

CMPE362

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HOMEWORK 2

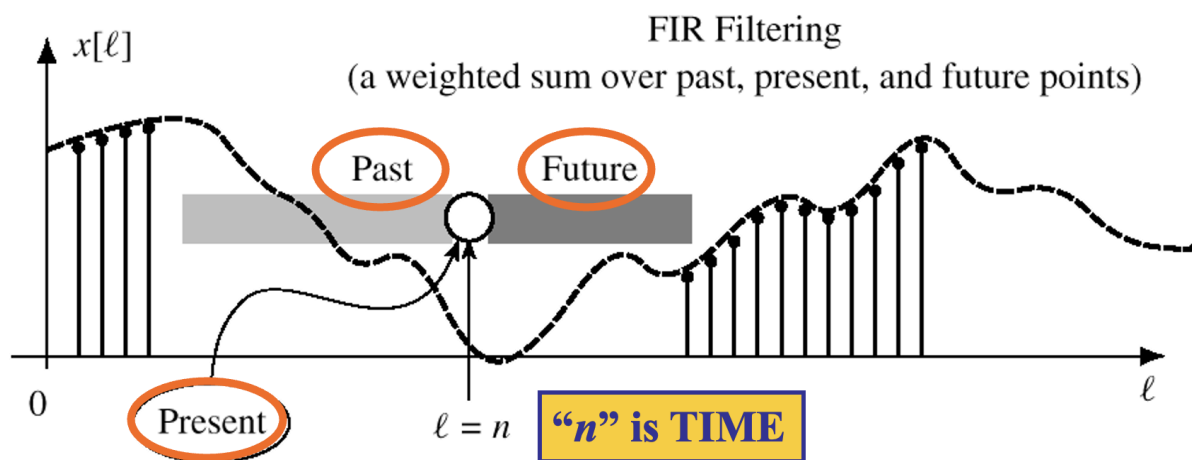
Part 1: Signal Processing for Trend Extraction

1.1 Simple Moving Average (FIR Filter)

SMA is a filtering mechanism that calculates the average of the most recent N data points. In essence, it smooths out the data to highlight general trends while filtering out short-term fluctuations or noise caused by daily events. Its primary goal is to provide quantitative analysts with a clearer view of the overall behavior of the data.

In the context of High-Frequency Trading, where most strategies operate within the span of just a few milliseconds, the chosen window size for the SMA should reflect that time scale. On the other hand, Medium-Frequency or Low-Frequency Trading strategies typically focus on longer timeframes, such as hours or days.

Given that our dataset spans the last 1000 days, it would not be accurate to even classify our approach as Low-Frequency Trading. Therefore, an optimal SMA window might be around 50 days. This value, however, can vary depending on the specific product or trading strategy. For instance, if a trader is interested in short-term behavior, 10 or 20-day windows might be more appropriate. In our case, where we aim to capture long-term trends across 1000 days, a 50-day window provides a more reasonable view of the general behavior.



Firstly, I was using the weighted sum over the **past** data, but there was a delay in the graph, so I decided to use the weighted sum over the **present** data. The delay disappeared.

$$y[n] = \sum_{k=0}^M b_k x[n-k]$$

In our SMA calculation, M is 49, and the b_k is $\{1/50, 1/50, 1/50, 1/50, 1/50, 1/50, \dots\}$.

The code below has 3 options to calculate SMA.

```

1 function y = SMA(productFeedPrices, windowSize)
2     % y[n] =(1/windowSize) * (y[n-windowSize] + ... y[n])
3     y = zeros(1000,1);
4     index = 1;
5     for j = 1:1000
6         last = j + windowSize/2 - 1;
7         first = j - windowSize/2;
8         if (first < 1)
9             first = 1;
10        end
11        if (last > 1000)
12            last = 1000;
13        end
14        y(index, 1) = mean(productFeedPrices(first:last));
15        index = index + 1;
16    end
17 end
18
19 function y = SMA_CONV(data, windowSize)
20     bk = ones(windowSize, 1)/windowSize;
21     y = conv(data(end - 1000 - windowSize + 2 :end, :), bk, 'valid');
22 end
23
24 function y = SMA_BUILTIN(productFeedPrices, windowSize)
25     y = movmean(productFeedPrices, windowSize);
26 end
27
28

```

1.2 Exponential Moving Average (IIR Filter)

For EMA, the formulation is below. This calculation is actually the most used in trading for medium and high frequency traders since it puts more importance on the latest updates than stale information. Therefore, it directly responds to the movement. As you may already know, in trading, if there is an opportunity, all of the counterparts see those. Only the fastest one can take the opportunity, so EMA will help one in this manner.

$$EMA = Price(t) \times k + EMA(y) \times (1 - k)$$

where:

t = today

y = yesterday

N = number of days in EMA

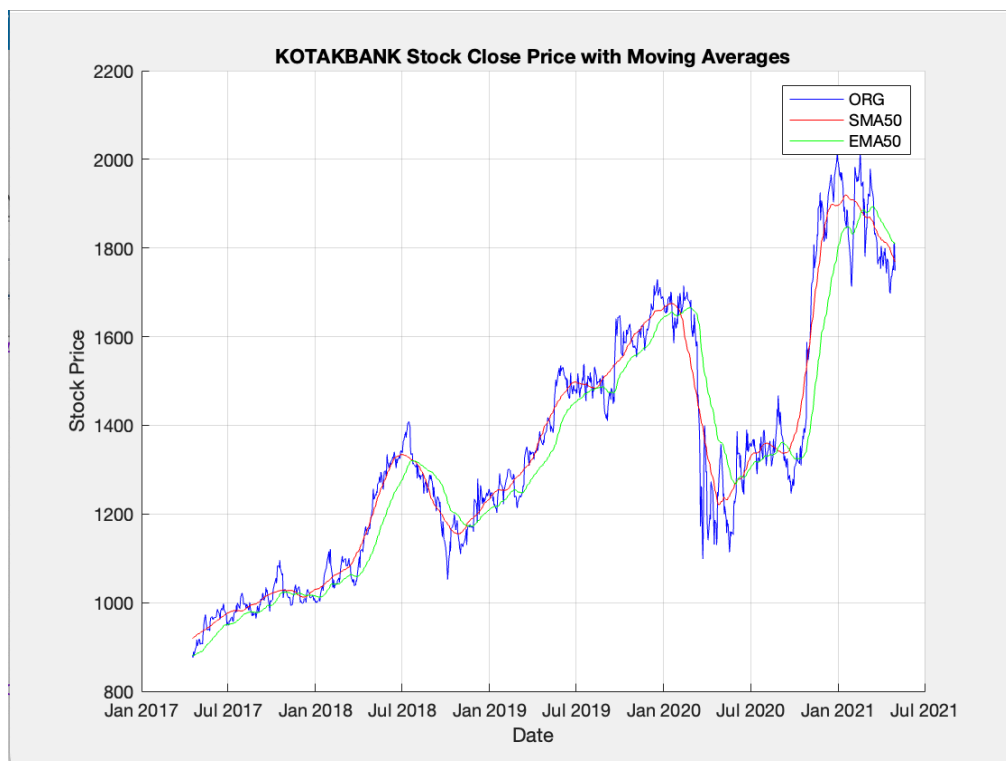
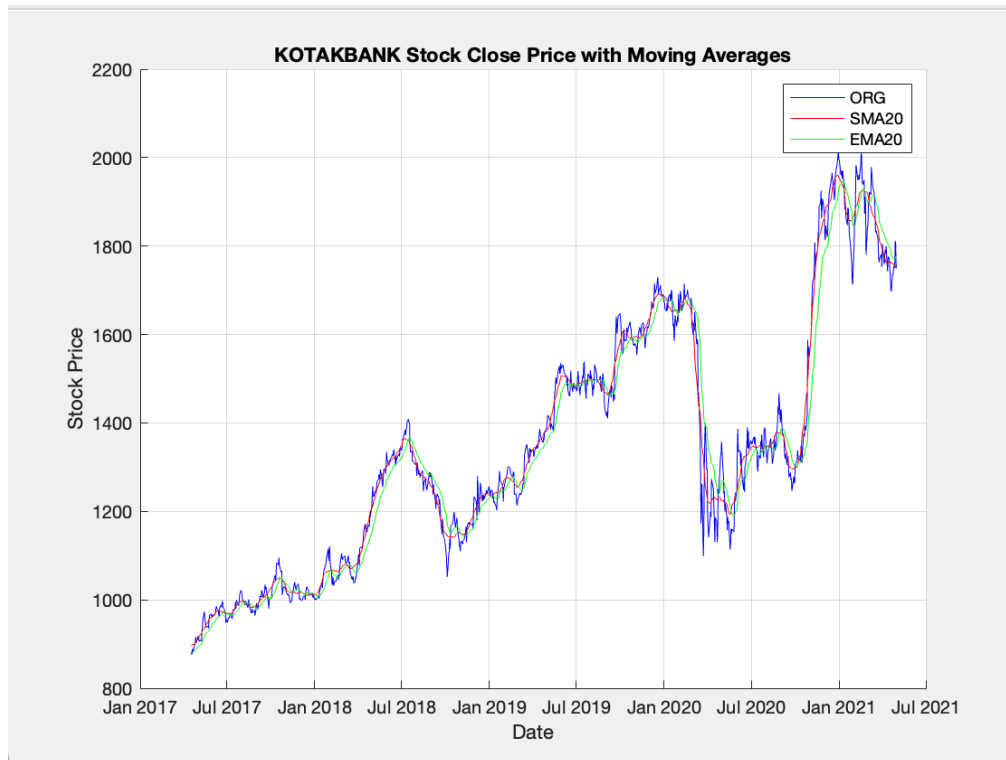
$$k = 2 \div (N + 1)$$

For the alpha value here, larger alpha means more weight on the recent values, in other words more responsive EMA, less values means a more smooth graph. In this experiment, I followed the standards of the industry which is 2.

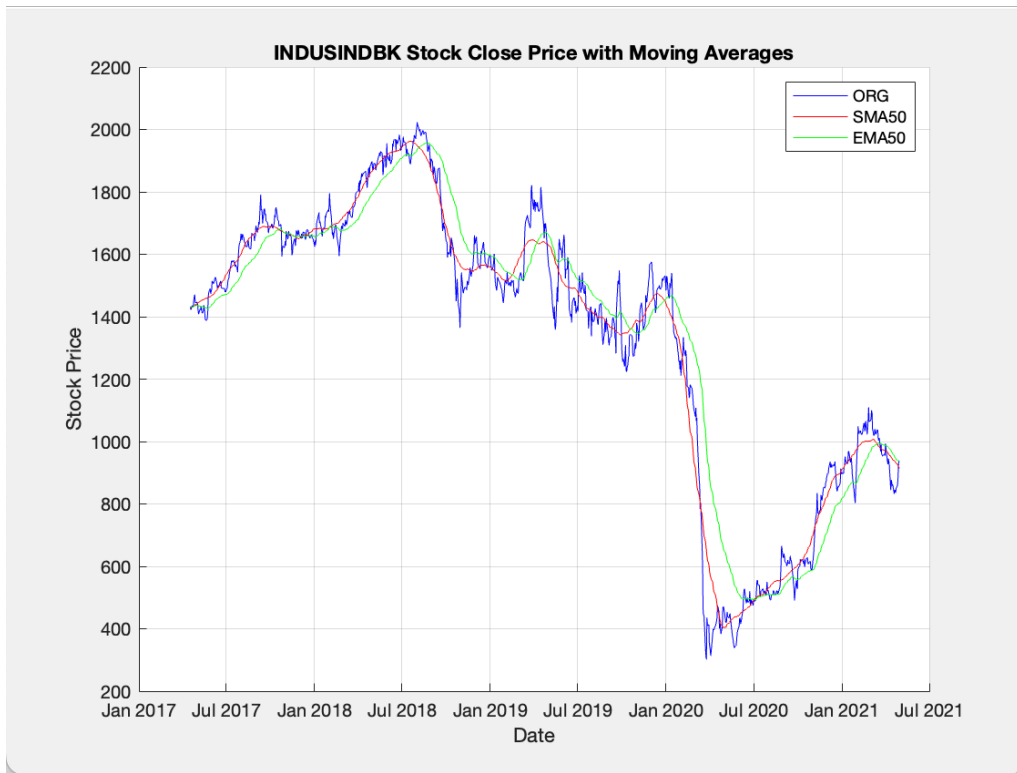
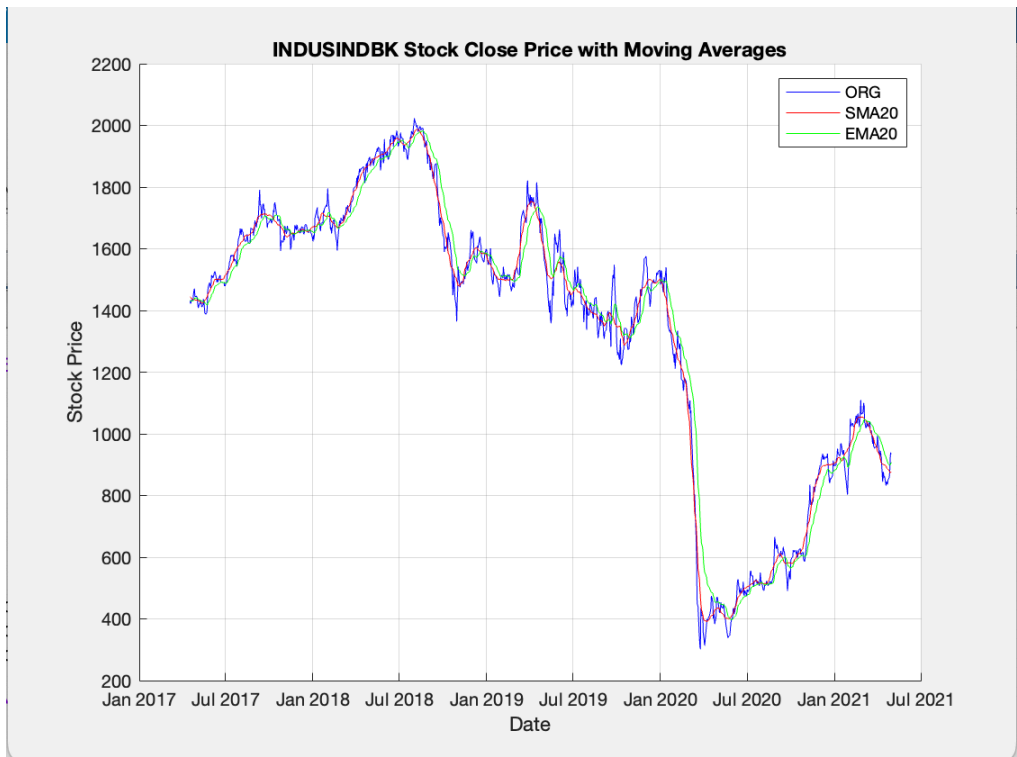
The code is below.

```
1 function y = EMA(data, windowSize)
2     % EMA = Price(t)*k + EMA(y)*(1-k)
3     % where:
4     % t = today
5     % y = yesterday
6     % N = number of days in EMA
7     % k = 2/(N+1)
8     smoothing = 2
9     k = smoothing / (windowSize + 1)
10
11     ema = zeros(length(data), 1)
12     ema(1) = data(1)
13
14     for t = 2:length(data)
15         ema(t) = data(t) * k + ema(t - 1) * (1 - k);
16     end
17     y = ema
18 end
19
20 function y = EMA_FILTER(data, windowSize)
21     smoothing = 2
22     alpha = smoothing / (windowSize + 1);
23     bk = [1, -(1 - alpha)];
24     y = filter(alpha, bk, data(end - 1000 + 1 : end, :));
25 end
26
27
```

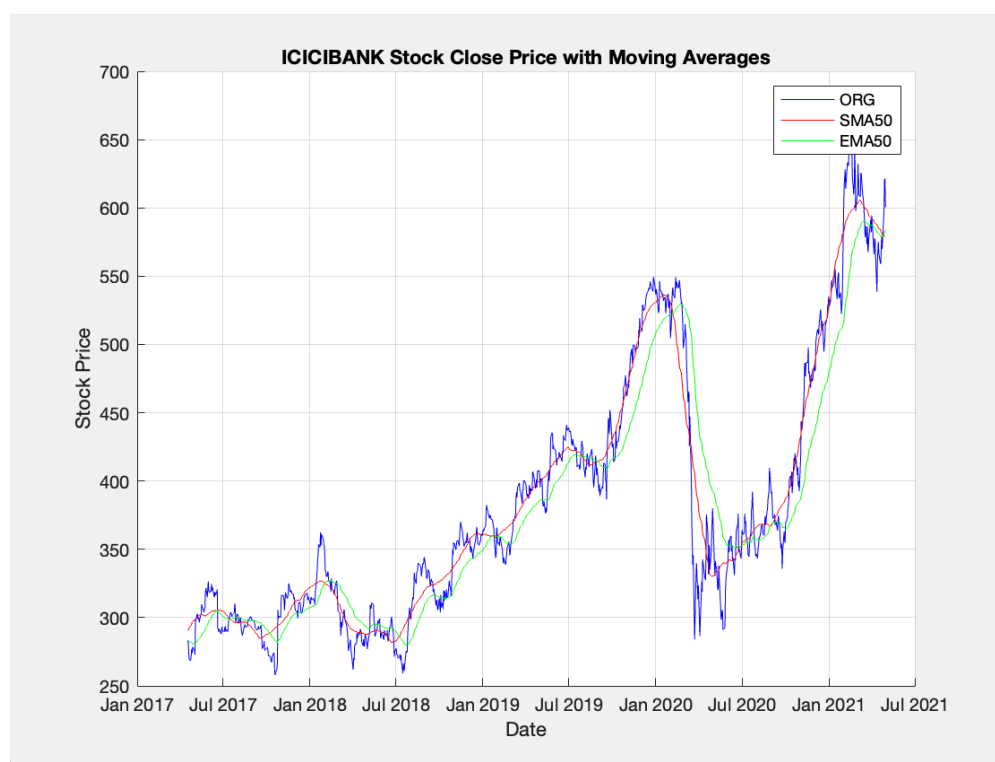
KOTAKBANK Product;



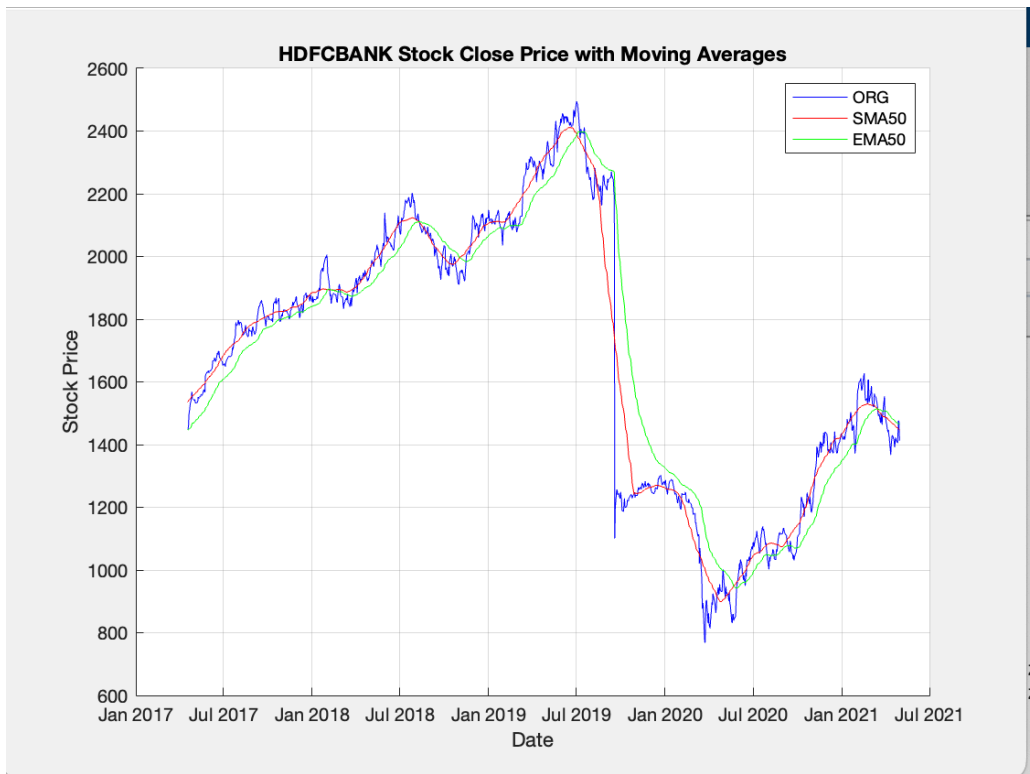
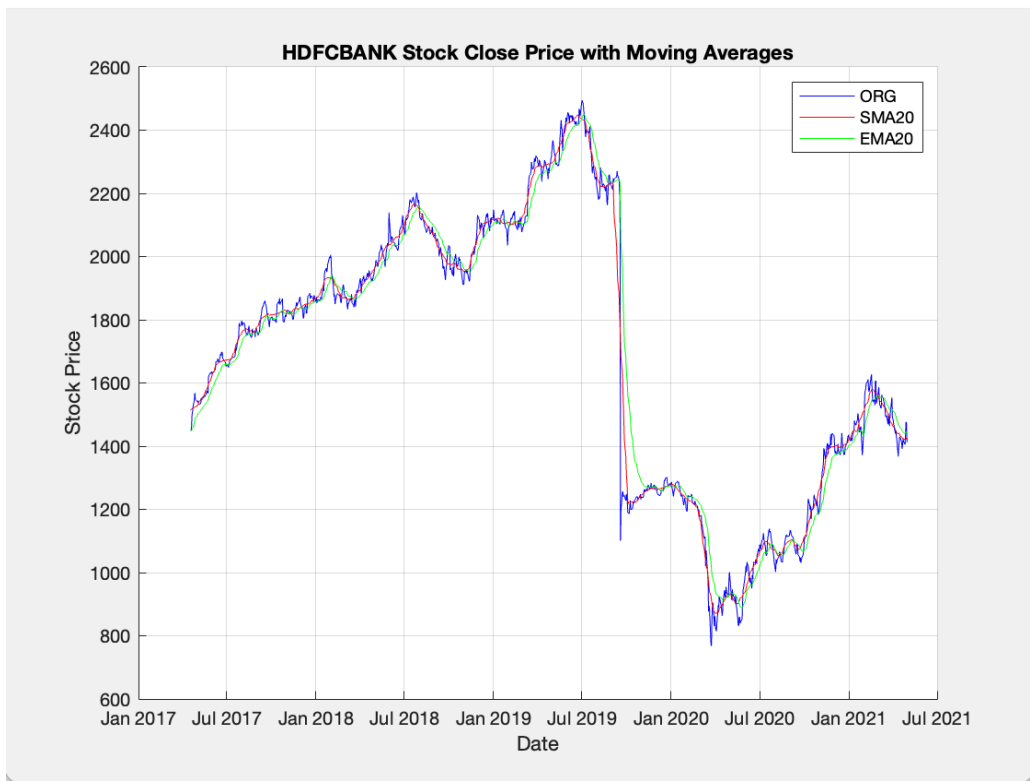
INDUSINDBK Product:



ICICIBANK Product;



HDFCBANK Product;

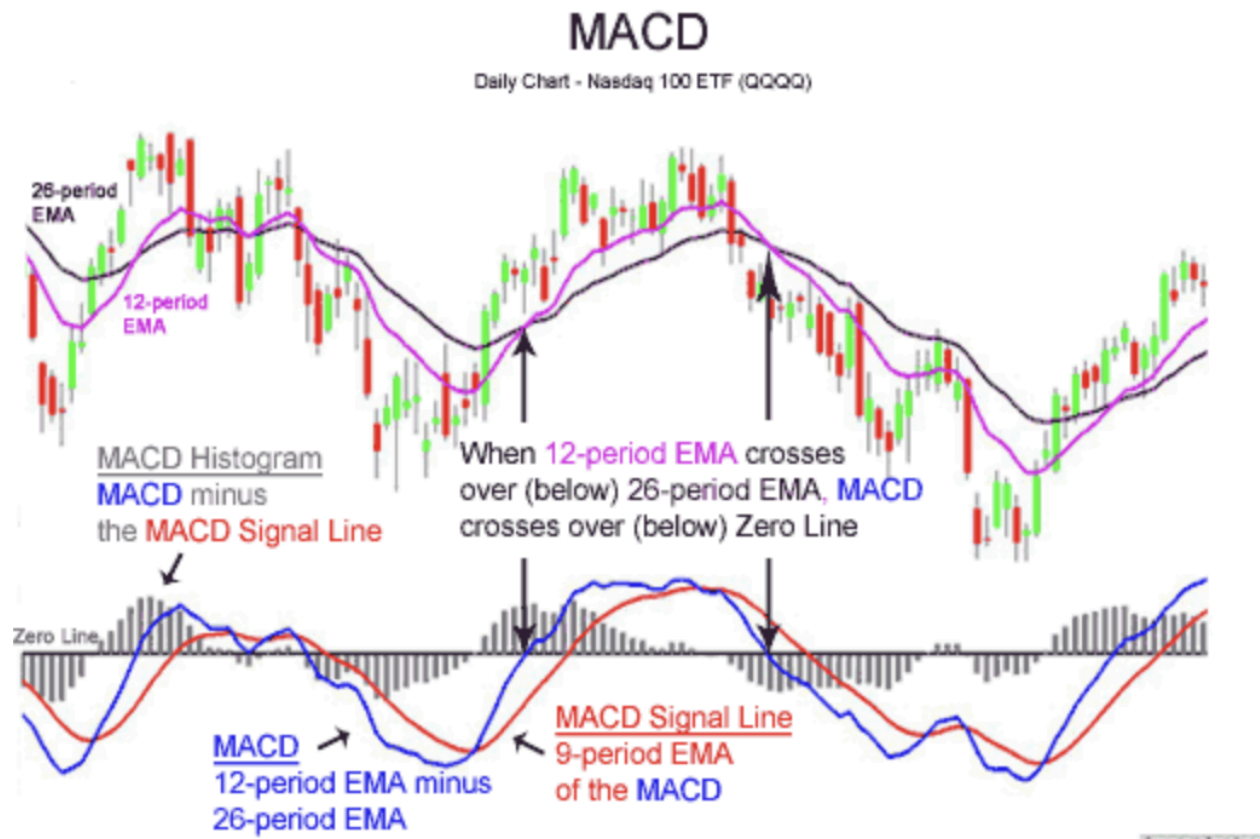


ICICIBANK has the most volatile product, so using a 50-window rate is particularly meaningful for it. As shown in the last graph, the SMA-50 effectively smoothes out the volatility. For the other two products, a 20-window rate is also beneficial.

From the plots, it's clear that when trades sweep the market to the buy side, the EMA captures the movement earlier than the SMA, as expected, since the SMA has some lag. For someone looking to estimate the near-term price, the EMA is more appropriate. On the other hand, if a trader plans to take a longer-term position, the SMA is more suitable.

In conclusion, the window size should be chosen to match the product's volatility on the corresponding date. Volatility naturally varies from day to day. For a more volatile market, a larger window size helps filter out daily noise. Once again, traders should consider these factors based on their trading frequency.

1.3 Your Suggested Method



In this part, I went in a way that as if I started to write my first strategy. Since I do not have much experience in trading, the first step should be simple. As Leonardo Da Vinci says '*Simplification is the ultimate sophistication*'. Between the choices, the most understandable and doable one seemed to be MACD. For an expert trader, the choice may vary for sure. You can get insight into the market movements easily with this method.

In this case, since the data is collected at the end of the day, the HFT is not the topic, so we can think as if we are trading a low-frequency prop firm. So, there is no problem with using MACD. Moreover, it is very easy to use. When I researched on the Internet, the signals can be interpreted as below:

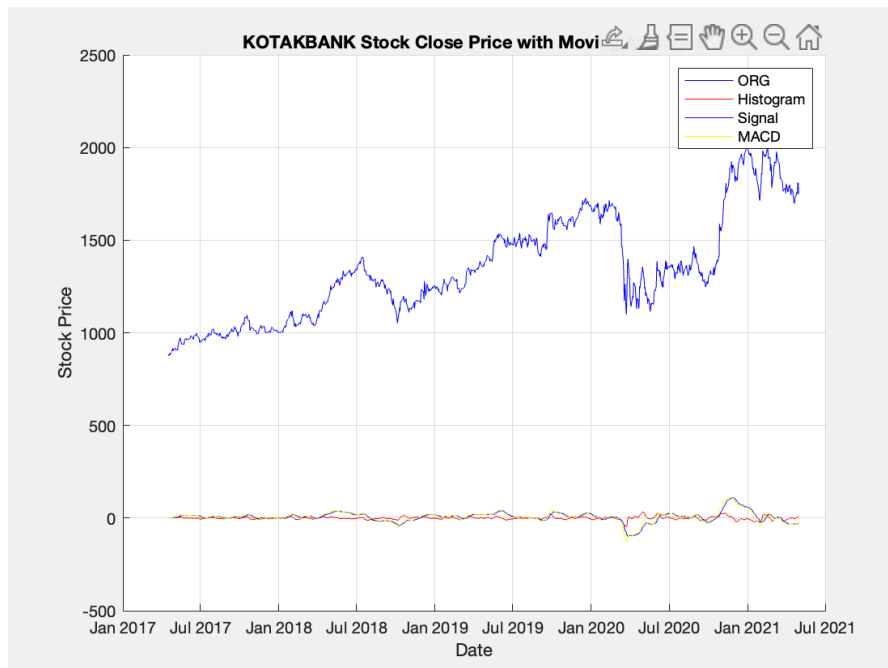
- **MACD Line crosses above Signal Line** : Possible **Buy Signal**
- **MACD Line crosses below Signal Line** : Possible **Sell Signal**
- **Histogram > 0 and increasing** : Strengthening trend
- **Histogram < 0 and decreasing** : Weakening trend

Therefore, as I said, for one who is new to the industry, it is a good start, right?

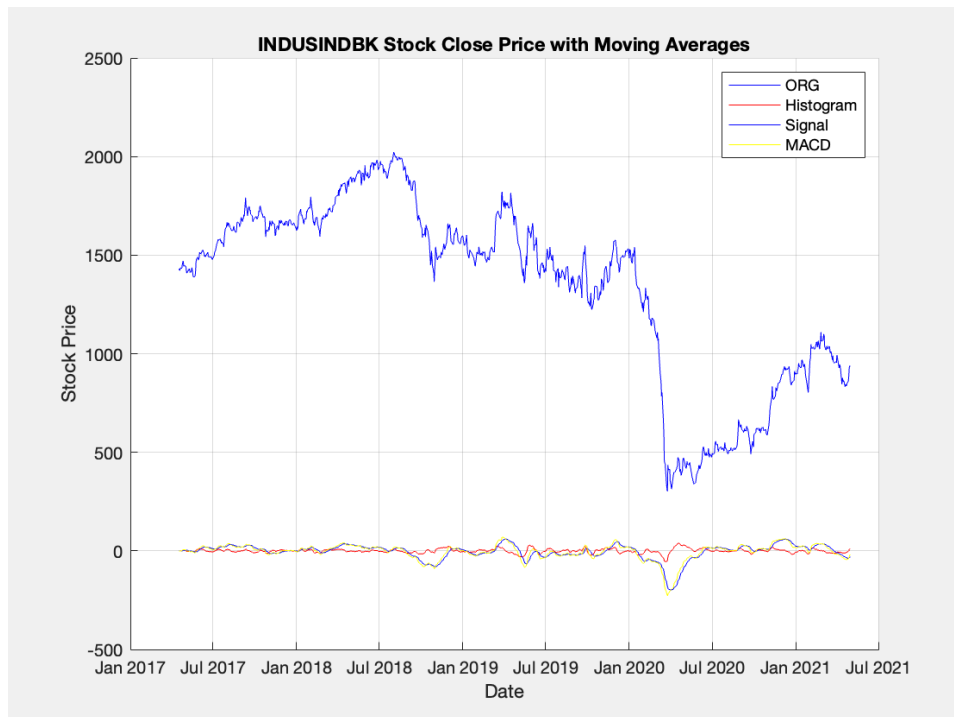
After the research, it turned out that there is a weakness in this method for sure. The most important problem with it is the lag it has. So, it may have some lag after the event begins. The solution could be using it with a Kalman Filter.

For the products we have, I do not have the background. The correct behaviour would be to choose the method according to the nature of the product. As far as I can see from the plot, they do not have huge peaks and valleys. Therefore, I do not comment on it.

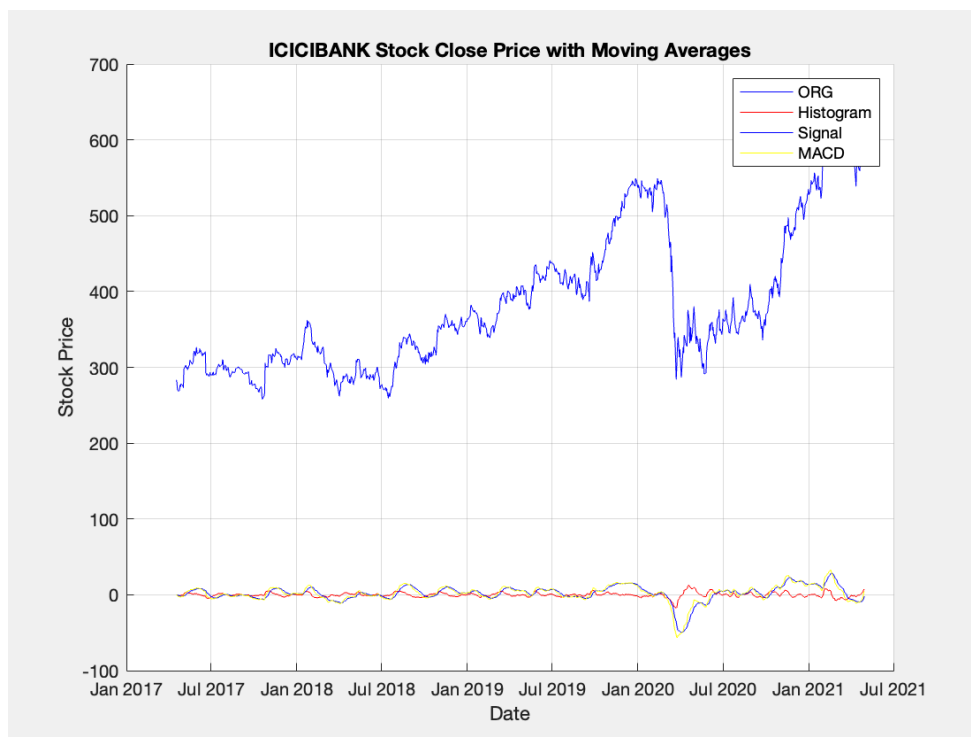
KOTAKBANK Product;



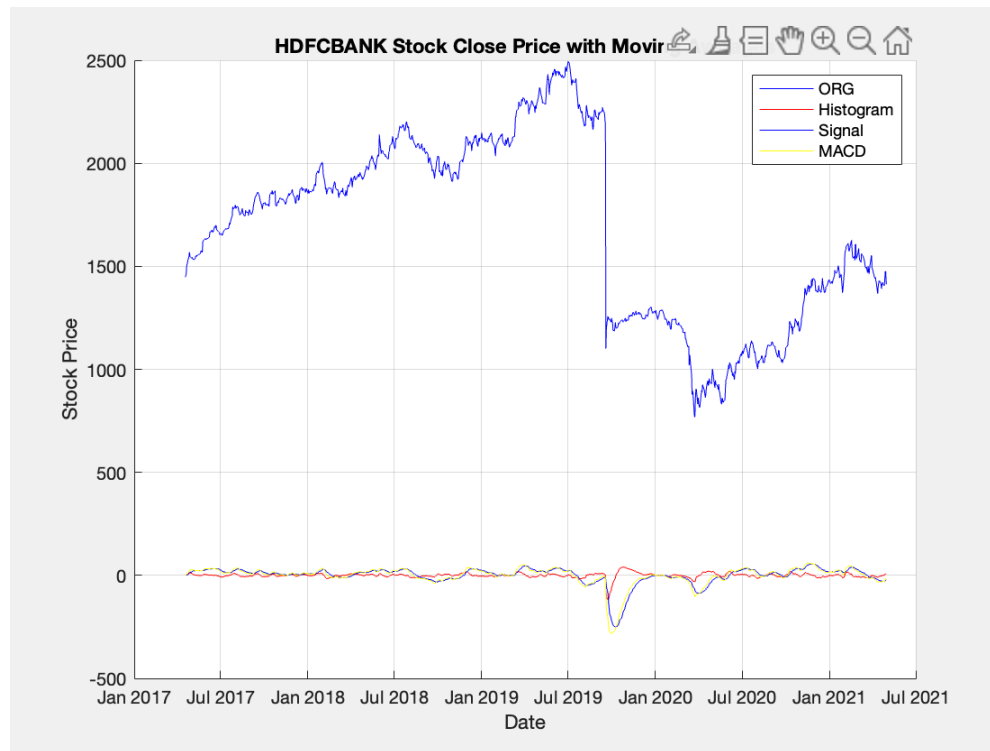
INDUSINDBK Product;



ICICIBANK Product;



HDFCBANK Product;



From the plots we have here, it can clearly be seen that the indicator is not affected by daily events or short-term trends. It primarily captures momentum. Therefore, it can help identify inefficiencies in the market.

Around Jan-Mar 2020, the MACD and Histogram dropped significantly before the price bottomed out, signaling weakening momentum. **Isn't that a compelling opportunity to take a position?** In that sense, we achieved our goal. A strategy algorithm based on MACD could have capitalized on this setup.

However, as we know, such a strategy might lose a substantial amount in other market conditions. This is not a trivial problem that can be solved with a few backtests. Thousands of backtests should be conducted, and the trader should invest time in Monte Carlo simulation systems.

Therefore, for the scope of this homework, this is a reasonable point to stop.

Part 2: Trading Strategy Design

In Part 1, I chose MACD to uncover the trends. There were indicators to buy and sell as below. Therefore, implemented a strategy to sell or buy according to these indicators.

- **MACD Line crosses above Signal Line** : Possible **Buy Signal**
- **MACD Line crosses below Signal Line** : Possible **Sell Signal**
- **Histogram > 0 and increasing** : Strengthening trend
- **Histogram < 0 and decreasing** : Weakening trend

The corresponding code is below:

```
alpha = 1
beta = 1
sigma = 1

for j = 401:1000
    % MACD Line crosses above Signal Line : Possible Buy Signal
    % MACD Line crosses below Signal Line : Possible Sell Signal
    % Histogram > 0 and increasing : Strengthening trend
    % Histogram < 0 and decreasing : Weakening trend

    crossUp = MACD_LINE(j-1)* alpha < SIGNAL_LINE(j-1) && MACD_LINE(j)*beta > SIGNAL_LINE(j)* sigma;
    crossDown = MACD_LINE(j-1)* alpha > SIGNAL_LINE(j-1) && MACD_LINE(j)*beta < SIGNAL_LINE(j)* sigma;

    hist_slope = HISTOGRAM(j) - HISTOGRAM(j-1);

    % Strength check
    bullish_strength = HISTOGRAM(j) > 0 && hist_slope > 0;
    bearish_strength = HISTOGRAM(j) < 0 && hist_slope < 0;

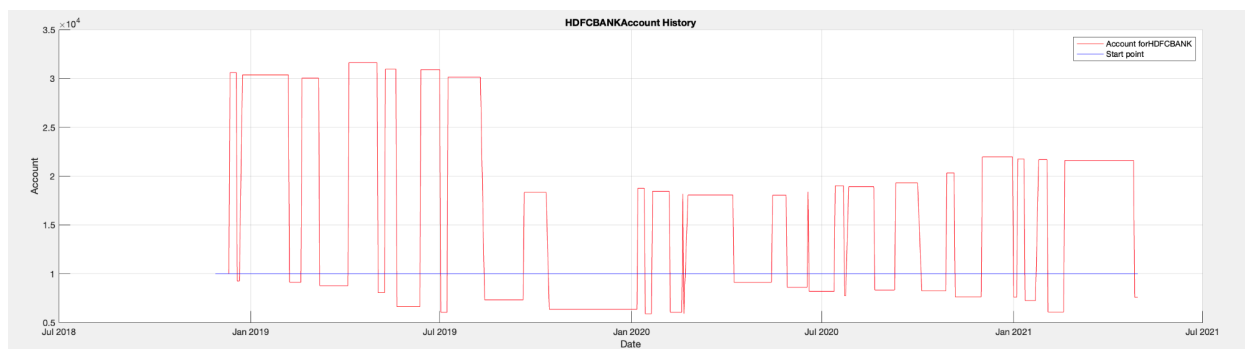
    % Final signals
    buy = crossUp && bullish_strength;
    sell = crossDown && bearish_strength;
```

As can be seen, the implementation is quite simple. It just applies the indicator to the instrument using a set of parameters. The key insight here is that there are three parameters, all currently set to their default values — that is, one.

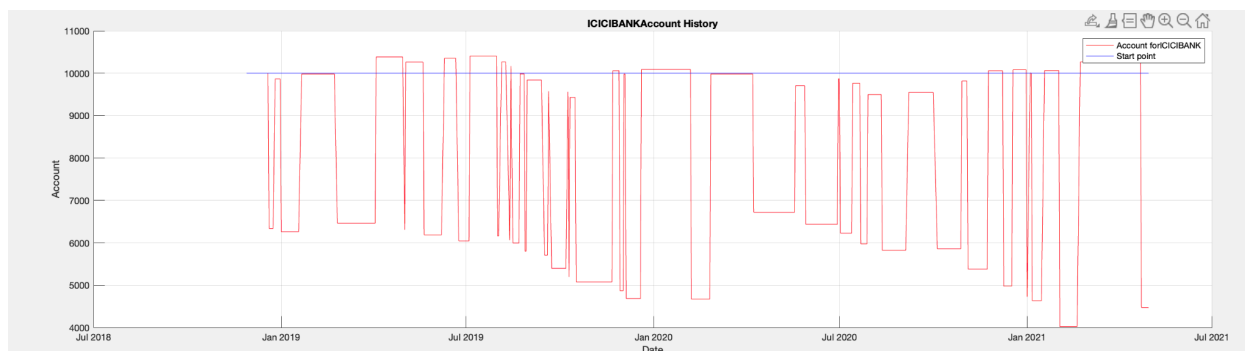
A more realistic approach would involve optimizing these parameters based on the specific instrument and time period. This requires the work of a quantitative analyst, who would need to backtest the strategy extensively to determine optimal values that could potentially generate profits. As it stands, the strategy is not profitable.

That said, this remains a valid strategy it's easily implemented via MACD, which makes it appealing for a new trader, right?

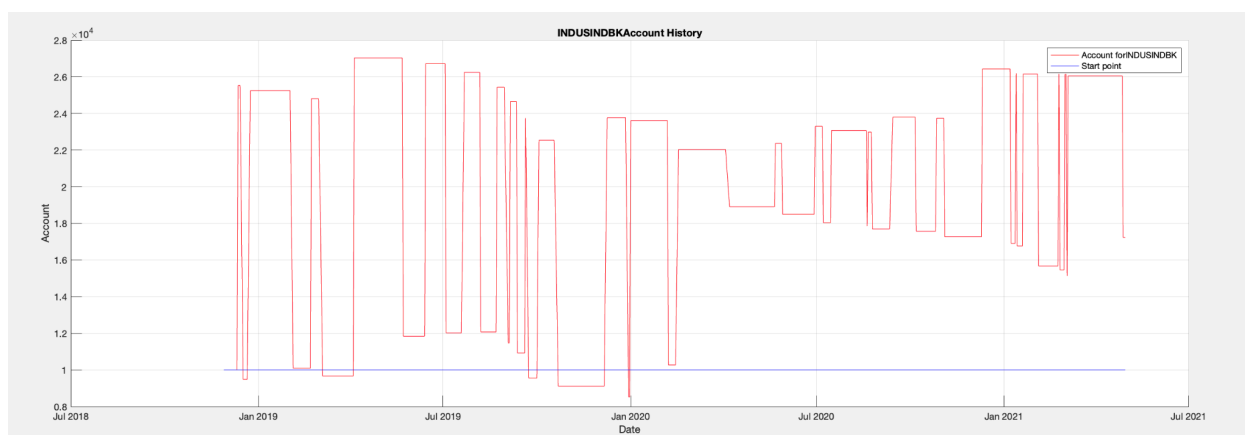
Net worth over time for HDFCBANK when running the strategy, which finishes with **-2431**.



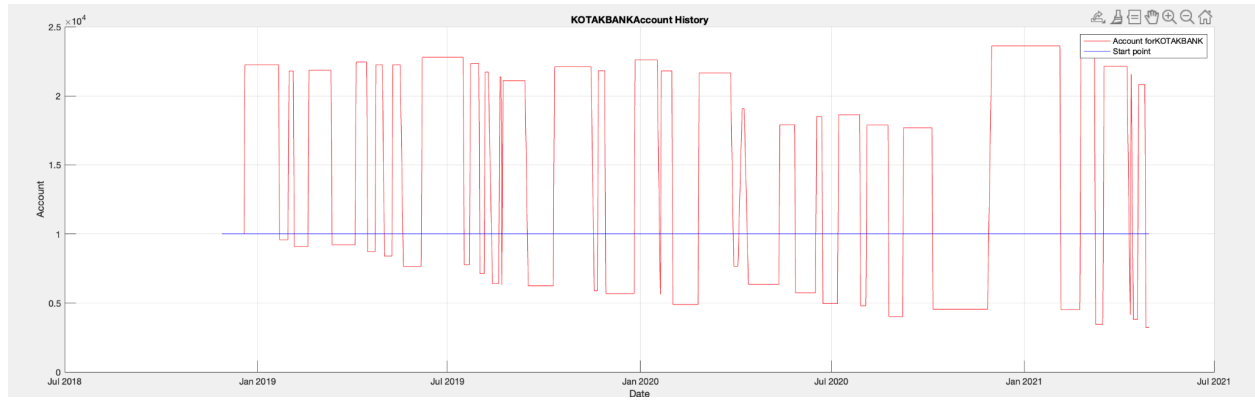
Net worth over time for ICICIBANK when running the strategy, which finishes with **-5528**.



Net worth over time for INDUSINDBK when running the strategy, which finishes with **+7233**.



Net worth over time for KOTAKBANK when running the strategy, which finishes with **-6772**.



Resources

- <https://en.wikipedia.org/wiki/MACD#/media/File:MACDpicwiki.gif>
- <https://www.goodreads.com/quotes/9010638-simplicity-is-the-ultimate-sophistication-when-once-you-have-tasted>
- <https://www.fidelity.com/viewpoints/active-investor/how-to-use-macd#:~:text=If%20the%20MACD%20line%20crosses,interpreted%20as%20a%20sell%20signal.>
- To make the grammar perfect, chatgpt.com is used.
- Also, some of the visuals are taken from the slides that the professor shared with us.