highest and lowest prices on the current trading day

2. The fluctuation of the closing price of the previous trading day and the highest price of the current trading day

3. The fluctuation of the closing price of the previous trading day and the lowest price of the current trading day

Position: When opening a position for the first time, that is, when the price breaks through Tang Chian's track, buy 1 Unit. The significance is to make a fluctuation of N value correspond to the fluctuation of 1% of the total funds held. If you buy 1 Unit (unit) of assets, the amplitude of the day makes the change of total assets not exceed 1%. Adding positions: If the price has increased by 0.5N on the basis of the last purchase (or adding positions), add a unit.

Dynamic Stop Loss: When the price is 2N lower than the last purchase price, sell all stop losses.

Take profit: When the stock price fell below the lower edge of the Tang Chian channel on the 10th, clear the position to end the transaction.

We can see that in fact the biggest feature of the turtle strategy is not how much gain is obtained but the control of the maximum backtest to ensure the safety of the principal.

The Turtle Trading Rule is not just at the stage of the indicator system, it has really formed the prototype of the trading system, and covers all aspects of trading. This rule leaves no room for traders to make subjective imagination decisions, thus giving full play to the advantages of programmatically operating the system.

2.2 Results

Figure 2: Performance of turtle strategy

3. Momentum Trading Strategy

3.1 Introduction of Momentum Trading Strategy

Momentum effect refers to assets with higher returns in the past, which will still obtain higher returns in the future, and assets with lower returns in the past will still receive lower returns in the future. Momentum effect was proposed by Jegadeesh and Titman (1993). They believe that the return of stocks has a tendency to continue the original direction of movement, that is, stocks with higher returns in the past period will still achieve higher than average returns in the future.

Momentum effect is to study the past historical market and predict that the past market willcontinue.

3.2 Results

Figure 3: Performance of Momentum strategy

4. Differential Trend Motion Strategy

4.1 Literature review and introduction

In the previous research, there is a quantitative approach is named Q-Quant (Q is quantitative). This approach introduces the random walk into the pricing of assets. Random does not mean that the price cannot be forecast at all. The volatility and trend also can be described by Geometric Brownian motion (Mikosch, 2012) and other process. By applying Ito integral, Black-Scholes model (Ursone, 2015) is used in pricing the derivatives. However, this approach assumes that there is no arbitrary space in the market, thus the price will regress to value sharply thus no one can make sure the constant return in the long term. Therefore, this research proposed a strategy called Differential Trend Motion combining the statistical analysis of OLS and logical framework of Q-quant.

4.2 Data selection

The stocks used to run the following strategy are AINV (Apollo Investment Corporation and ANF. (Abercrombie & Fitch Co.) The daily transaction data including open price, high price, low price and close price of two stocks are collected from Quantopian platform. Since, the trading system of Quantopian cannot support trading at special price, we rebuilt the back-testing system at the Jupyter-notebook platform of Quantopian. The timeline is from January 2nd, 2004 to May 22th, 2020. The first 80% of stock index data are training data and the rest of 20% (roughly from 2017 to 2020) are testing data.

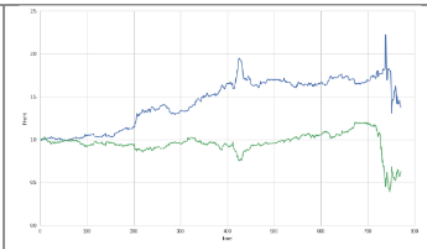
4.3 Results

For the details of differential trend motion model and optimal startegy of model, please refer to Appendix. The following table show optimal startegy for two stock.

4.3.1 Optimal back-testing results with compounding for two stock

Table 2. Optimal back-testing results with compounding

index	**AINV**	**ANF**

The optimal growth of accumulated return (blue line is the strategy performance and green line is benchmark which is buying and holding strategy)	 **Figure 10: The return of AINV**	 **Figure 11:The return of ANF**
Optimal order	677	1635
Annual return of strategy	0.12205754	1.09299462
Annual return of benchmark	-0.12091812	0.03012813
Sharp ratio of strategy	0.18268332	1.02593541
Sharp ratio of benchmark	-0.59718986	-0.01028494
Daily maximum drawdown	-0.31120463	-0.36371073
Daily 5% VAR of strategy	-0.04851153	-0.11235758

From above table, it is clear that in the testing period (most recent 800 days to May, 2020), the annual return, sharp ratio of this trading strategy outperforms the Buy& Hold strategy. For stock ANF, its average annual return can achieve 109%, which is really impressive.

5. Psy strategy

Based on the API of Pipeline, I can select assets by the method of flitering, set a function to determine the value of assets, and assign weights to each asset in the portfolio. Based on this idea, a simple strategy was set up.

As for the trading space, QTradabelStockUS in Quantopian is large enough, so set QTradabelStockUS as the trading space of the strategy and use the parameters inside.

The Pipeline API has many built-in functions available. Using the data set in quantopian.pipeline.data.psychsignal, I use the simple moving average and bull_minus_bear index in the stockwits module to define a three-day moving average curve, and get the object which is named psy. Therefore, this strategy means that assets with high psy values are considered high-value assets and vice versa. Then, based on the psy value of the asset and accepting some restrictions, find a target portfolio with the highest profit.

This strategy rebalances once a week and the execution time is set to the beginning of the first trading day of the week. After the objective is defined, three constraints are defined. The first one is the ratio of each asset to all assets held. This is for the purpose of risk diversification. The ratio set in the strategy is 0.05, which means that the maximum share of an asset in all assets cannot exceed 5%. The second one is the leverage ratio. In the strategy, the leverage ratio is set to 1, that is, short selling is not allowed. The third is the turnover rate.The turnover rate is set to 0.60 according to the contest criteria, which means that all assets cannot be changed at the same time in one rebalance.

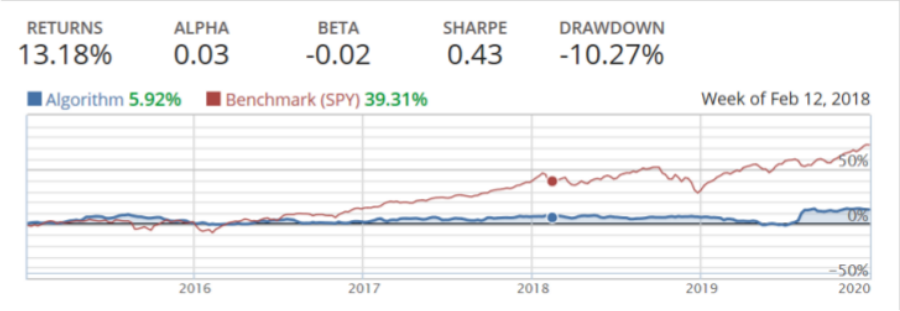


Figure 4: Performance of Psy strategy

It can be seen that this strategy does not outperform the benchmark. Therefore, I think that for complex financial markets, simple models cannot construct effective strategies, and the factors used are too subjective and worth improving.

6. Pairs trading strategy

6.1 Model introduction:

The general theme for investing in the marketplace from a valuation point of view is to sell overvalued securities and buy the undervalued ones. However, it is possible to determine that a security is overvalued or undervalued only if we also know the true value of the security in absolute terms. But, this is very hard to do. Pairs trading attempts to resolve this using the idea of relative pricing; that is, if two stocks whose prices showed similar behavior over a long period of time (i.e., they are historically correlated), then the prices of both securities must be more or less the same. The spread is computed using the quoted prices of the two securities and forms a time series. Pairs trading involves a long-short position when the spread is substantially away from its mean value, betting that the mispricing is likely to correct itself. The positions are then reversed and profits made upon converge. In this project, we will look at one version of pairs trading in the US equity markets; namely, statistical arbitrage pairs.

Statistical arbitrage pair trading is based on the idea of relative pricing. The underlying premise in relative pricing is that stocks with similar characteristics must be priced more or less the same. The spread in this case may be thought of as the degree of mutual mispricing. The greater the spread, the higher the magnitude of mispricing and greater the profit potential.

For being a successful strategy, it is of great importance to know when to initiate the pairs trade and when to close all positions.

6.2 Stock selection

JD.COM (‘JD’), Alibba (‘BABA’), Apple Inc. (AAPL), Microsoft Corporation (‘MSFT’), Concho Resources Inc. ('CXO'), Poineer Natural Resources Compa ('PXD'), Analog Devices Inc. ('ADI'), Texas Instruments Incorporated ('TXN'), McDonald’s Corporation ('MCD'), Coca-Cola Company('KO').

6.3 Our strategy

Instead of trading just one pair of stocks, I traded all possible pairs among 10 stocks. In other words, I am trading 45(10 choose 2) pairs simultaneously.

Idea of the Multiple Pair Trading Strategy:

Step 1 : Define hedged spread : Spread = Stock1Price – HedgeRatio x Stock2Price

Step 2 : Define Z-score : Z-score = (SMA30(Spread) - Spread) / STD30(Spread)

Step 3 : Short spread when its value rises above 2 standard deviations (Z-score >EnterThreshold); long the Spread when its value rises above 2 standard deviations (Z-score < -EnterThreshold).

Step 4 : Exist any spread position when its value is within 0.2 standard deviation of its mean (Exit the short position if Z-score <ExitThreshold; exit the long position if Z-score > -ExitThreshold)

Step 5 : Trade all possible pairs among selected securities.

6.4 Parameter Setting:

Hedge ratio (the numbers of shares of the second security versus one share of the first security): perform a regression analysis to determine the hedge ratio

N_days = 30

EnterThreshold: -2; ExitThrehold: 0.2

6.5 Performance

Initial Investment: $0.5 million; time horizon: January 1, 2015 - January 1, 2020

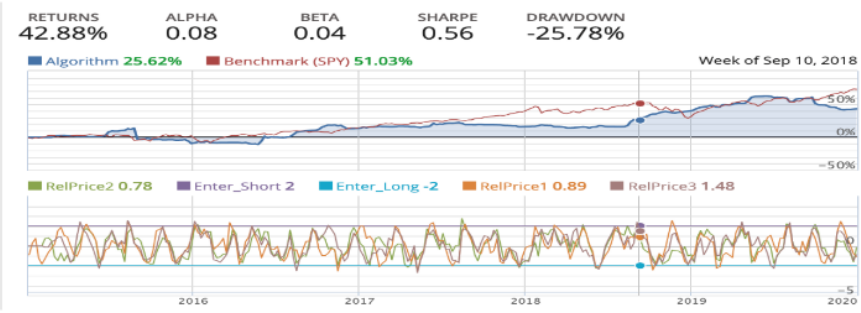


Figure 5: Performance of Pairs trading

The cumulative return is 42.88% and drawdown is -25.78%.

7. Control leverage strategy

7.1 Model introduction:

The main idea of the strategy is doing momentum strategy while keep account leverage limited to 2.5x.

7.2 The momentum strategy:

Firstly we define two score (FastMa(The average of the stock price in the past 100 days) and SlowMa(The average of the stock price in the past 20 days).Secondly we define the long-short signal (Go long if the fast moving average is equal to or above the slow moving average.)and Short signal of the momentum strategy(Sell short if the fast moving average is below the slow moving average.) Thirdly we define the control leverage limit. At the beginning, we set equal weights in several volatile stocks based on their moving averages. The portfolio is firstly leveraged to 2.45x and starts to exit positions if the leverage exceeds 2.5x.

We selected a few volatility stocks: 'FSLR', 'CREE', 'GRPN', 'NFLX', 'GMCR'

7.3 Performance:

Initial Investment: $0.5 million; time horizon: January 1, 2015 - January 1, 2020

The cumulative return is 102.14% and drawdown is -64.39%.

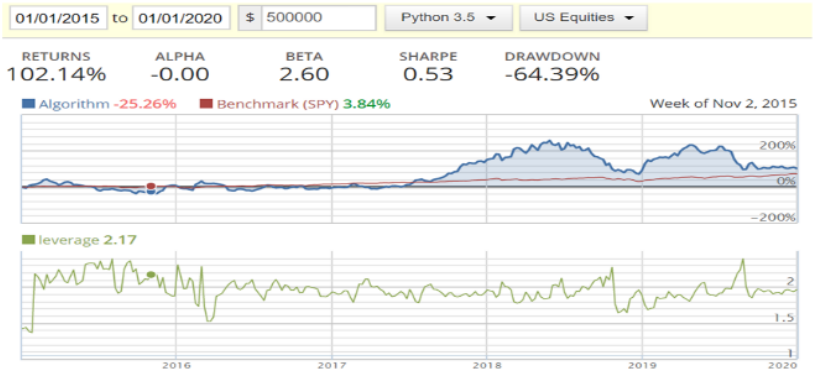


Figure 6: Performance of momentum strategy

III. Conclusion

Relative Strength Index is favored by many investors because of it is practical and easy to use. RSI can show the moving trend in the selective period of the price of the currencies. RSI can indicate overbought and oversold region in the market and the price of stock may reach the peak to go down or hit the bottom to rise up. However, our RSI strategy do not catch the upward trend in 2017 and 2019 since it may sell at a very early period on the when the market is on an upward trend.

The returns of Turtle Trading and Momentum Trading strategy are not good enough. We think the reason is that we use basic turtle and momentum strategy and did not optimize them. In the future, we can optimize the strategies to get better results.

The reason why psy strategy does not outperform the benchmark is that for complex financial markets, simple models cannot work well, and the factor used is too subjective and worth improving.

For being a pairs trading successful strategy, it is of great importance to know when to initiate the pairs trade and when to close all positions. Also, how do we go about calculating the spread? How do we identify stock pairs for which such a strategy would work? What value do we use for the ratio in the construction of the pairs portfolio? When can we say that the spread has substantially diverged from the mean. All these will affect the performance.

Control leverage strategy performs very well, especially after 2018, since it can make take advantage of the momentum strategy as well as limit the leverage.

In conclusion, differential trend motion strategy has been successfully applied to two stocks--ANF and AINV. Their annual return and sharp ratio can outperform the benchmark. Especially, ANF can gain 109% of annual return.

Reference

[1] Mikosch, T. (2012) *Elementary stochastic calculus with Finance in view.* Beijing, World Scientific Publishing Company Press.

[2] Ursone, P. (2015) *How to Calculate Options Prices and Their Greeks: Exploring the Black Scholes Model from Delta to Vega.* TJ International Ltd, Padstow, Cornwall, UK

Appendix

A. Methodology for Differential trend motion startegy

A1. Least square regression

The least square regression also called ordinary least square.

The objective function is:

$$\min_{w} \|Xw - y\|_2^2$$

The unique solution of it is:

$$w^* = (X^T X)^{-1} X^T y$$

This research we apply it to estimation of differential trend (The moving average of first order differential price)

A2. Differential trend motion model

Since we do not directly forecast the level of price but the moving average of first order differential price, which is called 'differential trend'. The term 'motion' means the model concerns about the direction of differential trend rather than the value of it.

$MV_{(n)}(P_t^* - P_{t-1}^*)$ is the differential trend of price and it is **estimated byOLS model**.

$MV_{(n)}(P_t - P_{t-1})$ is the real value of differential trend.

$MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2})$ represents the change (or called motion) of differential trend.

For this system, if LSTM model find estimated differential trend motion is positive, it can deduce that the differential trend motion is also positive in probability.

$$MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) > 0 \qquad (1)$$

$$\Downarrow p_1$$

$$MV_{(n)}(P_t - P_{t-1}) - MV_{(n)}(P_{t-1} - P_{t-2}) > 0 \qquad (2)$$

If LSTM model finds estimated differential trend motion is negative, it can deduce that the differential trend motion is also negative in probability.

$$MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) < 0 \qquad (3)$$

$$\Downarrow p_2$$

$$MV_{(n)}(P_t - P_{t-1}) - MV_{(n)}(P_{t-1} - P_{t-2}) < 0 \qquad (4)$$

For example, first order differential trend motion model with five-day moving average can be presented like below.

Under this model, if we know the estimated differential trend motion is positive or negative, given the history of last term(P_{t-1}), last n terms(P_{t-n}) and last n+1 terms(P_{t-n-1}), we can predicted the Supprted line or Restricted line of next term(P_t).

$$MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) > 0 \qquad (5)$$

$$\Downarrow p_1$$

$$(P_t - P_{t-n}) - (P_{t-1} - P_{t-n-1}) > 0$$

$$P_t > P_{t-n} + P_{t-1} - P_{t-n-1}$$

$$MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) < 0 \qquad (6)$$

$$\Downarrow p_1$$

$$(P_t - P_{t-n}) - (P_{t-1} - P_{t-n-1}) < 0$$

$$P_t < P_{t-n} + P_{t-1} - P_{t-n-1}$$

A3. Judgement and trading strategies

For the trading strategies,

In the case of Supprted line (formula 5), there are two step of trading strategies:

(1) when Open price $< P_{t-n} + P_{t-1} - P_{t-n-1}$

LONG at Open price

SHORT at Close price

(2) if (1) cannot be satisfied, however, $Low\ price < P_{t-n} + P_{t-1} - P_{t-n-1} < High\ price$, which means that the market price crosses the Supprted line,

LONG at Supprted line

SHORT at Close price

In the case of Restricted line (formula 6),

(1) when Open price $> P_{t-n} + P_{t-1} - P_{t-n-1}$

SHORT at Open price

LONG at Close price

(2) if (1) cannot be satisfied, however, $Low\ price < P_{t-n} + P_{t-1} - P_{t-n-1} < High\ price$,

which means that the market price crosses the Restricted line,

SHORT at Restricted line

LONG at Close price

A4. Successful transaction rate

In last part, weknow that there are two types of transaction. One is LONG or SHORT at standard line, including Supprted line and Restricted line. The other is doing the transaction at open price.

However, different stock index may have different successful transaction rate. For example, in a specific transaction date for one stock index, it may do the judgement right, yet it cannot do the transaction, because the open price cannot satisfy the condition and the market price also cannot cross the standard line. In opposite, if the we make a wrong judgement, unfortunately, the conditions always can be satisfied and transaction always can be done. It means we may frequently loose the money.

Therefore, the success rate of judgement does not represent we finally can do the transaction and earn the profit. The higher profit also depends on whether the market price can satisfy our setting conditions.

A5. Profit gain whenever transaction

Furthermore, if we have the high success judgement rate and high success transaction rate, the strategy may still not earn the profit, since it depends on the conditional profit.

For example, for one strategy original should LONG at standard line and SHORT at close price. Whenever judgement is right, the strategy always earns little money. Nevertheless, whenever judgement is wrong, the strategy always losses huge amount of money. Then, we should totally change our strategy, we should SHORT at standard line and LONG at close price in order to maximum our profit.

The standard form is presented like this:

	Judgement	
	Right	Wrong
Have transaction	Profit	Loss
No transaction	No profit	No profit

Table. A1 The relationship between judgement, successful transaction, and the profit

If |Profit| > |Loss|, keep the original trading strategy.

If |Profit| < |Loss|, change the LONG&SHORT direction of trading strategy.

In summary, the total profit gained from strategy depends on judgement, successful transaction rate, and the profit gain whenever transaction.

B. Differential trend motion Strategy for two stocks(AINV and ANF)

AINV

$line = P_{t-n} + P_{t-1} - P_{t-n-1}$ (optimal n for AINV is 677)

(1) If $MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) > 0$and $\text{line} - \text{open} < 0$:

SHORT at open price and LONG at close price

(2) If $MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) > 0, \text{line} - \text{open} > 0$ *and low price* $< line <$ *high price* (*when price cross the standard line*):

SHORT at standard line and LONG at close price

(3) If $MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) < 0$and $\text{open} - \text{line} > 0$:

SHORT at open price and LONG at close price

(4) If $MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) < 0, \text{open} - \text{line} < 0$ *and low price* $< line <$ *high price*

SHORT at standard line and LONG at close price

ANF

$line = P_{t-n} + P_{t-1} - P_{t-n-1}$ (optimal n for ANF is 1635)

(1) If $MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) > 0$and $\text{open} - \text{line} < 0$:

SHORT at open price and LONG at close price

(2) If $MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) > 0, \text{open} - \text{line} > 0$ *and low price* $< line <$

high price (when price cross the standard line):
SHORT at standard line and LONG at close price
(3) If $MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) < 0$and line $-$ open > 0:
SHORT at open price and LONG at close price
(4) If $MV_{(n)}(P_t^* - P_{t-1}^*) - MV_{(n)}(P_{t-1} - P_{t-2}) < 0$, line $-$ open < 0 *and low price* $<$ *line* $<$ high price
LONG at standard line and SHORT at close price

Table B1. Optimal Strategies for two stocks (AINV and ANF)

Link of presentation video :

https://www.youtube.com/watch?v=ylyOzdBfYQ0

Link of Github or Dropbox share :

https://github.com/king-yellow/MAFS6010U_Quantopian_trading_strategy

Contribution of each group member :

LI, Fanyi：Part of RSI strategy and Control Leverage Strategy. I also summarized the PPT.

Du Yushu：Part of Turtle Strategy and Momentum Strategy, and summarized the report.

HUANG, Jian：Part of Differential Trend Motion Strategy, and Code Summary

Tong Jiaqu：Part of Psy strategy, organizing the report and summarizing the beginning and end.

YU Rong：Multiple Pairs Trading, and Video Editing.

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