Project 8: Strategy Evaluation

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***Abstract*—Manual and Q-Learner strategies, are constructed using three technical indicators. The performance of the both strategies are compared against each other as well as a benchmark strategy. Effect of impact values on the Q-Learner Strategy is also investigated.**

1 INTRODUCTION

In this project, manual and Q-Learner strategies, are designed using three technical indicators, 'BBP', 'Momentum' and 'price to EMA ratio'.

The learning period, or in-sample, are the "JPM" stock price data from 1 Jan 2008 to 31 Dec 2009. The performances of the strategies are compared against each other as well as versus a benchmark.

The manual strategy is also tested for the out-of-sample interval, that is "JPM" stock price from 1 Jan 2010 to 31 Dec 2011, and its' performance was compared again the benchmark.

In the last part of the project, the effect of different impact values for the Q-learner strategy is investigated.

2 INDICATORS OVERVIEW

The utilized technical indicators in this project are "Bollinger Band Percentage", "Momentum" and "price to EMA ratio". Those indicators are briefly explained, accompanied with plots focusing on the in-sample period. The plots are meant to design effective cutoffs, to establish buy and sell signals. Once the cutoffs are decided for the individual indicator, all three indicators need to be combined to form one consolidated strategy, that is called "Manual" in this project. It should be noted that for designing the cutoffs, Look-back period of 10 days is used for all the indicators.

2.1 Bollinger Band Percentage (BBP)

The Bollinger band percentage reflects closing price as a percentage of the lower and upper Bollinger Bands [1].

$$\%B=(Price-Lower\ Band)/(Upper\ Bound-Lower\ Band)$$

Figure 1 represents the used BBP for the in-sample period, Bollinger Bands and Simple Moving Average (SMA) for 10 days, along with normalized adjusted price for "JPM", are displayed in the top plot, and Bollinger Band percentage, is shown in the bottom plot. The red horizontal lines that are displayed in the bottom part, BBP=0.1 & BBP = 0.85, represent the cut-offs that are used for the Manual Strategy in this project. The Buy and Sell signals associated with those cut-offs are:

Buy: BBP <= 0.1 ; Sell: BBP >=0.85

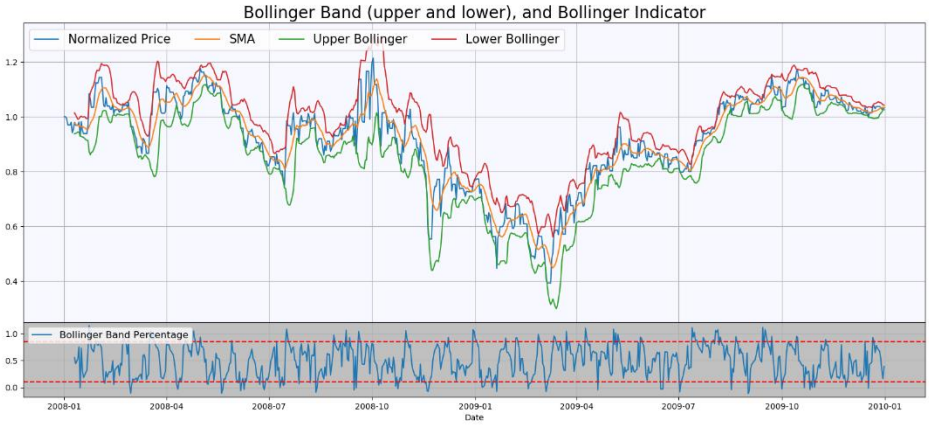

Figure 1, In-sample period, Normalized Price, SMA, Bollinger Bands (Top Plot) and BBP (Bottom Plot); Horizontal red lines at BBP= 0.1 and 0.85 are meant to facilitates the Buy and Sell signals

2.2 Momentum (MMNT)

Momentum is an indicator that reveals the speed of a price movement, and measures the rate of rise or fall of a stock price.
It is calculated as the difference between the most recent price and the closing price of a previously determined period [2].

$$\text{Momentum (n day)} = (\text{today price/price n days ago}) - 1$$

As it is said earlier, Look-back period of 10 -days is used for all the indicators. Figure 2 shows the Normalized price, top, and the 10-days momentum, bottom. The green and red horizontal lines represent, MMNT = 0.05 & MMNT= -0.05, and the associated Buy and Sell signals are:

Buy: MMNT >= 0.05 ; Sell: MMNT <= -0.05

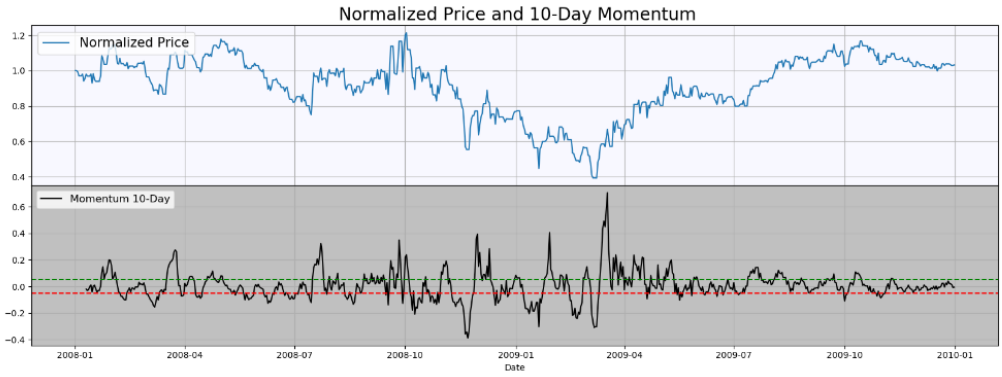

Figure 2, Normalized Price (top) and 10-Day MMNT (bottom), Horizontal red lines are at MMNT = 0.05 and -0.05, and are meant to assist Buy and Sell decision

2.3 Price to Exponential Moving Average Ratio (PEMR)

The Exponential Moving Average (EMA) is a moving average that places a greater weight and significance on the most recent data points [3]. In this project Price to Exponential Moving Average Ratio (PEMR) is used, which practically is easier to be combined with the other two indicators, that are earlier explained. Figure 3, represent the Normalized Price, top, and the PEMR, bottom. The horizontal red line shows PEMR = 1.0, and the composed Buy and Sell signals, associated with the PEMR are:

Buy: PEMR <1 & Sell: PEMR>1

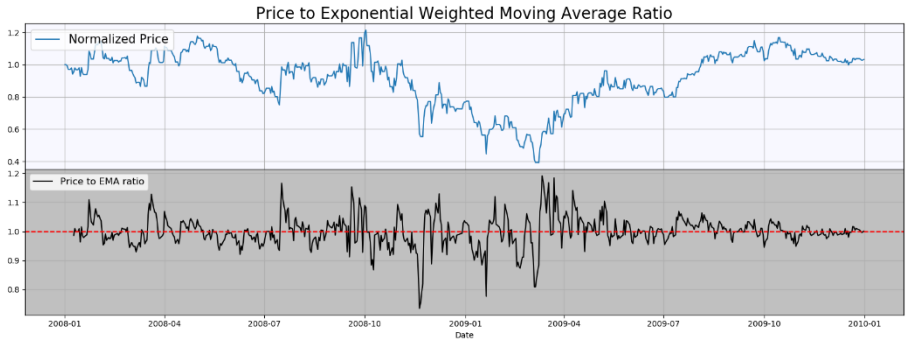

Figure 3, Normalized Price (top) and PEMR (bottom), Horizontal red line is at PEMR = 1, and is meant to help Buy and Sell Decision

3 MANUAL STRATEGY

The manual Strategy was developed with combing of the three aforementioned indicators, BBP, PEMR and MMNT. The majority vote is used to establish the ultimate buy and sell signal, meaning that the trade would proceed if two out of three indicators suggest the sell/Buy decision. The reason to use the majority is satisfying all the three conditions may ends up with only very few trades.

Buy (long) opportunity (Signal = +1): if any two of the followings are met:

- PEMR < 1
- MMNT >= 0.05
- BBP <= 0.1

Sell (short) opportunity (Signal = 1): if any two of the below conditions are satisfied:

- PEMR > 1
- MMNT <= -0.05
- BBP >= 0.85

No trade (Signal = 0): We simply do not trade, and hold our ground, if none of the above Buy or Signal is satisfied.

A positive signal (+1) means to buy enough shares to reach +1000 long position and a negative signal (-1) commands to sell enough to reach a -1000 position.

As it is demonstrated earlier, those cutoffs are designed by looking at the in-sample period, and hence it is expected that manual strategy to perform well for this period. To examine that, we tested the manual strategy against a benchmark scenario, where 1000 shares of JPM is hold long for the whole period. We have tested both the manual and benchmark strategies for In-Sample and Out-Sample periods, and the results are included in the followings.

3.1 In-Sample testing of Manual Strategy

Figure 4, shows the performance of the manual strategy versus the benchmark for the in-sample period, the vertical blue lines indicate long entry points and the black lines shows short entries.

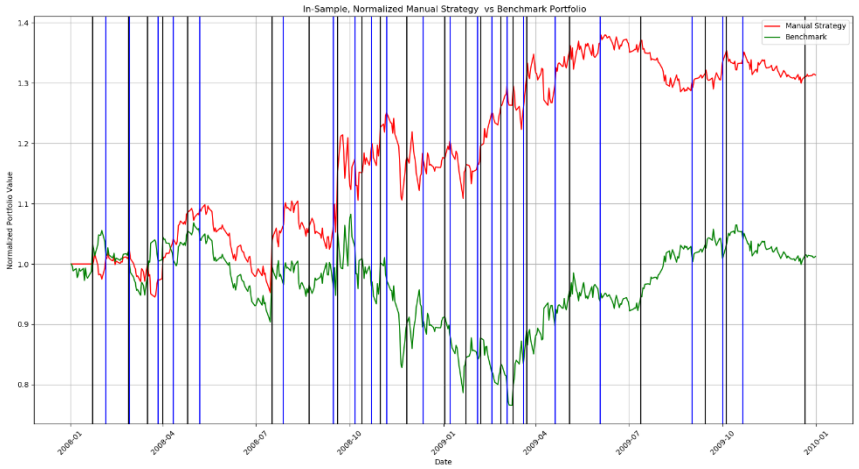

Figure 4, In-sample Manual Strategy vs. benchmark Normalized Portfolios the vertical blue lines indicate long entries and black ones show short

As it was expected, the manual strategy performed better than benchmark in the in-sample period and here is the statistics comparing both performances for this period:

In-Sample	Manual Strategy	Benchmark
Mean	0.0006	0.0002
Standard Deviation	0.013	0.017
Cumulative Return	0.313 (31%)	0.012 (1%)

Table 1: Manual Strategy and benchmark performance metrics for the in-sample period;

Out-of-Sample testing of Manual Strategy

The manual strategy, that is established (trained) using the in-sample period, is then tested out in the out-of-sample period. Figure 5 shows the performance of the manual strategy and the benchmark during the out-of-sample period.

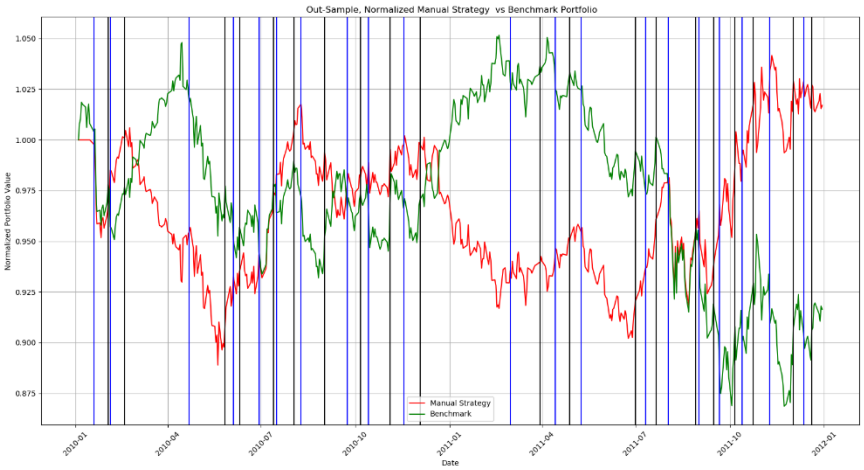

Figure 5, Out-of-sample Manual Strategy vs. benchmark Normalized Portfolios; the vertical blue lines indicate long entries and black ones show short

The benchmark and manual strategy performance statistics for the out-of-sample period is as follow:

Out-of-Sample	Manual Strategy	Benchmark
Mean	0.0001	-0.0001
Standard Deviation	0.008	0.009
Cumulative Return	0.017 (1.7%)	-0.084 (-0.8%)

Table 2: Manual Strategy and benchmark performance metrics for the out-of-sample period

3.2 Manual Strategy In-Sample and Out-of-Sample Comparison

As demonstrated in Figure 6, The manual strategy success, for the in-sample period was not repeated in the out-of-sample, and that may suggest the manual strategy is overfitted to the in-sample data. That might be expected, as the manual strategy is developed with prior knowledge and indicators and the associated thresholds were fine tuned to maximize return for the in-sample period.

We may probably need more data for t training, since the training portion should normally be 3-4 times more than the testing.

Figure 6, Manual and benchmark performances across in-sample and out-of-sample

4 STRATEGY LEARNER

We used the Q-Learner, from the project-6, to establish the Strategy Learner. State, Reward, and number of actions are the instrumental elements of the Q-Learner, as the Learner tries to maximize the rewards for its actions.
The number of actions that the Q-Learner can take is set to 3, to mimic the Long, Short and maintaining the ground in trading.
The reward is calculated as the portfolio holding (+1000, -1000, 0 shares) is multiplied by the change in stock price. In addition to that, if a trade is to be executed, reward was then subtracted by the computed effects of impact and commission.
Computing the state number was one of the challenges for this part, as the continuous values of the indicators had to be combined to establish a single integer number for the Q-Learner state number. This was achieved by discretizing and then binning of the indicator values. To turn the indicators into a discretized state, first, for a given day we calculate each indicator, then divide the values of each indicator into 10 bins. Consequently, each indicator has an index value from 0 – 10, corresponding to the bin that it belongs to. For the three indicators each having 10 possible values, we have a total of 1000 possible states for the Q-learner.

The hyper-parameters used in the Q-Learner for the Strategy Learner are listed in the table

Hyper-parameters	Value
Learning Rate (alpha)	0.2
Discount Rate (gamma)	0.3
Random Action Rate (rar)	0.8
Random Action Decay Rate (radr)	0.99
Dyna	0.0

Table 3, Hyper-parameters used for the Q-Learner

5 EXPERIMENT 1

In this experiment, we compared the performance of the Strategy Learner versus the manual strategy. To do this comparison, we used the in-sample period, 1st Jan 2008 to 31 Dec 2009, with the allowed positions of only 1000 shares long, 1000 shares short or 0 shares. The impact considered to be as 0.005, with commission of 9.95 and starting value of $100,000.

It was anticipated that the Strategy Learner perform better than the manual one, for the in-sample period. As it is demonstrated in Figure 7, the Strategy Learner significantly outperformed the manual, as it was expected. That is due to the fact that the Strategy Learner was trained with 10 discrete cutoffs for each indicator, whereas we picked two or only one cutoff for the manual one for each indicator; hence the Strategy Learner is more equipped to pick up the stock market activity and take the required actions accordingly.

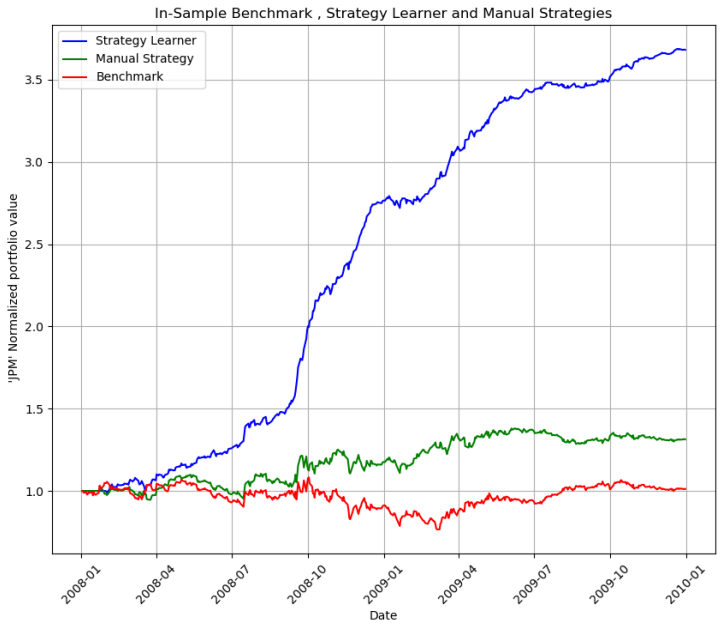

Figure 7, Strategy Learner and Manual Strategy performance against benchmark.

While it is always expected for the Strategy learner to outperform the manual strategy in the in-sample period, we need to be super cautious not to push both strategies too hard as that may lead to extreme over-fitting of the strategies to the training dataset, and not being practically useful for out-of-sample dataset.

6 EXPERIMENT 2

The experiment is meant to showcase the effect of different impact values on the performance of the Strategy Learner. Other than commission value that is set to 0.0 for this experiment, the other parameters are the same as the previous experience.

It is expected to produce less profit while impact value increases, since that reduces the rewards for actions for the Q-Learner.

Figure 8, shows the normalized portfolio values for the in-sample period in respect with different used impact numbers. The impact values that have been tested for are 0.0, 0.005, 0.01 and 0.05.
As it is expected, the performance of the strategy gets worse once the impact value is increased, as it cost more to produce profit, and for super high impact values, impact =0.05, the strategy concludes with consistent negative return throughout the in-sample period.

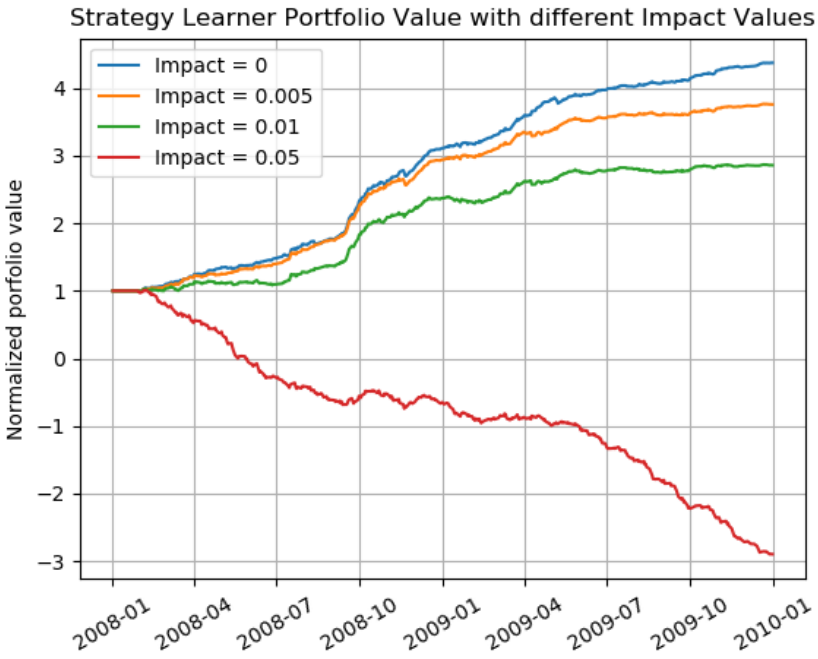

Figure 8, Effect of Impact values on the Strategy Learner performance

Table 4, summarize the cumulative return and number of trades for the strategy learner with difference impact values. It was anticipated to see less trades as the impact value increases, however the number of trades did not show a clear trend.

Impact	Cumulative Return	Number of Trades
0.0	3.37	203
0.005	2.76	201
0.01	1.86	191
0.05	-3.9	196

Table 4, Hyper-parameters used for the Q-Learner

7 REFERENCES

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