PROJECT 6: Indicator Evaluation
CS7637

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***Abstract*—The project attempts to explore and study the implementation of different technical analysis indicators, Additionally, the projects also aims to implement the Theoretically Optimal policy, assuming future sight, which will be used as a Future project maximum benchmark.**

1 INTRODUCTION

In a world with future sight, profitable investments could be made with growth regardless in which direction the market moves. While foresight is not possible in real world, the future price movements can be predicted over past price and volume patterns. Indicators can be derived to better understand these patterns.

The following section covers the description and implementation of 5 technical factors including Simple Moving Average, Bollinger bands, Stochastic Oscillator, Pivot Point Moving Average and Chaikin money flow indicator.

The subsequent section covers the implementation of Theoretically optimal strategy along with benchmark evaluation of JPM Adjusted Close price, for the period starting 2008-01-01 till 2009-12-31. As some indicators are aggregated over time, they are created on extended data from 2007-01-01 till 2009-12-31 and from 2008-01-011 for analysis.

2 INDICATORS

To Analyze and predict future values, following 5 indicators were explored and implemented, explaining different aspects of the stock price.

2.1 Bollinger Bands: Understand price volatility

2.1.1 *Description and mathematical Implementation*

Bollinger Bands aspire to identify investment opportunities on the presumption that when stocks are over sold or under sold, the investors behavior changes

, governed by emotions like fear and hope, pushing the prices towards the expected trend. This expected trend in Bollinger bands is depicted by Simple moving Average **μ**, given over a specified time window which may differ from one security to other based on past volatility and trend . The confidence in actionable volatility is identified with the help of upper and lower bounds, defined with the help of Rolling Standard Deviation **σ** over the time window **n**, as per the equation below.

$$\mu_t = \frac{1}{n}\sum_{k=0}^{n} \textbf{Adjusted close}_{t-k} \quad , \quad \sigma_t = \left[\frac{\sum_{k=0}^{n}(\textbf{Adjusted close}_{t-k} - \mu_t)^2}{n}\right]^{\frac{1}{2}}$$

$$\textbf{\textit{Upper Bound}} = \mu + 2\sigma$$

$$\textbf{\textit{Lower Bound}} = \mu - 2\sigma$$

$$\textbf{BB\%} = \frac{\textbf{Price} - \textbf{Lower Bound}}{\textbf{Upper Bound} - \textbf{Lower Bound}}$$

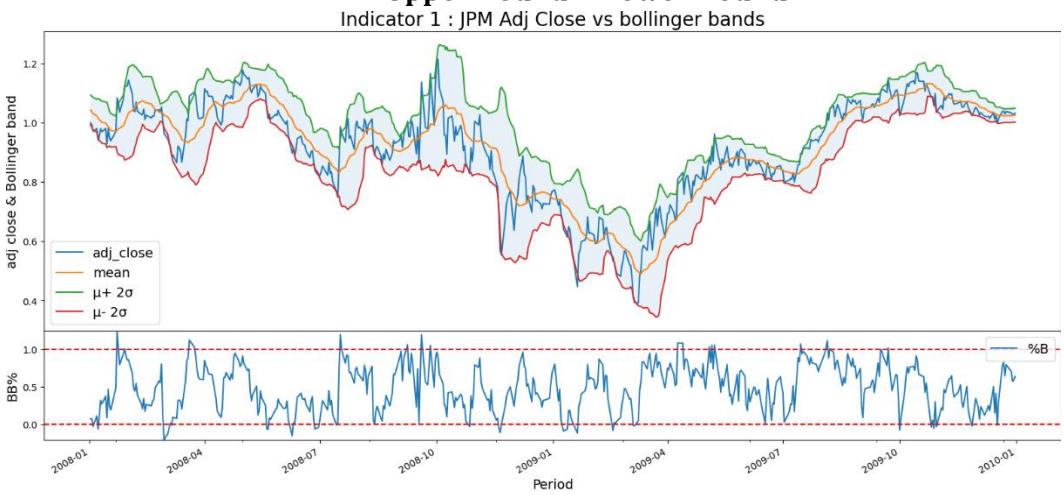

Figure 1 — Relationship of Bollinger band an JPM adj close, from 2008-01-01 till 2009-12-01, with 15 days window

2.1.2 *Buy and Sell signals*

These deviations, as shown in ***fig 1.0,*** could highlight possible **buying opportunities**, when the price is more than the upper bound and moves towards the moving average. **Sell signal** can be identified when the price is less than the lower bound and moves towards the moving average. Change can be normalized as **BB%** as a ratio of difference between price and lower bound at the time vs the total difference in lower and upper bounds, therefore when BB% is more than 1, it indicates a Sell signal and when less than 0 than a Buy signal.

Based on the initial assumption, Bollinger bands might indicate the possible change in volatility and therefore depict potential entering and exiting strategies. While the distance between Upper and Lower bound is small, the volatility is low indicating upcoming high volatility period, with potential trading opportunities, additionally a very high distance could mark upcoming low volatility period, marking a good exit position.

As Depicted in ***Fig 1.0***, BB could identify at least 13 trading opportunities correctly on its own. Therefore, can be considered an essential tool for market volatility-based trading.

2.1.3 *Challenges and Possible Set-backs*

Each security/fund follows its own volatility and trend patterns, therefore, the same window may not work for different securities, and may require individual analysis to identify the right window.

Additionally, the maturity of the security's business and market listing, effects the widow considerably. While a small cap new listing could be more volatile than large cap old listed firms. The growth in the business might effect this window as well, generating false positive signals with a fixed window. Due to its lagging volatility estimation, even though Bollinger bands may direct to future variation in price movements, these expectations could go wrong.

2.2 Simple Moving Average – Rolling Mean: Understand Trend

2.2.1 *Description and mathematical Implementation*

While the Bollinger Bands depict the volatility for a security's price, it may have a biased myopic view over a window. To answer this, relationship of price and its trend could be understood by looking at the relative distance of the current price from a rolling average of Adjusted Close price. Similar to Bollinger bands, the rolling aggregation window may differ from once stock to other.

For a selected rolling window **n,** i.e. number of days for aggregation, and for a specific date/timestamp **t**, SMA can described as follows:

$$SMA_t^{\{n\}} = \frac{1}{n}\sum_{i=0}^{n-1}(Adjusted\ close\ Price_{t-i})$$

$$\frac{Price}{SMA} = \frac{Adjusted\ close\ Price_t}{SMA_t}$$

Similar for BB, SMA can be used for understanding the deviation of the price as a lagging factor, from average expected trend, depicting the direction of future price movement, filtering the short term fluctuation noise. This can be better understood by the ratio of current price to SMA ratio discussed below.

2.2.2 *Buy and Sell signals.*

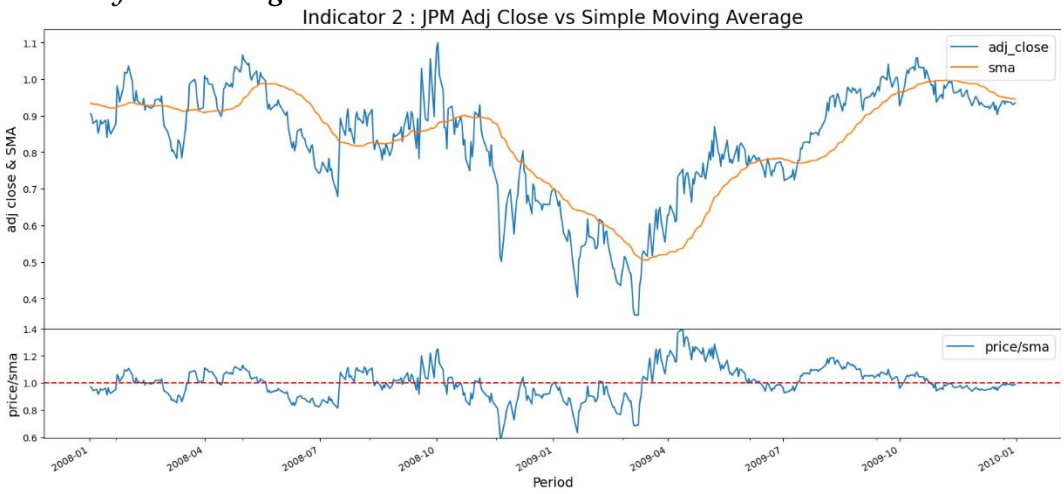

Figure 2 — Relationship of Simple moving average and Adjusted close price of JPM, with a 40 days window.

The window size highly defines the strategy. A shorter window may depict frequent trend reversals and identify trading opportunities, And very long window, may act as resistance or support for the trend. As per ***fig 2.0*** , with a window of 40 days, a **buying** opportunity can be identified when prices move above the SMA, where the Price/SMA ratio change from less than 1 to more than 1. A **Sell signal** can be seen with prices moving below SMA, when the Price/SMA ratio changes from more than 1 to less than 1.

Additionally, in the medium window, like 40 day, SMA behaves as support and resistance indicator along with reversal identifications, i.e. during a growth or a dip cycle, prices bounce/remain above or below SMA respectively. ***Fig 2.0***, depict 10 normalized possible trading opportunities, where the price/SMA reverses its position over a sustained period.

2.2.3 *Challenges and Possible Set-backs*

Similar to BB, SMA is a lagging indicator and therefore is based on rational and is not predictive in nature. Additionally, when the price shows a choppy pattern,

with very frequent ups and down, the indicator may show high frequency reversals and trading signals which are possibly false positives. While the time frame can be used to adjust for this choppiness, the same window may not work over different periods.

2.3 Stochastic Indicator – Oscillator : Understand Momentum

2.3.1 *Description and mathematical Implementation*

SMA may not perform in a choppy market, whereas a Stochastic Indicator may still define opportunities, describing the momentum of the stock price, by comparing the Adjusted closed price for a day with the historical price ranges. Stochastic indicator is built on an assumption that when the market is trending upwards, the closing prices will be close to recently seen high, and in a downwards market the prices will close near recently seen low. This stochasticity is better defined by the overlay of fast (%K) and slow (%D) stochastic signals, with the below equations:

$$\%K = \frac{Adjusted\ Close_t - LLow_{t:t-n}}{HHigh_{t:t-n} - LLow_{t:t-n}} \times 100$$

$$\%D = \frac{1}{d}\sum_{i=0}^{d} \%K_{t-d}$$

Where:
t = close price time stamp
$n.d$ = Window size for fast and slow stochastic indicator respectively
LLow = lowest price seen in the last n time-period from t
HHigh = highest price seen in the last n time-period from t

2.3.2 *Buy and Sell signals.*

Similar to SMA, %D stochastic signal identify overbought or oversold stocks. Being bound to 0-100%, it is generally assumed when the signals are more than 80% and less than 20%, create a Sell and Buy opportunities respectively.
Since stock prices are assumed to follow a momentum, the crossover of these fast and slow signal may suggest reversal, indicating a large shift in the momentum.

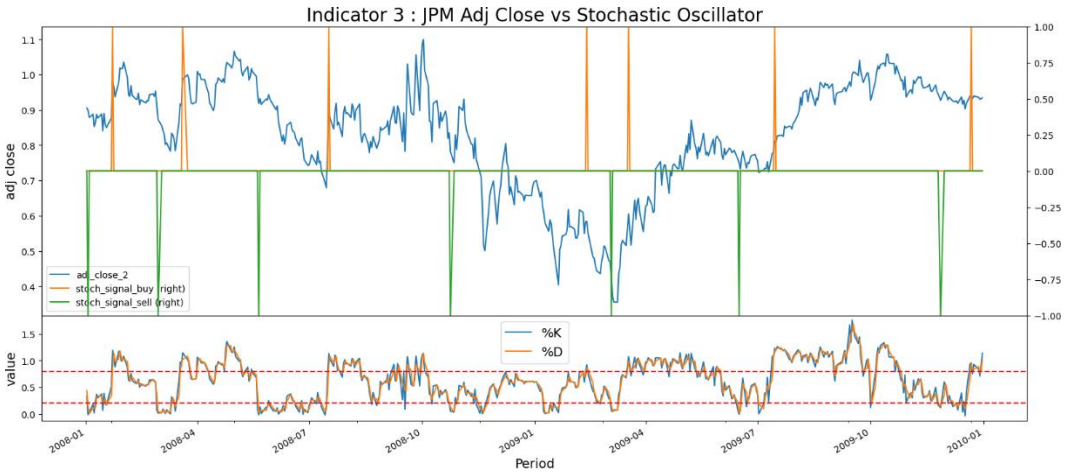

Figure 1 — Representation of Comparison of Stochastic oscillator with JPM adjusted close price, along with possible buy signal with downward orange spikes and sell signal as upward orange spikes. With n = 25 and d = 2

2.3.3 *Challenges and Possible Set-backs*

The Stochastic indicator may create false trade signal in a volatile market, when the stock price may not follow. This discrepancy can be resolved partially by restricting signal usage when the price as well as %D are in the same direction.

2.4 Pivot point: Understand momentum.

2.4.1 *Description and mathematical Implementation*

%D focus on short/long term momentum of High and Low prices, however, it may not depict associated risk. Pivot points focus on the momentum of the prior average trading price. Average trading price **P** is defined as Average of the highest High, average Close and lowest Low, over the recent period, which is more robustly define price trends. **P** could also be used as resistance and support for trading to minimize risk by determining market entry positions and place stops.

$$P_{t-1} = \frac{HHigh_{t-1:t-n} + LLow_{t-1:t-n} + Avg\_Close_{t-1:t-n}}{3}$$

$$Resistance\ 1_t = 2P_{t-1} - LLow_{t-1:t-n}$$

$$Resistance\ 2_t = P_{t-1} + (HHigh_{t-1:t-n} - LLow_{t-1:t-n})$$

$$Support\ 1_t = 2P_{t-1} - HHigh_{t-1:t-n}$$

$$Support\ 2_t = P_{t-1} - (HHigh_{t-1:t-n} - LLow_{t-1:t-n})$$

$$Pivot\ ratio_t = \frac{Adjusted\ Close_t}{P_{t-1}}$$

Where:

t = close price time stamp

n = Window size

LLow = lowest low price seen in the last n time-period from t

HHigh = highest low price seen in the last n time-period from t

Avg_Close = highest low price seen in the last n time-period from t

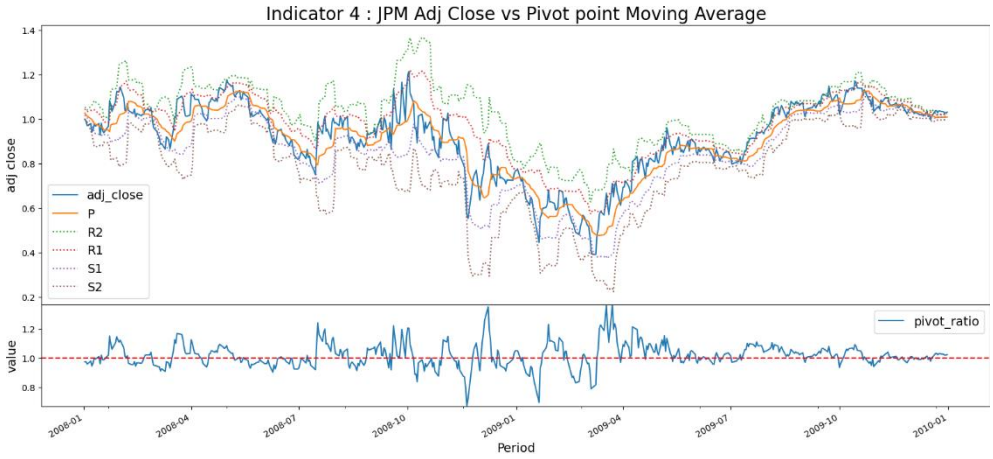

Figure 2 — Relationship of pivot point and JPM adjusted close price, with 11 days window for calculation of HHigh, LLow and Avg_Close.

2.4.2 *Buy and Sell signals.*

As depicted in ***fig 4.0***, Comparison of price with previous day's **P** might indicate ongoing bullish sentiment, therefore creating a **buying signal**. Similarly, price less than **P** signify bearish market and **sell signal**. This could be defined as +ve and -ve Pivot ratio respectively. Additionally, a trader can create a limit order if the price goes above a resistance level, similarly a stop loss can be created at a support level, where **P** itself could be used as support and resistance, however based on the risk level preferred by the trader, additional supports S1 and S2 along with Resistance R1 and R2 can be used for making a trade.

2.4.3 *Challenges and Possible Set-backs*

While the Pivot points are identified as reliable leading factors, it could suffer from historical biasness, like SMA and may not be accurate, which may result in possible losses. This error can be reduced by utilization of pivot point variants such as Fibonacci and Camarilla.

2.5 Chaikin Money Flow : Understanding Price and Volume movement.

2.5.1 *Description and mathematical Implementation*

Chaikin Money Flow indicator monitors the accumulation and distribution of the stocks, i.e. the money flow volume over a period of time. Unlike other covered indicators, CMF measures the total buying and selling pressure over a period and can help anticipate future price movements and therefore is predictive in nature. CMF accumulates price change and money flow in 3 steps before.

1. Money Flow Multiplier: Identify the general position of close with respect to high and low prices of the day.

$$MFM = \frac{[(Adj\ close - Adj\ low) - (Adj\ high - Adj\ close)]}{Adj\ high - Adj\ low}$$

2. Money Flow Volume : calculate buying and selling pressure per day.

$$MFV = MFM \times volume$$

3. CMF : Aggregation money flow volume of the period

$$CMF_t = \frac{[\sum_{k=0}^{n} MFV_{t-k}\ ]}{[\sum_{k=0}^{n} Volume_{t-k}]}$$

2.5.2 *Buy and Sell signals.*

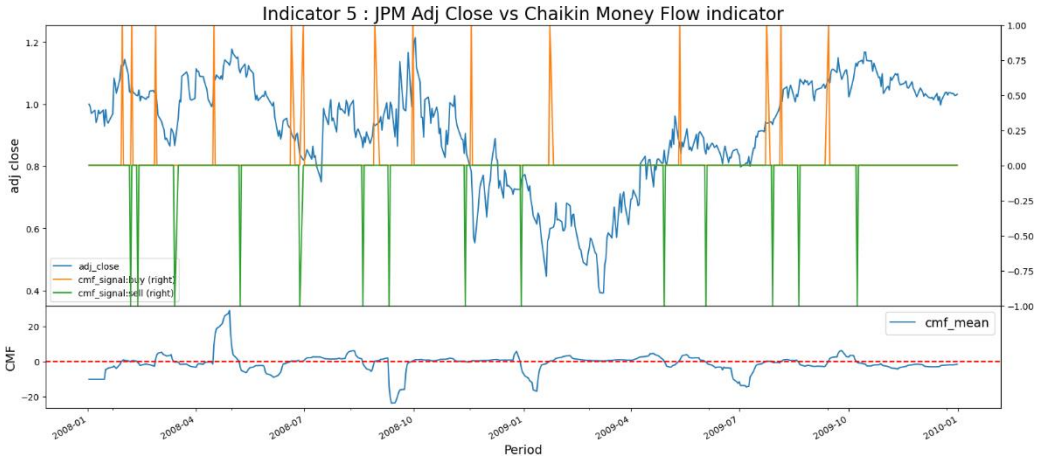

Figure 3 — Chaikin MF indicator over JPM Adj Close,with a 10 days window and a 3 days ema of CMF

When normalized, the trading pressure using CMF remains between 1 and -1 . MFM depict high buying pressure, when more than 0.5 and high selling pressure otherwise. This information is weighted with volume and therefore CMF show the volume weighted MFM, where values closer to 1 depict higher buying

pressure, and closer to -1 depict selling pressure, which can add a confidence in price trend analysis. Additionally, change of CMF from -ve to +ve at 0, may signify Bullish Cross and a **Buy signal**, whereas change from +ve to -ve at 0, indicate a bearish change and a **Sell signal**.

2.5.3 *Challenges and Possible Set-backs*

CMF and price may become out of sync due to possible price gaps, as MFM does not take into account the change in trading range between periods, and only look at the daily ranges.

3 THEOROTICALLY OPTIMAL STRATEGY - TOS

3.1 Definition, Assumptions, and steps:

TOS, is a trading strategy which depict the actions to achieve maximum possible return, over a period of time for a specific security. This can be achieved with a one step look ahead in future, i.e taking action on day **t** based on the change in price from **t to t+1**. While this is not possible in real life, a backdated optimal strategy can be used as a benchmark for different modeling techniques. **Assumptions:** On a trading day, a total portfolio size and order limit can only be in the interval [1000,-1000], including 0 shares. There is no limit assumed on borrowable cash from the broker for transactions. There are $0.00 commission and impact loss during TOS. JPM Adjusted close price is used for the creating TOS and Analytical benchmark for comparison. JPM stock price over the period of 2008-01-01 till 2009-12-31 is identified as benchmark itself. All prices are normalized to 1 at the start.

Strategy and Implementation steps:

Initialize trades for all days to 0.

Trading Day 1. (2008-01-02): Identify the 1st day **t,** where Adjusted closed is different from **t+1,** if it increases, then on Day t record a trade of +1000 shares , else if it decreases, then record short of -1000 shares.

Trading till second last day: for the subsequent day follow the below strategy:

if Adj close at **t** and **t+1** are same: hold the position

if Adj close at **t** is less than **t+1 :**

- if previous transaction was a short or sell of 1000 shares, than clear shorted shared buy buying them, and make a long of 1000 more shares.
- if previous transaction was a long of 1000 shares, hold the position

if Adj close at **t** is more than **t+1 :**

- if previous transaction was a short or sell of 1000 shares, hold position.
- if previous transaction was a long of 1000 shares, then sell those shares and short 1000 more shares.

Trading on the last day: if previous trade was a long than sell the shares, if it was a short then clear the short by buying 1000 shares.

This trade data frame was processed with market simulator to gather portfolio value on each day, based on adjusted daily close price.

3.2 Comparative Analysis

The TOS is compared with JPN benchmark, over the evaluation period, with the help of Cumulative return , Standard deviation and Average of daily return.

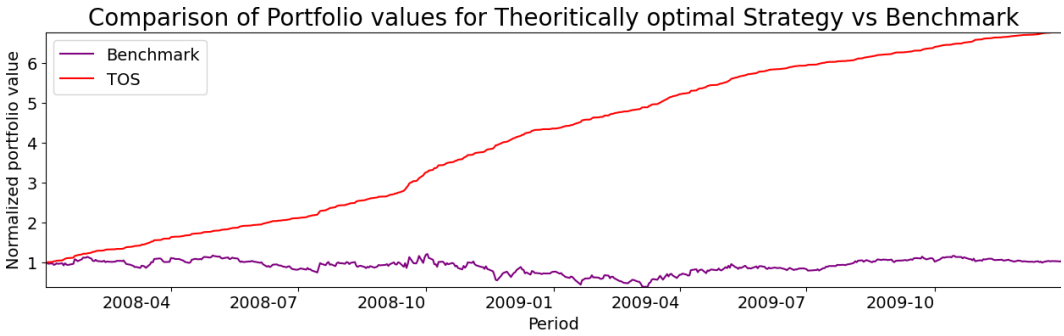

Figure 4 — TOS portfolio value vs Benchmark price comparison over 2008-01-01 : 2009-12-31.

	cumilative Return	std_dr	mean_dr
Benchmark	0.031973	0.052145	0.001396
TOS	5.780700	0.004552	0.003815

Table 1 — TOS and benchmark statistics comparison.

As depicted in *fig 6.0* and *table 1*, TOS cumulative returns are 5.75x more than benchmark a cumulative return defines the total growth in the portfolio over a period. TOS also show 92% less deviation risk , that is the growth in the daily portfolio is highly stable. Additionally, TOS is found to give a ~2.7x daily return compared to benchmark.

4 SUMMARY

The project explored Technical indicators in depth and encouraged building trading strategies around these indicators, which could be used for future price predictions, additionally, TOS benchmark was created for performance validation in project 8.