Project 8: STRATEGY EVALUATION

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1 INTRODUCTION

Technical indicators can generate trading signals, which can be combined to form a trading strategy. Indicator signals can also be converted into features to feed into a learning model to learn a trading strategy, classification-based, reinforcement-based or optimization-based. Implement a manual strategy and a strategy learner to evaluate and compare these two methods.

2 INDICATOR OVERVIEW

We can divide indicators into three categories:

- Momentum indicators measure the fluctuations or momentum of a stock and determine the rate of reversing market.
- Trend following indicators measure the direction and strength of market trends.
- Volatility indicators measure how much price fluctuates around a mean.

Table 1 — Indicator categories.

Momentum	Trend	Volatility
Stocastic	Moving average	Bollinger bands
RSI	MACD	
CCI	ADX	
Rate of Change		
Percentage Price		

Individual indicators are weakly predictive. Combination of them can form applicable trading strategies. While indicators from same categories may give you duplicate information. It is not only redundant but can also be misleading, ends up overemphasizing information. In order to get complimentary signals, combine indicators from different categories.

2.1 RSI

RSI (relative strength index) is a momentum indicator that measures the magnitude of recent price changes to indicate overbought or oversold conditions.

$$RSI(look\_back) = 100 - \frac{100}{1 + RS}$$

$$RS = \frac{Average\ gain}{Average\ loss}$$

Where:

look_back: lookback period parameter

Average gain: moving average percentage gain within the lookback period

Average loss: moving average percentage loss within the lookback period

RSI values range from 0 to 100. It measures the speed of price movement and compares the candlesticks (bullish vs. bearish) and the size of candlesticks. The RSI forecasts an upcoming reversal sooner than almost any other indicators.

- RSI values > 70 –> Overbought (look to sell)
- RSI values < 30 –> Oversold (look to buy)

2.2 EMA

EMA (exponential moving average) is a variant of moving average that places more weight on most recent data points.

$$EMA_{Today} = Value_{Today} \times \frac{Smoothing}{1 + Days} + EMA_{Yesterday} \times (1 - \frac{Smoothing}{1 + Days})$$

Where:

Days = lookback period parameter

Smoothing = factor controls how recent observations are valued, usually use 2

Value = price

EMA measures a weighted average closing price and is more responsible to recent price changes. The EMA(8) and EMA(20) are used as indicators for short-term trends, EMA(50) and EMA(200) tend to be used more for long-term goal. The basic approach is to use price / EMA to indicate the market sentiment.

- Price / EMA > 1 –> Bullish
- Price / EMA < 1 –> Bearish

The slope of the EMA can also be informative

- EMA is sloping up –> Bullish
- EMA is sloping down –> Bearish

2.3 Bollinger bands

Bollinger bands is the most commonly used volatility indicators. Wider bands show a high volatility market and vice versa.

$$upper\_band = SMA_{look\_back} + n * std$$

$$lower\_band = SMA_{look\_back} - n * std$$

$$BBP = \frac{Price - lower\_band}{upper\_band - lower\_band}$$

Where:

look_back: lookback period parameter

n: parameter controls the width of the bands, usually use 2

SMA: moving average within the lookback period

std: moving standard deviation within the lookback period

When the price is close to upper or lower band, it may indicate overbought or oversold situations.

For a range trade,

- Price tags upper band –> Look to sell
- Price tags lower band –> Look to buy

3 MANUAL STRATEGY

Develop the trading rules by using indicator signals directly.

Each indicators generate a single signal as -1, 0 or 1, representing an overbought, uncertain or oversold signal, which recommend a "short," "out" or "long" position. Based on the discussion in Section 2,

Call symbol overbought when:

- Price/EMA ratio > 1.05
- BBP > 0.85
- RSI > 70

Call symbol oversold when:

- Price/EMA ratio < 0.95
- BBP < 0.15
- RSI < 30

The trading strategy can be formed as:

- Go long when both indicators signal oversold.
- Go short when both indicators signal overbought.
- Close positions when symbol crosses through its EMA.

The given portfolio starts with $100,000 cash and trades only the symbol JPM. The allowable positions are 1000 shares long, 1000 shares short and 0 shares. Therefore, up to 2000 shares can be traded at a time. Only buy/sell actions are allowed. The commission and impact are $9.95 and 0.005 for each transaction.
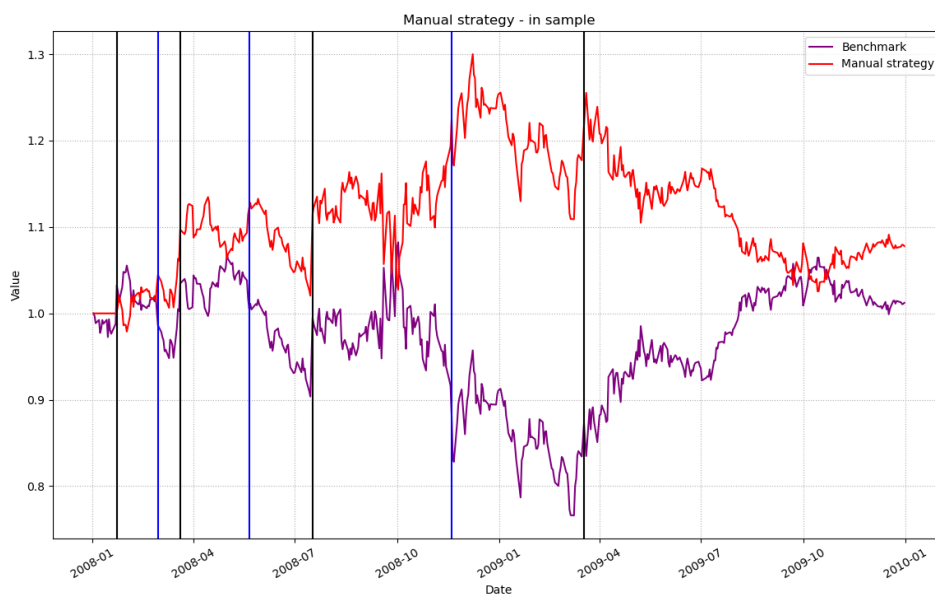

Figure 1 — Manual strategy vs. benchmark for in-sample period.

Another portfolio starting with $100,000 cash, investing in 1000 shares of JPM and holding that position is treated as benchmark. The in-sample period is January 1, 2008 to December 31, 2009. The out-of-sample period is January 1, 2010 to December 31, 2011.
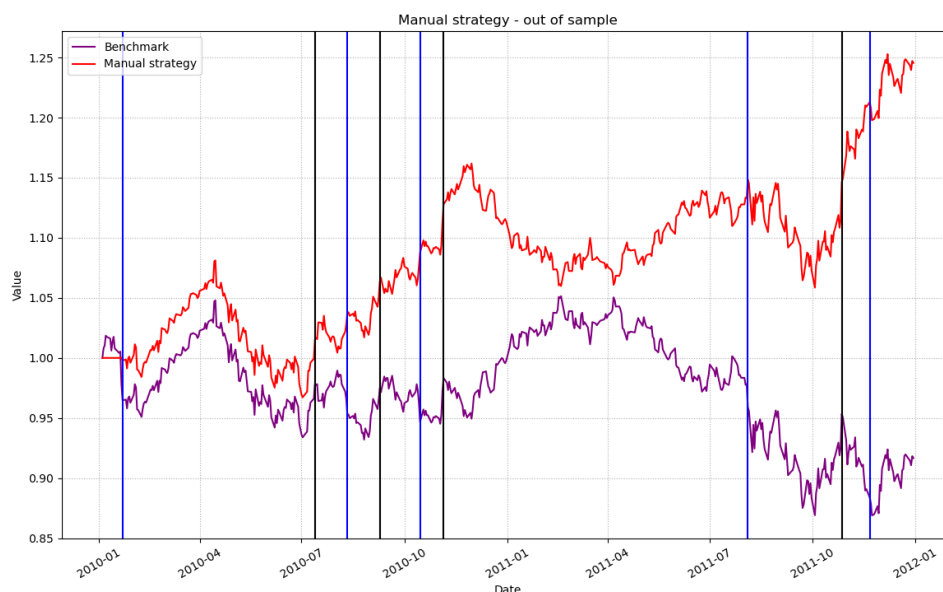

Figure 2 — Manual strategy vs. benchmark for out-of-sample period.

In Figure 1 and 2, the vertical blue lines indicating LONG entry points and vertical black lines indicating SHORT entry points. From the results, the Manual strategy outperform the benchmark but not perfect. Sometimes it fails to catch up on the trends, especially when the price fluctuates around its mean. It does better when there are large momentum. This may explain why the out of sample results are better than those of in sample.

Table 2 — Statistics of manual strategy vs. benchmark.

		Cumulative returns	Std of daily returns	Mean of daily returns
In sample	Benchmark	0.012300	0.017004	0.000168
	Manual strategy	0.077869	0.014063	0.000247
Out of sample	Benchmark	-0.083400	0.008481	-0.000137
	Manual strategy	0.245512	0.007298	0.000463

4 STRATEGY LEARNER

Develop the trading rules using artificial intelligence. Indicator signals can also be converted into features to feed into a learning model to learn a trading strategy. Classification-based, reinforcement-based or optimization-based learners can be used.

A random forest classification learner (Bagging + Random tree) is trained:

- +1: LONG
- -1: SHORT
- 0: CASH

The same indicators are used as manual strategy. The X data for each example (day) are the values of each indicators. The Y data are classified based on future N day's cumulative return CR:

- +1: CR > YBUY
- -1: CR < YSELL
- 0 otherwise

Tune the hyper-parameters to maximize daily returns during the in-sample period:

- leaf size: 8
- number of bags: 15
- lookback period for indicators: 20
- N: 5
- YBUY: 0.03 + impact
- YSELL: -0.03 - impact

The in-sample period is January 1, 2008 to December 31, 2009. The out-of-sample/testing period is January 1, 2010 to December 31, 2011.

5 EXPERIMENT 1

Evaluate and compare the performances of the Manual strategy and the Strategy learner. The portfolio, benchmark and trading restrictions are the same as described in Section 3.

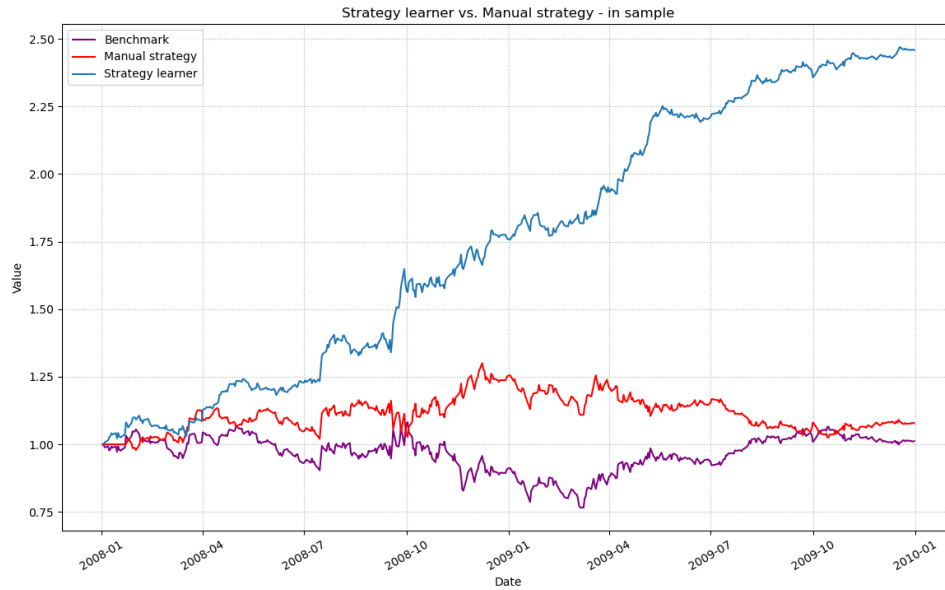From the results in Figure 3 and 4, Strategy learner outperforms both Manual strategy and benchmark.
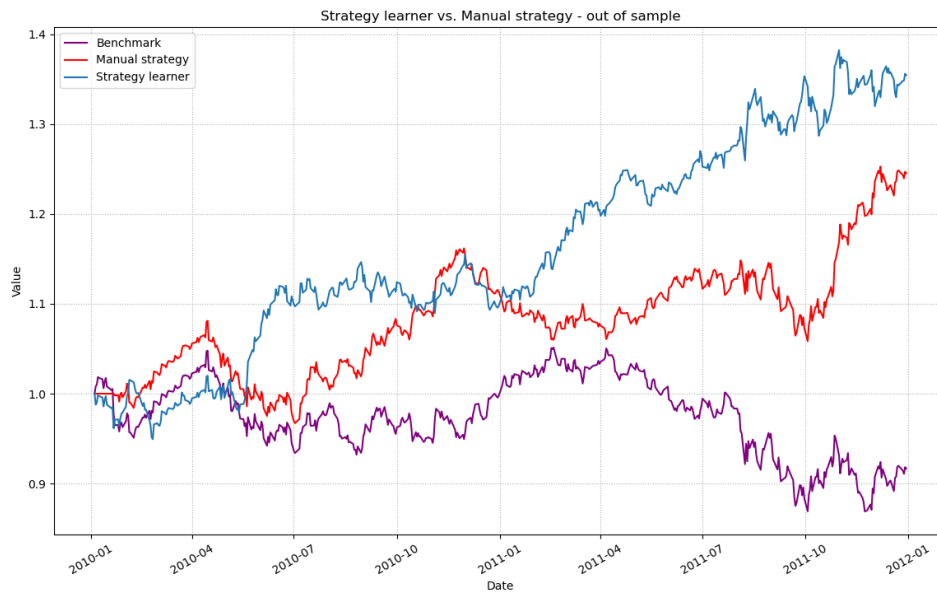

Figure 3—Strategy learner vs. Manual strategy for in-sample pe-

riod.

Figure 4—Strategy learner vs. Manual strategy for out-of-sample period

Not only using historical information to predict the future like Manual strategy, Strategy learner can also peek into the future to make decision. This results in better performance while may cause overfitting. Besides, the classification based learner does not fully utilize the time information. And by the nature of the random forest, without setting the random seed, we cannot expect this relative result every time with in-sample data.

Table 3 — Statistics of Strategy learner vs. Manual strategy

		Cumulative returns	Std of daily returns	Mean of daily returns
	Benchmark	0.012300	0.017004	0.000168
In sample	Strategy learner	1.458355	0.010438	0.001840
	Manual strategy	0.077869	0.014063	0.000247
	Benchmark	-0.083400	0.008481	-0.000137
Out of sample	Strategy learner	0.354550	0.007170	0.000629
	Manual strategy	0.245512	0.007298	0.000463

6 EXPERIMENT 2

Explore how changing the value of impact should affect trading behavior of the Strategy learner. Various values of market impact: 0.0, 0.005, 0.01, 0.05, 0.1, 0.2 are experimented on the same portfolio of JPM with a commission of $0.00.

The effects are evaluated based on two metrics: number of trades (long or short) and cumulative return. As described in Section 4, the impact determines the YBUY and YSELL. Higher impact will decrease the willingness to bet on the market, thus resulting less transactions (long or short). Higher thresholds lower the risks while may potentially lose chances at the same time. It's not deterministic, but if the impact is too large, it will have worse cumulative return since you can hardly make transactions.

Table 4 — How impact affects number of transactions

	Impact					
	0	0.005	0.01	0.05	0.1	0.2
Transaction number	505	505	505	503	450	317

The results from Table 4 prove that the impact restrain the wiliness to trade. The transaction number decreases with higher impact value.

The results from Figure 5 also in accordance to the hypothesis. When the impact is small: 0, 0.005, 0.01, the threshold is dominated by the constant 0.03. The results of 0.05, 0.1, 0.2 show the trend that impact may worsen the performance.
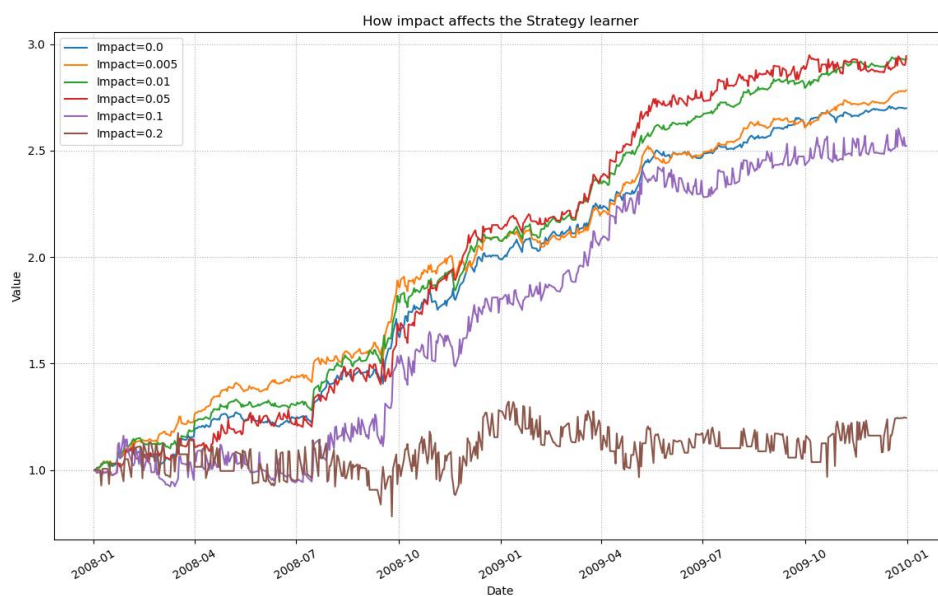
Figure 5 — How impact affects the cumulative returns