CITI CODE CHALLENGE - 2022

PAIR TRADING using Signal Optimizer

Description:

Pair Trading is a market neutral trading strategy which allows traders and firms to increase profit (or limit losses) agnostic to the market movement.

The most crucial step to pairs trading is to identify the pairs that have a leading correlation of one instrument on another. While there are simple pairs like 2 stocks in same industry (TCS and INFOSYS); there are also other asset classes which impact the price of some stocks. These pairs are often missed as they are not easy to spot, driven by multiple attributes, have a low success rate and potentially correlated for certain periodic cycles.

There are multiple ways to establish the pair trading model based on indicators, like moving averages, trade ratio, and momentum oscillators.

These indicators provide market signals to eventually generate stack rank of respective pairs by executing predetermined strategy.

Generated stack rank identifies the leading correlated pairs.

Objective:

Design a solution to rank the pair(s) using the any desired Indicator.

Stack ranking will be based on the maximum cumulative profit generated over a defined period (provided in input data).

The solution needs to provide following outcomes -

1. Find pairs of instruments that gives leading correlation to generate maximum profit based on the chosen model and prepare a report that explains the model used to generate the desired outcome.
2. The report should explain the features along with their rationale, scoring & weighing technique.
3. Make use of best software design methodologies with a working front-end to display the output.

Datasets:

You will be provided with historic publicly available data for NIFTY 50 stocks along with key Commodities for the same period. Some attributes of the data are synthetic, as the objective of the challenge is not identify the actual trading pair but to evaluate the technique employed in doing so for the given data. If

required more attributes can be taken into consideration with disclosures on the source of the data (dummy or actual).

**For each strategy execution (assume trade value of 100000 INR for each constituent of pair is available.

Evaluation Criteria

You will be evaluated on your data understanding, feature design, model testing and tuning proposal and visualization.

Sample model:

Following example explains the use of one of the momentum oscillator (RSI) that can be used as an indicator for establishing the stack rank.

Relative Strength Index (RSI)

The relative strength index (RSI) is a momentum indicator used in technical analysis. RSI measures the speed and magnitude of a security's recent price changes to evaluate overvalued or undervalued conditions in the price of that security.

RSI provides technical traders with signals about bullish and bearish price momentum, and it is often plotted beneath the graph of an asset's price.

Low RSI levels, below 30, generate buy signals and indicate an oversold or undervalued condition. High RSI levels, above 70, generate sell signals and suggest that a security is overbought or overvalued. A reading of 50 denotes a neutral level or balance between bullish and bearish positions. Anything above neutral level (i.e. closer to overbought level) signifies selling opportunity and vice versa.

How the Relative Strength Index (RSI) Works

As a momentum indicator, the relative strength index compares a respective pair's strength on days when prices go up to its strength on days when prices go down. Relating the result of this comparison to price action can give traders an idea of how a pair may perform.

RSI Calculation

$$RSI = 100 - \left[\frac{100}{1+RS} \right]$$

$$RS = Average\,Gain / Average\,Loss$$

To simplify the calculation explanation, RSI has been broken down into its basic components: **RS, Average Gain and Average Loss**.

The very first calculations for average gain and average loss are simple past 14-period averages:

$$\text{First Average Gain} = \left[\frac{\text{Sum of Gains over the past 14 periods}}{14} \right]$$

$$\text{First Average Loss} = \left[\frac{\text{Sum of Losses over the past 14 periods}}{14} \right]$$

The second, and subsequent, calculations are based on the prior averages and the current gain/loss:

$$\text{Average Gain} = \left[\frac{(\text{previous Average Gain}) \times 13 + \text{current Gain}}{14} \right]$$

$$\text{Average Loss} = \left[\frac{(\text{previous Average Loss}) \times 13 + \text{current Loss}}{14} \right]$$

The formula uses a positive value for the average loss. 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.

Below table depicts the sample price input data.

Date	PRICE (ASSET A)	PRICE (ASSET B)
01-Jan-22	1,595.60	1,250.45
31-Dec-21	1,599.30	1,256.50
30-Dec-21	1,583.25	1,241.35
29-Dec-21	1,564.00	1,240.25
28-Dec-21	1,556.45	1,248.15
27-Dec-21	1,562.35	1,238.50
26-Dec-21	1,575.65	1,227.20
25-Dec-21	1,612.85	1,236.30
24-Dec-21	1,612.65	1,225.65
23-Dec-21	1,639.55	1,237.10

Respective processing for change ratio of the sample input data is below:

Date	PRICE (ASSET A)	PRICE (ASSET B)	Ratio	Change	Daily Gain	Daily Loss
01-Jan-22	1,595.60	1,250.45	1.276021	0.003199	0.003199	0
31-Dec-21	1,599.30	1,256.50	1.272821	-0.00261	0	0.002605
30-Dec-21	1,583.25	1,241.35	1.275426	0.01439	0.01439	0
29-Dec-21	1,564.00	1,240.25	1.261036	0.014031	0.014031	0
28-Dec-21	1,556.45	1,248.15	1.247006	-0.01448	0	0.01448

27-Dec-21	1,562.35	1,238.50	1.261486	-0.02245	0	0.022453
26-Dec-21	1,575.65	1,227.20	1.283939	-0.02064	0	0.020639
25-Dec-21	1,612.85	1,236.30	1.304578	-0.01117	0	0.011173
24-Dec-21	1,612.65	1,225.65	1.315751	-0.00957	0	0.009566
23-Dec-21	1,639.55	1,237.10	1.325317	-0.01081	0	0.010811

The standard number of periods used to calculate the initial RSI value is 14. For example, imagine the market closed higher seven out of the past 14 days for "security pair" with an average gain of 1%. The remaining seven days all closed lower with an average loss of −0.8%.

The calculation for the RSI would look like the following expanded calculation:

$$55.55 = 100 - \left[\frac{100}{1 + \frac{\left(\frac{1\%}{14}\right)}{\left(\frac{0.8\%}{14}\right)}} \right]$$

[Source: Investopedia.com]

After the RSI is calculated, the RSI indicator can be plotted beneath an pairs price chart, as shown sample below. The RSI will rise as the number and size of up days increase. It will fall as the number and size of down days increase.

Note: This image is just for illustration.

[Source: Investopedia.com]

Strategy execution criteria's on the pair, basis RSI Indicator:

Position Entry:

For RSI (14 days): RSI Value <= 30,

- Long position on stock A
- Short position on stock B.

For RSI (14 days)): RSI Value >=70,

- Long position on stock B
- Short position on stock A

Note: Long (holding a positive amount of the instrument) and a Short (holding a negative amount of the instrument).

Position Exit:

- Define your own exit strategy (square-off the positions).

Example exit strategy can be based on a certain x% Profit reached or y-days elapsed for a signal.

Objective is to maximize the cumulative profit over a defined time period.

Good to have

1) Time Space complexity should be optimal.
2) UI workflow for complete objective achievement.
3) Visual analysis of strategy execution.

Input

Sample input data will be provided separately.

[Sample Data Source: nseindia.com]