

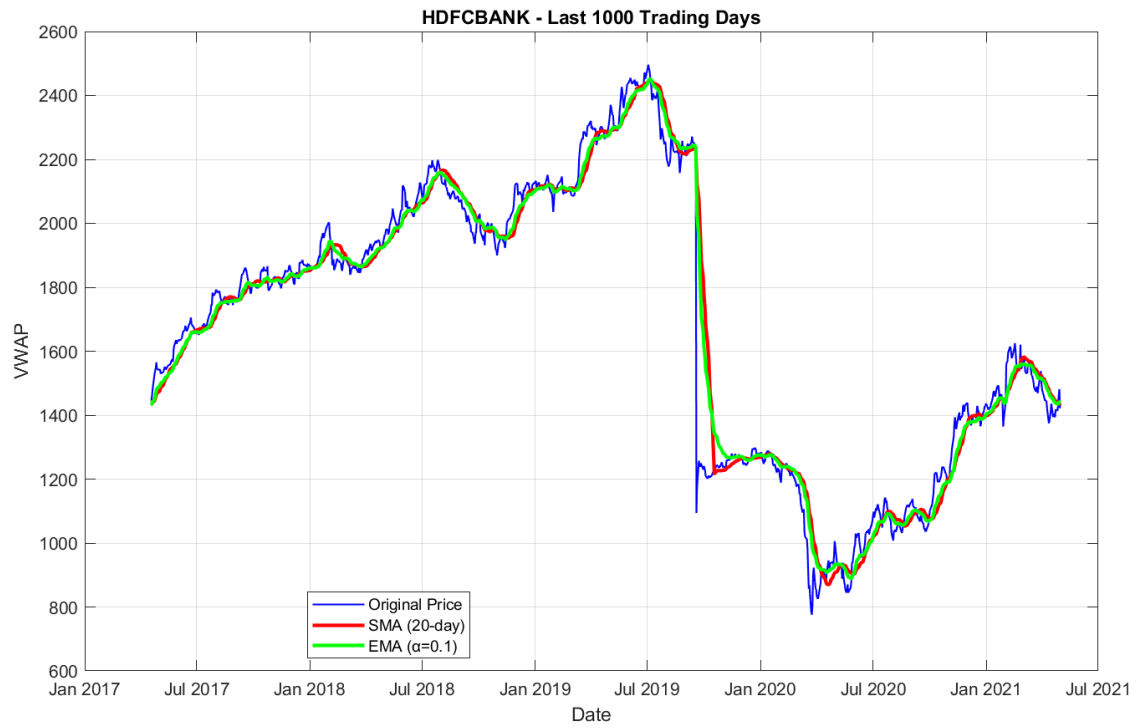
# CMPE 362 Homework 2

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## Part 1.1 & 1.2

### HDFCBANK



### **Observed Delays**

The 20-day SMA exhibits significant lag compared to the EMA ( $\alpha = 0.1$ ) during major price movements. This delay is particularly evident during the sharp decline in early 2020, where the SMA continued moving upward for several days after prices had already begun falling substantially. Similarly, during the recovery phase in mid-2020, the SMA took approximately one week longer than the EMA to confirm the upward trend.

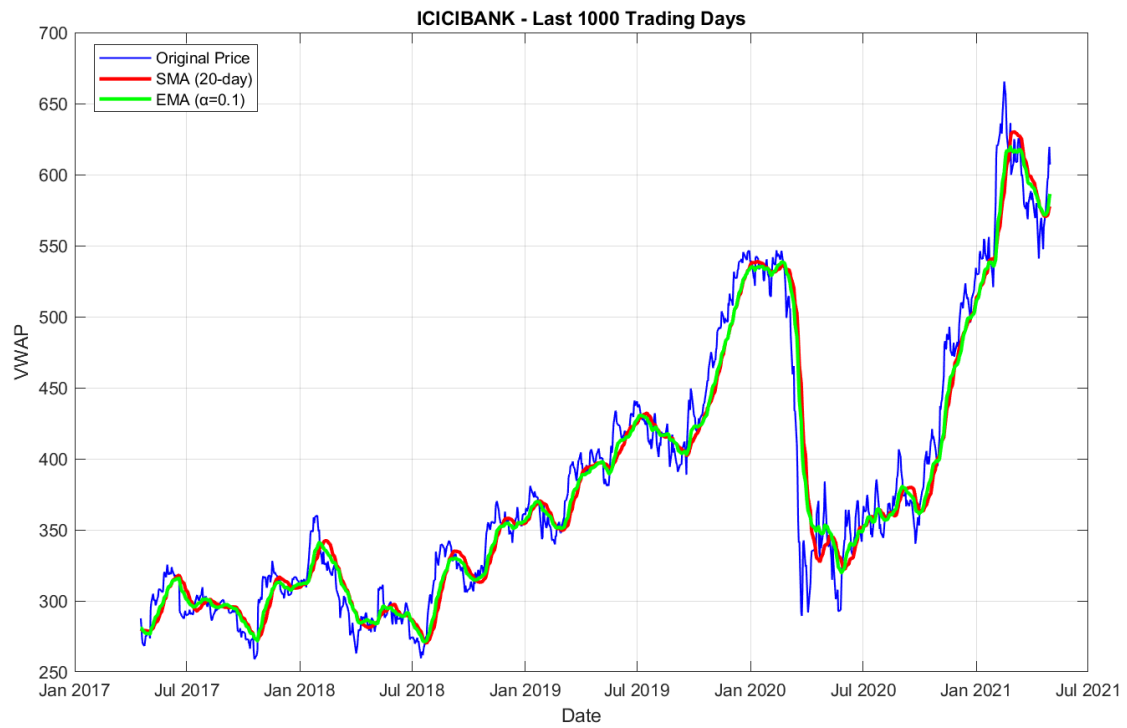
### **Smoothing Effects**

The SMA produces a noticeably smoother line throughout the entire period compared to the EMA, effectively filtering out minor price fluctuations. This smoothing is most evident during the volatile trading periods in early 2019 and mid-2020, where the SMA maintains a steadier path while the EMA captures more of the intermediate price movements.

### **Trend Identification**

During the strong uptrend from 2017 to 2019, both indicators effectively capture the overall direction, but the EMA identifies subtle trend changes earlier. For instance, the EMA signaled the beginning of the accelerated uptrend in late 2018 approximately 3-4 days before the SMA confirmed this change.

# ICICIBANK



### **Observed Delays**

The SMA demonstrates consistent lag behind price movements, particularly visible during the rapid recovery phase in late 2020. When the stock began its sharp ascent from around 350 to 500, the EMA began turning upward approximately 4-5 days before the SMA, providing earlier trend confirmation.

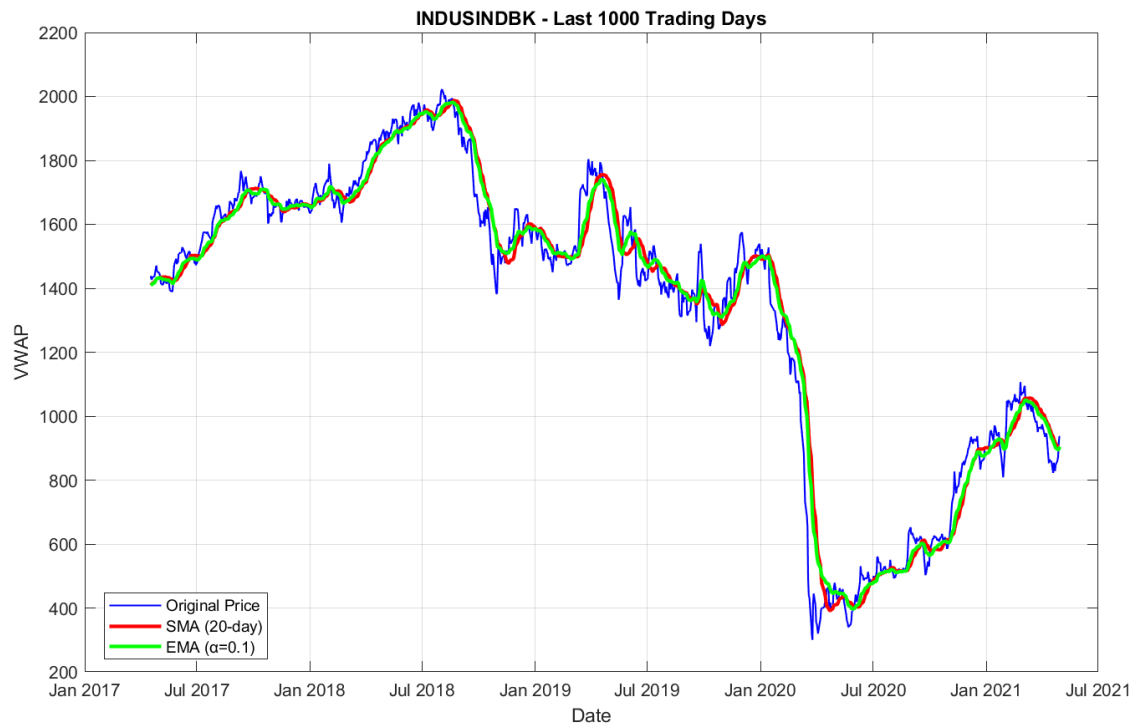
### **Smoothing Effects**

Throughout the sideways trading period in 2017-2018, the SMA provides greater noise reduction than the EMA, filtering out several short-term price swings that might have generated false signals. However, this comes at the cost of responsiveness during genuine trend changes.

### **Trend Identification**

The EMA captures the beginning of the strong uptrend in late 2019 more effectively, staying closer to the price action during the acceleration phase. During the volatile trading following the crash in early 2020, the EMA's closer adherence to price action reflects the actual market conditions more accurately than the heavily smoothed SMA.

## INDUSINDBK



### **Observed Delays**

The stock's dramatic price movements highlight the delay differences between these indicators. During the catastrophic decline in early 2020, the SMA lagged significantly, continuing to show relatively high values while the actual price had already collapsed by over 40%. The EMA adjusted more quickly but still exhibited some delay during this extreme market condition.

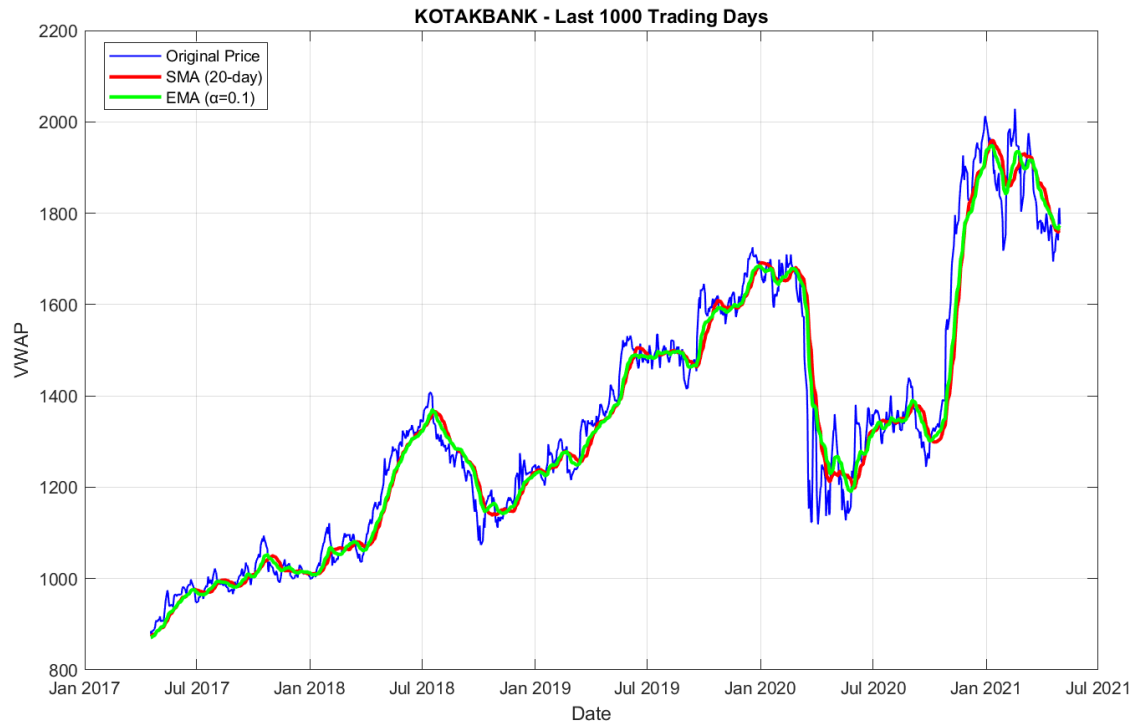
### **Smoothing Effects**

The prolonged downtrend from mid-2018 through 2020 shows how the SMA smooths out several attempted recoveries that ultimately failed. While the EMA responds to these temporary upward movements, the SMA's stronger smoothing effect maintains the downtrend signal, which proved correct in this case.

### **Trend Identification**

During the post 2020 recovery, the EMA identified several minor trend changes that the SMA missed entirely. For example, the temporary pullback in November 2020 was captured by the EMA but almost completely smoothed out by the SMA, potentially providing different trading signals to investors using these respective indicators.

# KOTAKBANK



### **Observed Delays**

The stock's steady growth pattern highlights how the SMA consistently lags behind price changes during trend reversals. This is particularly evident during the strong uptrend in late 2020, where the EMA tracked the price appreciation much more closely than the SMA.

### **Smoothing Effects**

During the consolidation period in mid-2019, the SMA provides a clearer sideways signal while the EMA responds to minor price fluctuations that ultimately proved insignificant to the longer-term trend. This demonstrates the SMA's superior ability to filter out market noise during non-trending periods.

### **Trend Identification**

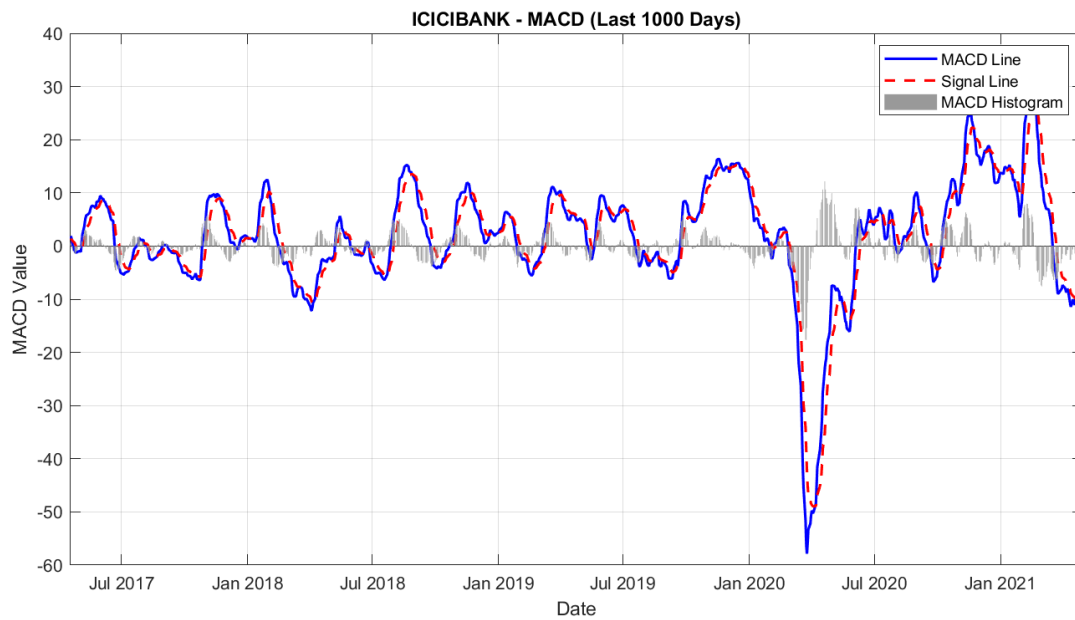
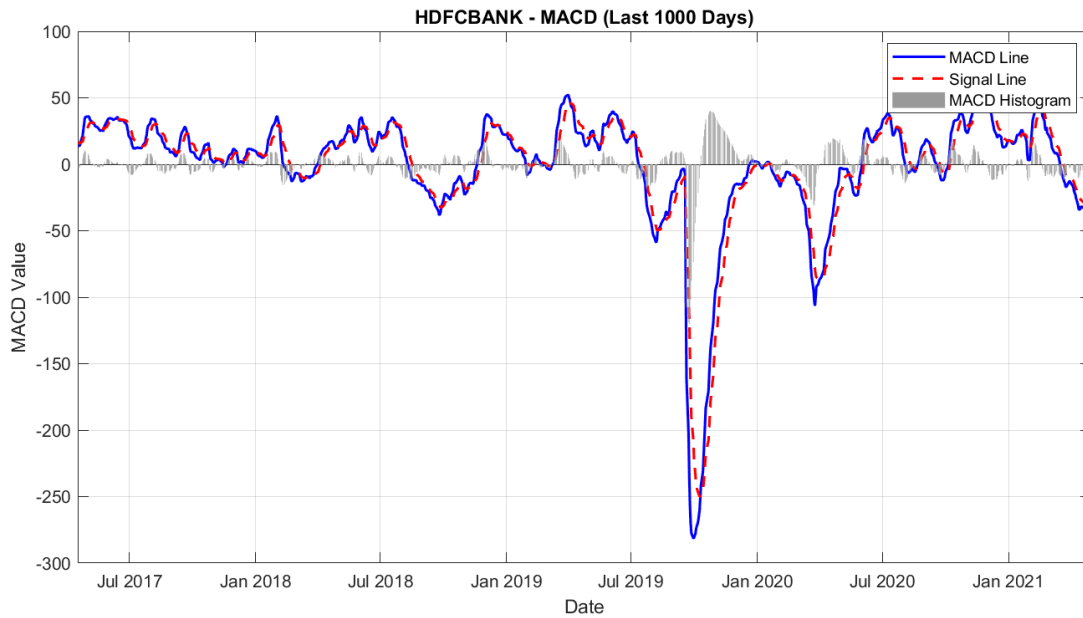
The most notable difference appears during the strong uptrend in late 2020 through early 2021, where the EMA hugs the price action closely while the SMA provides a more measured confirmation of the trend. The EMA would have provided earlier entry signals during this highly profitable period, while the SMA would have prevented premature entries during the choppy trading in mid-2020.

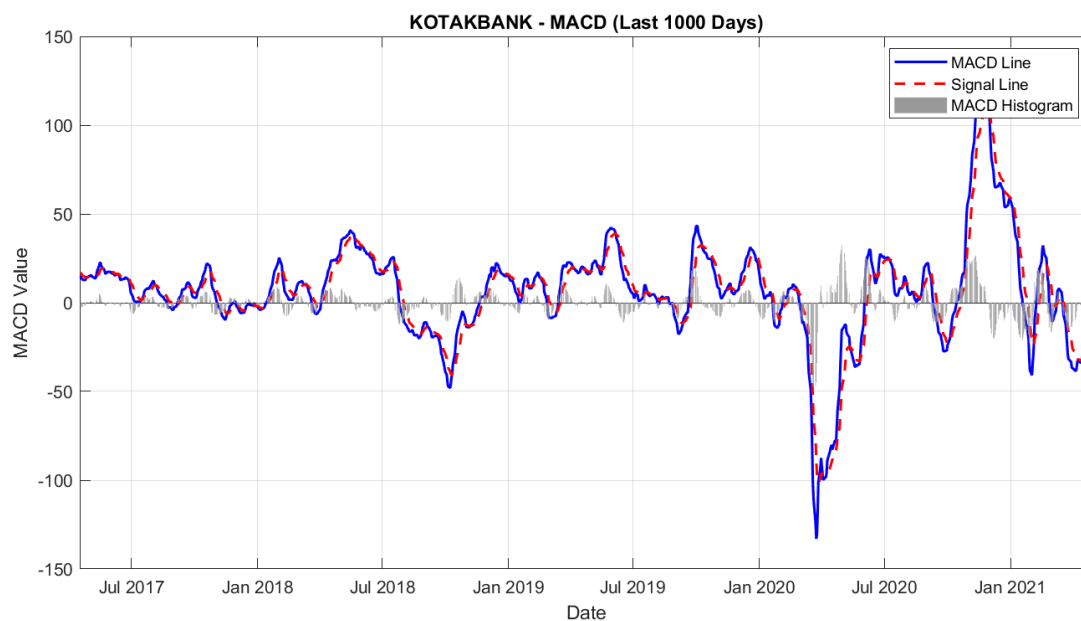
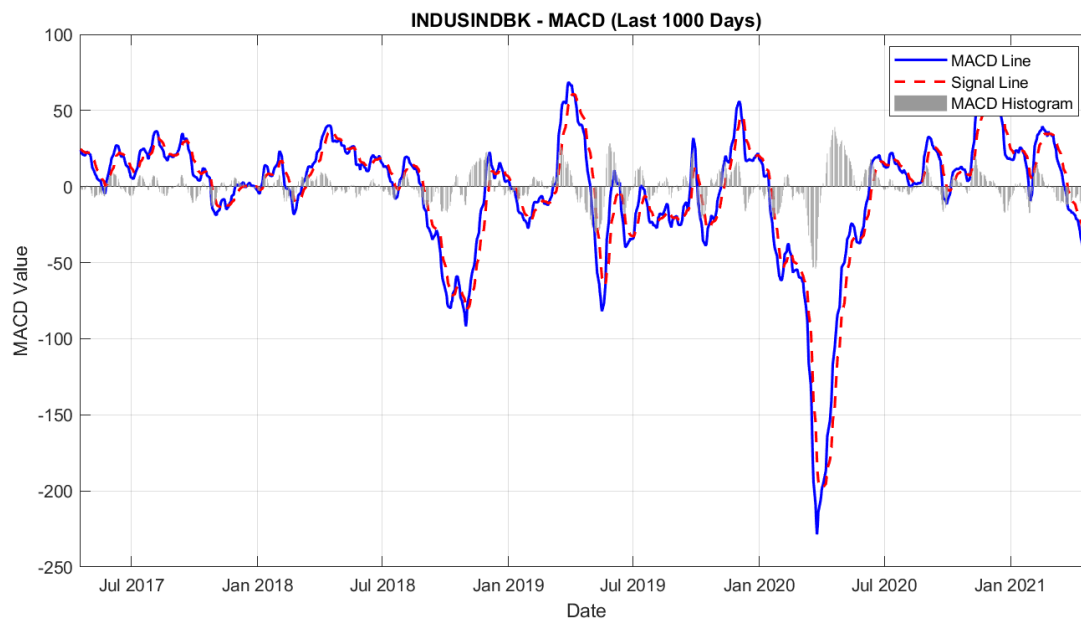
### **Comparing EMA responsiveness to SMA**

- Looking at the charts, the EMA responds more quickly to price changes than the SMA during critical market movements
- During the sharp market crash in early 2020 (visible in all four banks), the EMA line begins declining earlier and recovers sooner
- The EMA curves display more subtle movements during price fluctuations while still maintaining overall smoothness
- At turning points, the EMA shows earlier signals for potential trend changes while the SMA confirms these changes with less false signals but more delay



## Part 1.3





## MACD Method

The Moving Average Convergence Divergence (MACD) is a momentum-based indicator widely used in quantitative finance and technical analysis. It helps traders identify potential buy or sell signals by analyzing the relationship between two Exponential Moving Averages (EMAs) of different periods. The MACD was developed by Gerald Appel in the late 1970s and remains a popular choice for identifying trend changes and momentum shifts in stock prices.

### Computation

The MACD line is calculated using the difference between a short-term EMA and a long-term EMA. Common choices for the periods are 12 and 26 days. A signal line, typically a 9-day EMA of the MACD line, is used to generate actionable trading signals. The formulas are as follows:

- **Short-term EMA:**

$$EMA_{short}(t) = \alpha_{short} \cdot Price(t) + (1 - \alpha_{short}) \cdot EMA_{short}(t - 1)$$

- **Long-term EMA:**

$$EMA_{long}(t) = \alpha_{long} \cdot Price(t) + (1 - \alpha_{long}) \cdot EMA_{long}(t - 1)$$

- **MACD Line:**

$$MACD(t) = EMA_{short}(t) - EMA_{long}(t)$$

- **Signal Line (9-day EMA of MACD):**

$$Signal(t) = \alpha_{signal} \cdot MACD(t) + (1 - \alpha_{signal}) \cdot Signal(t - 1)$$

Typical smoothing factors are derived from the formula:  $\alpha = \frac{2}{N+1}$ , where  $N$  is the period length (e.g., 12, 26, or 9).

### Interpretation and Trading Signals

- When the MACD line crosses above the signal line, it suggests increasing upward momentum. This is typically interpreted as a **buy signal**.
- When the MACD line crosses below the signal line, it indicates downward momentum. This is interpreted as a **sell signal**.
- If the price is making new highs/lows but the MACD is not, it could signal a potential reversal.

## Rationale and Suitability

The MACD is a well-established and a literature-based method with strong empirical support in quantitative finance and is widely used by traders to detect trends and momentum shifts. It balances trend-following and momentum-based insights by combining EMAs of different periods combining aspects of both trend-following and momentum indicators, making it effective in identifying the strength and direction of a trend. Unlike simple moving averages (SMA), the EMAs used in MACD give more weight to recent prices, making them more responsive to changes.

In our project, we calculated both the SMA and EMA to compare performance and provide smoother trend information. The MACD, which relies directly on EMA values, was then used as the primary trading indicator. It provides a simple but effective mechanism to determine entry and exit points without requiring future information, thus aligning well with real-time trading scenarios.

In my trading strategy, I used the MACD crossovers as the primary decision-making mechanism. Specifically, buy signals were generated when the MACD line crossed above the signal line, and sell signals were triggered when the MACD line crossed below the signal line. These decisions were further reinforced by comparing current prices to SMA and EMA levels for more robust filtering.

This method enabled me to respond dynamically to market momentum, making it suitable for algorithmic trading over historical data. The MACD strategy is particularly suitable for our dataset due to these factors:

- It is literature-based and used by professionals in financial markets.
- It offers clear entry and exit signals based on crossovers, reducing ambiguity.
- Simplicity and interpretability for algorithmic simulation.
- It adapts to changes in market dynamics better than simple moving averages alone.
- It is able to detect momentum shifts
- High responsiveness to price changes (via EMA)

Although it may generate few but significant signals, it helps avoid overtrading and reduces exposure to noise in highly volatile markets.

## Part 2: Trading Strategy

### Trading Logic Explanation

The trading strategy is designed to utilize the outputs from Part 1 (SMA, EMA, and MACD) to make day-to-day buy or sell decisions based on certain conditions derived from the indicators.

- Start with 10,000 currency units for each stock.
- Part 1 Outputs: SMA (Simple Moving Average): This is used to smooth out short-term fluctuations and highlight longer-term trends. It's typically slower to react than the EMA or MACD.  
EMA (Exponential Moving Average): The EMA responds more quickly to recent price changes than the SMA and can provide quicker trend signals.  
MACD (Moving Average Convergence Divergence): This is the key decision-making tool. It helps identify potential buy/sell signals based on the crossover between the MACD line and the signal line.
- Decision-Making Logic:  
Buy Signal: When the MACD line crosses above the signal line, and the price is above the SMA and EMA (confirming an uptrend).  
Sell Signal: When the MACD line crosses below the signal line, and the price is below the SMA and EMA (confirming a downtrend).
- Execute Trades:  
If a buy signal is triggered and there is available cash, the strategy buys fractional shares of the stock with the 20% of the cash.  
If a sell signal is triggered and there are shares held, the strategy sells fractional shares of the stock worth 20% of the current holdings.  
Trading 20%:
  - Diversifies risk by only using 20% of our cash or shares, we avoid going "all-in" on a single trade, which reduces the chance of large losses.
  - Leaves room for future trades as market conditions can change quickly. Trading a smaller portion allows us to respond to new signals without being fully committed.
  - Balances opportunity and safety as 20% is often considered a conservative but active portion—it's enough to benefit from good signals, but small enough to preserve capital in volatile markets.
- Log the actions for each day: The algorithm logs the decisions (Buy/Sell) and the corresponding day in a text file for tracking.

- Repeat the above process day by day for the last 600 days of each stock, making decisions based on the current values of SMA, EMA, and MACD for each day.

## Pseudocode

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**Algorithm 1** Trading Strategy Based on MACD, SMA, and EMA

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1: Initialize cash = 10000, shares = 0
2: for each day  $t$  in the last 600 days do
3:   Retrieve  $SMA(t)$ ,  $EMA(t)$ ,  $MACD(t)$ ,  $Signal(t)$ , and price  $P(t)$ 
4:   if  $MACD(t)$  crosses above  $Signal(t)$  and  $P(t) > SMA(t)$  and  $P(t) > EMA(t)$  then
5:     Buy with 20% of available cash
6:     Log "Day  $t$ : BUY [quantity] of [Stock]"
7:   else if  $MACD(t)$  crosses below  $Signal(t)$  and  $P(t) < SMA(t)$  and  $P(t) < EMA(t)$  then
8:     Sell 20% of current holdings
9:     Log "Day  $t$ : SELL [quantity] of [Stock]"
10:  end if
11: end for
12: Output final net worth: cash + shares  $\times$  price
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## Performance Analysis

### Net Worth

- KOTAKBANK: Final net worth = 11,911.95 (Profit of 19.12%)
- HDFCBANK: Final net worth = 9,283.04 (Loss of -7.17%)
- ICICIBANK: Final net worth = 13,444.75 (Profit of 34.45%)
- INDUSINDBK: Final net worth = 10,171.56 (Profit of 1.72%)

### Was it profitable?

The strategy was profitable for KOTAKBANK, ICICIBANK, and INDUSINDBK with positive returns.

However, it resulted in a loss for HDFCBANK, indicating that the strategy may not be universally profitable for all stocks in this dataset.

### What worked well?

The MACD crossover strategy worked effectively for some stocks, particularly ICICIBANK and KOTAKBANK. These stocks showed positive returns, indicating that the MACD was successful in identifying profitable trends.

The strategy was responsive to the rapid changes in price action due to the EMA, which allowed the model to react quickly to price movements.

### **What could be improved?**

- **Volatility Filtering:** The strategy may have been too sensitive to short-term fluctuations, especially in HDFCBANK. Implementing a band-pass filter to detect higher volatility or a stop-loss mechanism could help minimize losses during periods of high volatility.
- **Dynamic Adjustment of Indicators:** The use of fixed parameters (such as the period for SMA/EMA) may not be optimal for all stocks. A dynamic approach that adjusts these parameters based on market conditions such as using adaptive windows could improve performance.
- **Risk Management:** Incorporating a more sophisticated risk management strategy, such as limiting the proportion of portfolio allocated to any single stock or using trailing stop-loss orders, could protect gains and limit downside risks.
- **Additional Indicators:** Incorporating other technical indicators like RSI (Relative Strength Index) or Bollinger Bands could help refine buy and sell decisions and reduce the risk of false signals.