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**Research Article**

# A Study On The Effectiveness Of Moving Average Convergence And Divergence (MACD)

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**ARTICLE INFO**

**ABSTRACT**

In the digitalized word, it becomes easier to trade in stock but earning profit requires some analysis before investing. Analysis in stock can be categorized into fundamental and technical. Fundamental analysis is based on the performance, financials and future prospects of the company whereas technical analysis is based on the historical market data of stock mainly on stock price and volume. Technical analysis is done through charts and statistical indicators. One of the most popular technical analysis tools is Moving Average Convergence and Divergence shortly called as MACD. MACD can be interpreted in two ways i.e. through Centreline Crossover Strategy and Signal Line Crossover Strategy. The objective of this study is to analyse the effectiveness of the MACD with reference to select stocks in Information Technology Sector being traded in BSE. For this purpose, a comparative study on profitability is made among two strategies of MACD and with Buy and Hold strategy. In the Buy and Hold strategy itself, analysis is done for two variations i.e. buy based on MACD centreline crossover and then hold and Random buy and hold. Extended Internal Rate of Return (XIRR) has been used to measure profitability. Based on the sample data for the population taken for analysis, Centre Line Crossover Strategy is same or more profitable than Signal Line Crossover Strategy and Random Buy and Hold strategy.

**Keywords:** Moving Average Convergence and Divergence (MACD), Technical Analysis, Buy and Hold Strategy, Technical Indicator

## Introduction

In the digitalized word, it becomes easier to trade in stock by a common man who has no knowledge about investing in stock. Opening of online trading and demat account is a simple process nowadays. Mobile apps made the stock trading at the reach of everyone. Personalized dash board of the trading account helps the investor to know the holdings and current value of the invested stocks. Personalized dash board also gives more information about the stock in which the investor is interested to invest. But to make profit and to minimize loss, analysis about the stock, the price movements and the technical indicators are vital for the investor. Stock Analysis can be categorized into fundamental analysis and technical analysis.

Fundamental analysis is the analysis of financials through Balance Sheet, Profit and Loss accounts, Cash flows and financial Ratios. Analysis on competitors and future prospects of the company also part of fundamental analysis. Technical analysis is the analysis of historical data of the stock price and volume through charts, trends and other statistical indicators.

Technical analysis is based on few assumptions as given below.

- Market discounts everything: It means that the stock price reflects everything about the stock
- "How" is more important than "Why": Technical analysts are interested in knowing 'how' the price reacts than 'why'
- Price moves in Trend: The stock price establishes a trend and moves in the direction of the trend
- History tends to repeat itself: It is based on the assumption that market participants will react in the same way for the price movements. This will result in the history repeats itself.

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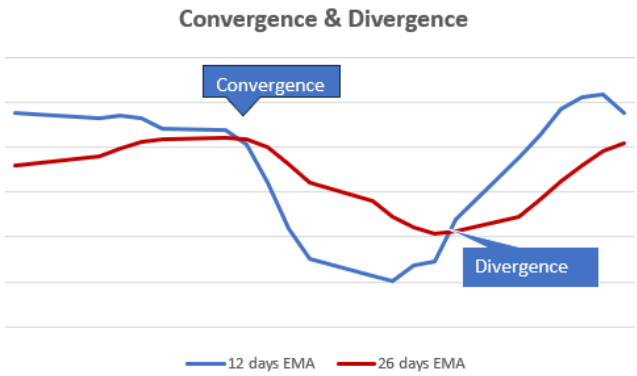
There are many technical indicators available for technical analysis. One of the most common technical indicators is Moving Average Convergence and Divergence, shortly called as MACD. It was created by Gerald Appel in the late 1970's. Though invented in nineteen seventies, MACD is still considered as one of the most reliable technical indicators.

## What is MACD?

Moving Average Convergence and Divergence (MACD) is about the Convergence and Divergence among two Exponential Moving Averages (EMA) of the same stock price for two different periods. 12 days and 26 days are considered as the standard period for MACD calculation though it is not sent in stone. For MACD, EMAs are being calculated on the closing price. Convergence happens when the 26 days EMA is moving towards 12 days EMA. Divergence happens when the 26 days EMA is moving away from 12 days EMA. Convergence is a signal to sell (short) and Divergence is a signal to buy (long). Both are illustrated in Graph 1.

*Graph 1*




MACD can be said as both Trend and Momentum indicator. Trend indicators analyse the direction and persistence of the price movements over time. Momentum indicators analyse the speed and strength of price movements. Trend indicators emphasize on the consistency of price movements whereas momentum indicators confirm the trends as well as signal the potential trend reversals. MACD performs both.

MACD graph is constructed as explained below.

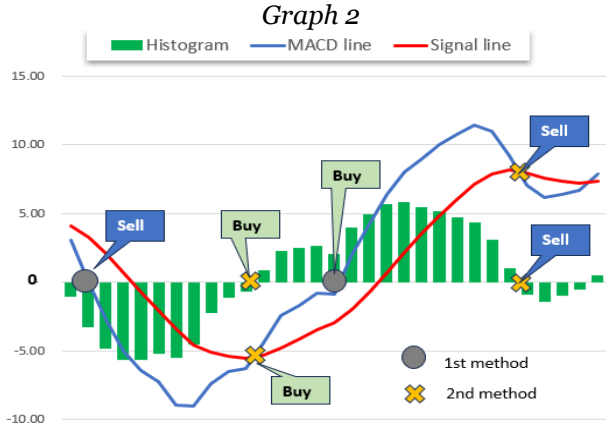
A. 12 days EMA is calculated on the day's closing price.
B. 26 days EMA is calculated on the day's closing price.
C. 26 days EMA is subtracted from 12 days EMA (A-B). These are MACD values and form MACD line.
D. 9 days EMA of MACD values are calculated. These values form Signal line.
E. Signal line values are subtracted from MACD values (C-D). These values form Histogram.

MACD graph is interpreted in two ways as explained below.

1. Centre Line Crossover: When the MACD line crosses above Zero from negative territory, it is assumed as the signal of bullish trend and stocks can be bought. When the MACD line crosses below Zero from positive territory, it is assumed as the signal of bearish trend and stocks can be sold. This method is nothing but the cross over of 12 days EMA with 26 days EMA.
2. Signal Line Crossover: When the histogram crosses above Zero from negative territory, it is assumed as the signal of bullish trend and stocks can be bought. When the histogram crosses below Zero from positive territory, it is assumed as the signal of bearish trend and stocks can be sold. This method is nothing but the cross over of MACD line with Signal line.

Both methods are illustrated in Graph 2.

*Graph 2*



This paper is focused on analysing the effectiveness of MACD as an indicator for buy, hold or sell decision. For this purpose, a study is made on the profitability of Buy and Sell decisions based on MACD and it is compared with the profitability on Buy and hold decision. In the Buy and Hold decision itself, two variants are used to analyse i.e. (i) Buy decision based on MACD and then Hold, and (ii) Buy decision taken randomly without considering MACD and hold. An attempt is also made to analyse the profitability between the two methods of MACD interpretation i.e. Centre Line Crossover Vs. Signal Line Crossover. This study has been made with reference to select stocks in Information Technology Sector being traded in BSE namely Tata Consultancy Services Limited, Infosys Limited, HCL Technologies Limited and Wipro Limited.

## Literature Review

Dipak Vishwakarma, Trupti Aod, Ghanshyam Gaur, Prof. Samir Thakkar in their study on "Trading Through Technical Analysis with MACD", tested whether the return from investment positions based on MACD tool is more significant than Buy and Hold Strategy. They also tested whether the return from investment positions based on EMA tool is more significant than Buy and Hold Strategy. They collected data for the period of 10 years for 3 currency pairs and 3 stocks of Indian companies and done their study. After studying, they found that different strategies are significant for different currency pairs and for different companies.

Abhisek Khatua, in his study on "An Application of Moving Average Convergence and Divergence (MACD) Indicator on Selected Stocks Listed On National Stock Exchange (NSE)" applied the MACD tool on selected 5 stocks for one year and analysed. He also pointed out the supplementary rules. Buy signals can be more reliable when the MACD line has crossed above "0" after some time since the recent sell signal is created. Sell signals can be more reliable when MACD line has crossed below "0" after some time since the recent buy signal is created.

Alex Spiroglou, in his research on "MACD-V, Volatility Normalised Momentum", tried to improve existing classic MACD through new techniques to eliminate its shortcomings. He explained the drawbacks of MACD as the MACD values are not comparable across time and across securities. Because of these drawbacks, he mentioned that it is not possible to standardise the intensity of MACD into quantitative such as high Vs low and/or overbought Vs. Oversold levels. He also pointed out one more drawback of MACD as the MACD signals are late while high momentum trend reversals. He first tested Percent Price Oscillator (PPO) which is normalised version of MACD by changing absolute value of MACD into percentage. PPO overcomes the drawback of comparability across time but not across securities. PPO failed to overcome other drawbacks as well. He then tested his new technique MACD-V which is volatility normalised momentum by defining MACD as percentage of Average True Range. He also used histogram MACD-VH which is based on MACD-V. After testing he found that MACD-V is capable of comparing the values across time and across securities.
Rashesh Vaidya, in his study on "Moving Average Convergence-Divergence (MACD) Trading Rule: An Application in Nepalese Stock Market (NEPSE)" analysed Nepalese stock market for the period 1998-2020 with the help of MACD. He found that high level market fluctuations were seen in FY 2019-20. He also found that there was more bearish trend in NPSE in the test period and only five percent of trading days were stable which is the indication of highly unstable and volatile market. He recommended using of candlestick charting along with MACD for better results.

Yogesh D Mahajan & Krishnamurthy Inumula in their study on "Optimization of MACD and RSI indicators: An Empirical Study of Indian Equity Market for Profitable Investment Decisions" tested the potential contribution of classical MACD & Relative Strength Indicator (RSI) over Buy and Hold strategy. They also tested optimised MACD and RSI over classical MACD & RSI and also over Buy and Hold strategy. For this purpose, they selected 30 stocks from 5 sectors which were traded continuously in NSE for the period of 3 years. They used a range for optimisation. They tested and concluded that Buy and Hold strategy is more profitable than classical MACD & RSI but normalised MACD & RSI leads to more profitability than classical MACD & RSI and Buy and Hold strategy.

Dejan Eric, Goran Andjelic & Srdjan Redzepagic in their study on "Application of MACD and RVI indicators as functions of investment strategy optimization on the financial market" tested whether the application of MACD and *Relative Volatility Index (RVI)* contribute significantly to the optimization of investment strategy in the financial market. They have done their study on the stocks which are continually traded on the financial market of the Republic of Serbia, i.e. Belgrade Stock Exchange Inc. Belgrade for the period of four years from June 2004 and May 2008. They optimised the standard parameter of (12, 26,9) of the MACD indicator as different time period for each stock based on their study. They used RVI indicator to confirm their optimized value. After their study, they found that the MACD and RVI indicators are effective in the formulation and optimization of investment strategy in the financial market of transitional country. They concluded that investment strategy by the optimization of MACD and RVI indicators is more profitable than the simple buy & hold approach.

Gabriel Dan I.Anghel in his study on "Stock market efficiency and the MACD. Evidence from countries around the world" tested whether MACD is capable of generating surplus returns for an investor if used in world markets. For this purpose, he selected stocks listed in 75 world stock markets and took the data for 12 years from 2001 to 2012. He used Standard and Bootstrap method and optimized the testing techniques. He concluded by saying that weak form market efficiency can be discarded for 34 out of the 75 studied markets while applying MACD as an investment technique. Based on his study, he ranked the relative market efficiency of the national stock markets.

Uzeyir Aycel and Yunus Santur in their study on "A new moving average approach to predict the direction of stock movements in algorithmic trading" back tested 30 stocks in BIST30 by using different approach. He used moving averages and used golden ratio to weigh the moving average. He compared the Profit Factor of his approach with MACD, RSI, Stoch, and PSAR and found his approach yield better result.

Ale J. Hejase, Ruba M. Srour, Hussin J. Hejase and Joumana Younis tested MACD in their study on "Technical Analysis: Exploring MACD in the Lebanese Stock Market". They found that MACD was ineffective in Lebanese stock market.

Rommy Pramudya & Sakina Ichsani in their study on "Efficiency of Technical Analysis for the Stock Trading" experimented whether MACD, RSI and Bollinger Band are capable of predicting buy and sell signals at the right time. They tested these indicators on LQ45 index. They found that MACD is slow in recognizing the buy and sell signals comparing to RSI and Bollinger Band.

Salma Khand, Vivake Anand, Muhammad Nadeem Qureshi and Naveeda K. Katper in their study on "The Performance of Exponential Moving Average, Moving Average Convergence-Divergence, Relative Strength Index and Momentum Trading Rules in the Pakistan Stock Market", tested the profitability of few variants of EMA, MACD, RSI and MOM on KSE-100 index and found they yield more than position trading.

## Objectives of the Study

The study has been made with the below objectives.

1. To compare the profitability on buy and sell decisions based on Centre Line Crossover Strategy Vs. Signal Line Crossover Strategy
2. To compare the profitability on buy and sell decisions based on Centre Line Crossover Strategy Vs. Buy decision based on Centre Line Crossover and then Hold Strategy
3. To compare the profitability on buy and sell decisions based on Centre Line Crossover Strategy Vs. Buy on Random day and then Hold Strategy

## Research Methodology

Research Design: Descriptive research design is used for this study.
Sources of Data: Collected data which is the closing price of the stocks from the official website of BSE https://www.bseindia.com/markets/equity/EQReports/StockPrcHistori.html?flag=0
Data Collection method: For this research, Secondary data has been used.
Population: Four Stocks from Information Technology Sector which are being traded in BSE are taken for this study. They are Tata Consultancy Services Limited, Infosys Limited, HCL Technologies Limited and Wipro Limited. Stocks are selected based on highest market capitalisation.
Sample Size: Data is collected for one year time period i.e. from 1st April 2023 to 31st March 2024.
Tools used for Data Analysis: The below formulas are used for the analysis of data.
1.EMA is calculated using the below formula

i. Initial EMA=SMA (Simple Moving Average)
ii. EMA= EMA(Previous Day)+(Closing Price - EMA(Previous Day)) X Smoothing Constant

Smoothing Constant= 2/ (time period+1)
It is 0.15 for 12days, 0.07 for 26days and 0.20 for 9 days
Note: SMA= (A1+A2+.....+An)/n where A= Closing Price, n= number of periods

2. MACD values= 12 days EMA - 26 days EMA
3. Signal line values= 9 days EMA of MACD values
4. Histogram= MACD values – Signal line values

Microsoft Excel has been used for the calculations and for graphs.
Profitability is calculated using Extended Internal Rate of Return (XIRR) of the cash flow. It is calculated using the Excel formula as below.

5. XIRR =XIRR(values, dates) in MS Excel.

## Data Analysis

Analysis is done using the below steps in MS Excel.

1. Date wise closing prices of stock are placed in a table and corresponding values of 12 days EMA, 26 Days EMA, MACD values, Signal line values and Histogram values are calculated as given below in the table CT 1.

*CT 1*

| Date | Close Price | 12 days EMA (A) | 26 days EMA (B) | MACD line (C = A-B) | Signal line (D) | Histogram (E = C-D) |
|---|---|---|---|---|---|---|
| | | | | | | |

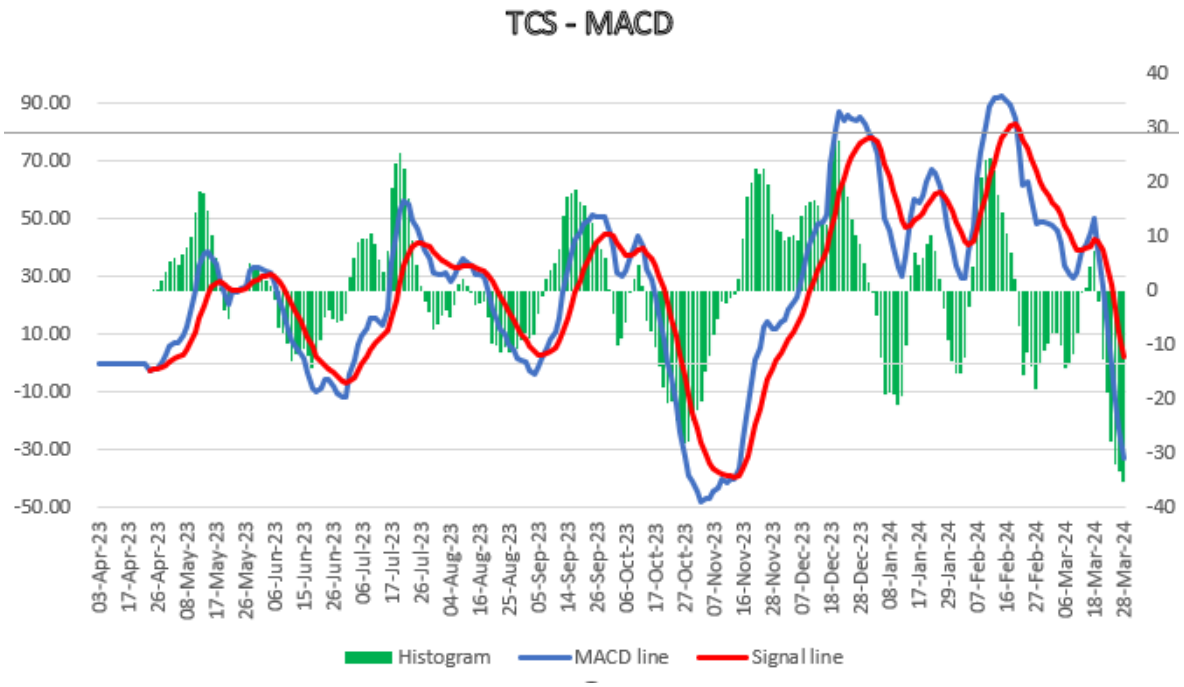
The date and the values C, D and E are plotted in graph. For the values of C & D, line chart is used and for E Value, histogram is used. Secondary axis is used for Histogram values.

2. For the method of MACD Centre Line Crossover, Buy decision is made if the C value is crossing above Zero. Sell decision is made if C value is crossing below Zero. Date wise closing price for each buy and sell signals are placed in a separate table. (Table-1)
3. For the method of MACD Signal Line Crossover, Buy decision is made if the E value is crossing above Zero. Sell decision is made if E value is crossing below Zero. Date wise closing price for each buy and sell signals are placed in a separate table. (Table-2)
4. To test the second objective, the date and closing price corresponding to the first buy decision is taken from Table-1. The date and closing price corresponding to the last day of the sample data is taken. Both are placed in separate table. (Table-3)
5. To test the third objective, the date and closing price corresponding to the first and the last day of the sample data are taken. Both are placed in separate table. (Table-4)
6. All the Buy prices are converted as negative to facilitate XIRR calculation.
7. XIRR has been calculated for the values of each table i.e. Table-1, Table-2, Table-3 & Table-4.

## Findings

For Tata Consultancy Services Ltd, the MACD graph has come as below in Graph 3.

*Graph 3*




By using the method Centre Line Crossover strategy, 4 Buy signals and 4 Sell signals are identified and placed in Table-1. For the Signal line Crossover Strategy, 9 Buy signals and 10 Sell signals are identified. The first being

the Sell signal on 19th May'23, it is ignored and the rest are placed in Table-2. For MACD Buy and Hold, the closing price of 27th Apr'23 i.e. the day on which the first Buy signal using Centre Line strategy is identified, is taken as Buy price. The closing price of the last trading day of sample period i.e. 28th Mar'24 is taken for Hold. Both are placed in Table-3. For Random Buy and Hold, the closing prices of the first trading day i.e. 3rd Apr'23 and the last trading day i.e. 28th Mar'24 of sample period are taken and placed in Table-4. All the 4 tables are given below in Result Table 1.

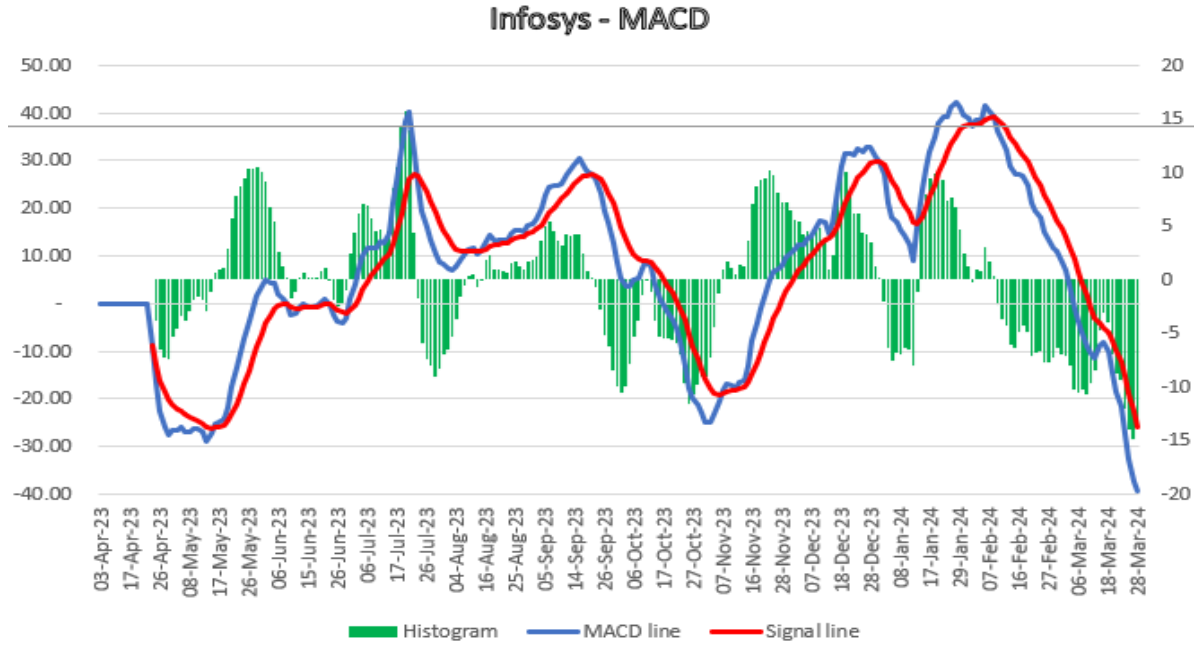
*Result Table 1*

**Tata Consultancy Services Limited**

| Table-1 (Centre Line Crossover) | | | Table-2 (Signal Line Crossover) | | | Table-3 (MACD Buy and Hold) | | | Table-4 (Random Buy and Hold) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **price** | **Signal** | **Date** | **price** | **Signal** | **Date** | **price** | **Signal** | **Date** | **price** | **Signal** |
| 27-Apr-23 | -3,200.00 | Buy | 25-May-23 | -3,290.00 | Buy | 27-Apr-23 | -3,200.00 | Buy | 03-Apr-23 | -3,225.00 | Buy |
| 16-Jun-23 | 3,203.95 | Sell | 06-Jun-23 | 3,289.00 | Sell | 28-Mar-24 | 3,856.45 | Hold | 28-Mar-24 | 3,856.45 | Hold |
| 04-Jul-23 | -3,294.00 | Buy | 03-Jul-23 | -3,306.70 | Buy | | | | | | |
| 01-Sep-23 | 3,359.05 | Sell | 27-Jul-23 | 3,385.05 | Sell | | | | | | |
| 06-Sep-23 | -3,429.55 | Buy | 08-Aug-23 | -3,483.85 | Buy | | | | | | |
| 23-Oct-23 | 3,475.00 | Sell | 11-Aug-23 | 3,440.00 | Sell | | | | | | |
| 21-Nov-23 | -3,523.00 | Buy | 07-Sep-23 | -3,445.95 | Buy | | | | | | |
| 22-Mar-24 | 3,899.00 | Sell | 03-Oct-23 | 3,531.05 | Sell | | | | | | |
| | | | 10-Oct-23 | -3,639.95 | Buy | | | | | | |
| | | | 13-Oct-23 | 3,529.95 | Sell | | | | | | |
| | | | 15-Nov-23 | -3,385.10 | Buy | | | | | | |
| | | | 02-Jan-24 | 3,814.40 | Sell | | | | | | |
| | | | 15-Jan-24 | -3,952.45 | Buy | | | | | | |
| | | | 25-Jan-24 | 3,836.80 | Sell | | | | | | |
| | | | 06-Feb-24 | -4,000.00 | Buy | | | | | | |
| | | | 21-Feb-24 | 4,018.85 | Sell | | | | | | |
| | | | 14-Mar-24 | -4,143.05 | Buy | | | | | | |
| | | | 19-Mar-24 | 4,055.65 | Sell | | | | | | |
| **XIRR** | **20%** | | **XIRR** | **20%** | | **XIRR** | **22%** | | **XIRR** | **20%** | |

The XIRR for Centre Line Crossover Strategy, Signal Line Crossover Strategy and Random Buy and Hold Strategy are same as 20%. For the Buy decision based on MACD Centre Line Crossover and then Hold yield a profit of 22% for the sample data of Tata Consultancy Services Ltd.
For Infosys Ltd, the MACD graph has come as below in Graph 4.

Graph 4




4 Buy signals and 4 Sell signals are identified using Centre Line crossover strategy and placed in Table-1. 8 Buy signals and 8 Sell signals are identified using Signal Line crossover strategy and placed in Table-2. It is assumed that the buy/sell action based on signal is taken though the signal changes on the next day i.e. on 2nd Feb'24 in Table-2. For MACD Buy and Hold, the closing price of 30th May'23 i.e. the day on which the first Buy signal

using Centre Line strategy is identified, is taken as Buy price. The closing price of the last trading day of sample period i.e. 28th Mar'24 is taken for Hold. Both are placed in Table-3. For Random Buy and Hold, the closing prices of the first trading day i.e. 3rd Apr'23 and the last trading day i.e. 28th Mar'24 of sample period are taken and placed in Table-4. All the 4 tables are given below in Result Table 2.

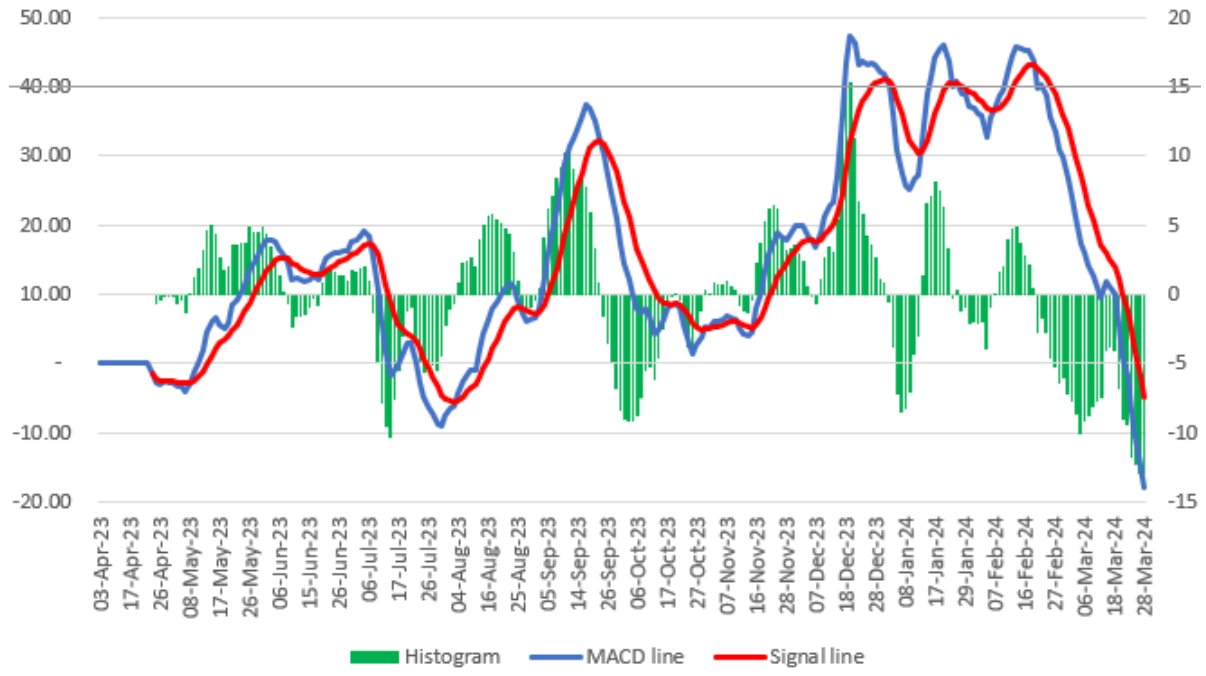
*Result Table 2*

**Infosys Ltd**

| Table-1 (Centre Line Crossover) | | | Table-2 (Signal Line Crossover) | | | Table-3 (MACD Buy and Hold) | | | Table-4 (Random Buy and Hold) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **price** | **Signal** | **Date** | **price** | **Signal** | **Date** | **price** | **Signal** | **Date** | **price** | **Signal** |
| 30-May-23 | -1,322.90 | Buy | 16-May-23 | -1,264.15 | Buy | 30-May-23 | -1,322.90 | Buy | 03-Apr-23 | -1,410.95 | Buy |
| 08-Jun-23 | 1,283.10 | Sell | 09-Jun-23 | 1,266.00 | Sell | 28-Mar-24 | 1,498.80 | Hold | 28-Mar-24 | 1,498.80 | Hold |
| 20-Jun-23 | -1,303.15 | Buy | 13-Jun-23 | -1,305.35 | Buy | | | | | | |
| 22-Jun-23 | 1,282.60 | Sell | 22-Jun-23 | 1,282.60 | Sell | | | | | | |
| 30-Jun-23 | -1,335.20 | Buy | 30-Jun-23 | -1,335.20 | Buy | | | | | | |
| 17-Oct-23 | 1,442.70 | Sell | 24-Jul-23 | 1,337.25 | Sell | | | | | | |
| 21-Nov-23 | -1,439.40 | Buy | 09-Aug-23 | -1,394.30 | Buy | | | | | | |
| 05-Mar-24 | 1,606.20 | Sell | 11-Aug-23 | 1,372.00 | Sell | | | | | | |
| | | | 16-Aug-23 | -1,418.50 | Buy | | | | | | |
| | | | 22-Sep-23 | 1,496.00 | Sell | | | | | | |
| | | | 07-Nov-23 | -1,404.35 | Buy | | | | | | |
| | | | 02-Jan-24 | 1,534.95 | Sell | | | | | | |
| | | | 15-Jan-24 | -1,652.00 | Buy | | | | | | |
| | | | 01-Feb-24 | 1,656.45 | Sell | | | | | | |
| | | | 02-Feb-24 | -1,693.85 | Buy | | | | | | |
| | | | 09-Feb-24 | 1,669.65 | Sell | | | | | | |
| **XIRR** | **26%** | | **XIRR** | **23%** | | **XIRR** | **16%** | | **XIRR** | **6%** | |

The XIRR for Centre Line Crossover Strategy is 26% whereas the XIRR for Signal Line Crossover is 23%. For the Buy decision based on MACD Centre Line Crossover and then Hold yield a profit of 16% whereas the Random Buy on 3rd Apr'23 and then Hold yield only 6% for the sample data of Infosys Ltd.
For HCL Technologies Ltd, the MACD graph has come as below in Graph 5.

*Graph 5*




3 Buy signals and 3 Sell signals are identified using Centre Line crossover strategy and placed in Table-1. 11 Buy signals and 11 Sell signals are identified using Signal Line crossover strategy and placed in Table-2. It is assumed that the buy/sell action based on signal is taken though the signal changes on the next day on 20th Oct'23, 24th & 25th Jan'24 in Table-2. For MACD Buy and Hold, the closing price of 11th May'23 i.e. the day on which the first Buy signal using Centre Line strategy is identified, is taken as Buy price. The closing price of the

last trading day of sample period i.e. 28th Mar'24 is taken for Hold. Both are placed in Table-3. For Random Buy and Hold, the closing prices of the first trading day i.e. 3rd Apr'23 and the last trading day i.e. 28th Mar'24 of sample period are taken and placed in Table-4. All the 4 tables are given below in Result Table 3.

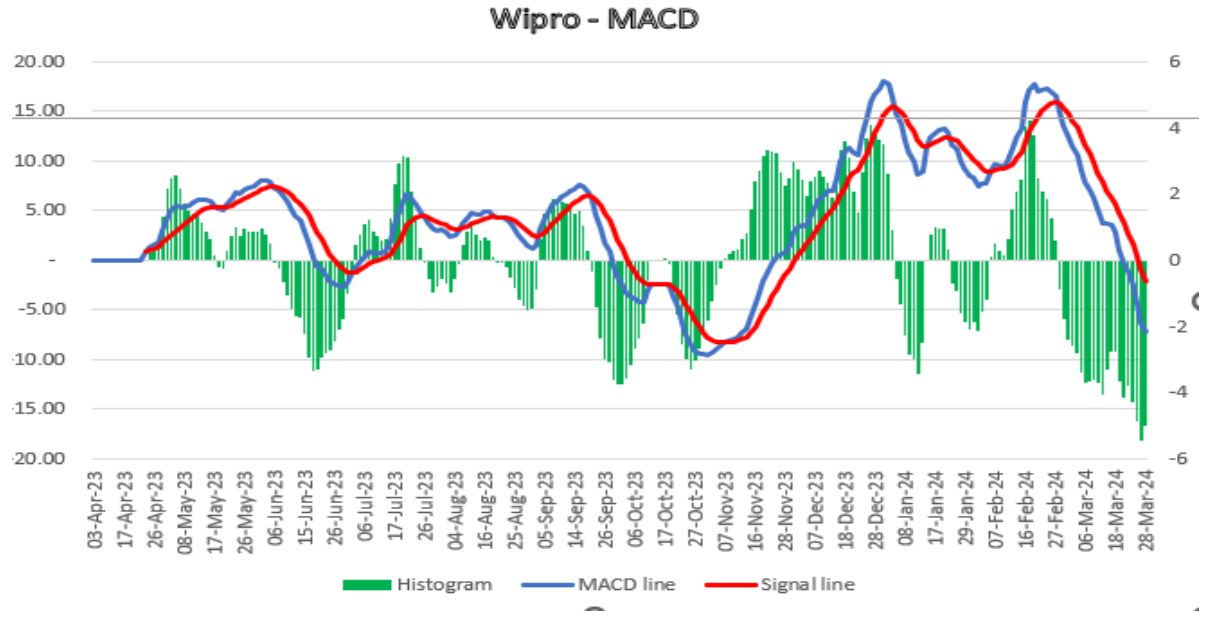
*Result Table 3*

**HCL Technologies Limited**

| Table-1 (Centre Line Crossover) | | | Table-2 (Signal Line Crossover) | | | Table-3 (MACD Buy and Hold) | | | Table-4 (Random Buy and Hold) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **price** | **Signal** | **Date** | **price** | **Signal** | **Date** | **price** | **Signal** | **Date** | **price** | **Signal** |
| 11-May-23 | -1,088.20 | Buy | 08-May-23 | -1,075.40 | Buy | 11-May-23 | -1,088.20 | Buy | 03-Apr-23 | -1,098.40 | Buy |
| 13-Jul-23 | 1,109.20 | Sell | 08-Jun-23 | 1,127.00 | Sell | 28-Mar-24 | 1,543.30 | Hold | 28-Mar-24 | 1,543.30 | Hold |
| 18-Jul-23 | -1,167.30 | Buy | 20-Jun-23 | -1,168.20 | Buy | | | | | | |
| 21-Jul-23 | 1,116.75 | Sell | 07-Jul-23 | 1,157.05 | Sell | | | | | | |
| 11-Aug-23 | -1,171.35 | Buy | 04-Aug-23 | -1,144.25 | Buy | | | | | | |
| 21-Mar-24 | 1,597.30 | Sell | 28-Aug-23 | 1,147.00 | Sell | | | | | | |
| | | | 01-Sep-23 | -1,185.40 | Buy | | | | | | |
| | | | 25-Sep-23 | 1,263.40 | Sell | | | | | | |
| | | | 19-Oct-23 | -1,267.50 | Buy | | | | | | |
| | | | 20-Oct-23 | 1,258.65 | Sell | | | | | | |
| | | | 31-Oct-23 | -1,276.85 | Buy | | | | | | |
| | | | 10-Nov-23 | 1,253.60 | Sell | | | | | | |
| | | | 16-Nov-23 | -1,311.05 | Buy | | | | | | |
| | | | 06-Dec-23 | 1,329.65 | Sell | | | | | | |
| | | | 08-Dec-23 | -1,362.90 | Buy | | | | | | |
| | | | 02-Jan-24 | 1,469.15 | Sell | | | | | | |
| | | | 12-Jan-24 | -1,543.00 | Buy | | | | | | |
| | | | 23-Jan-24 | 1,522.85 | Sell | | | | | | |
| | | | 24-Jan-24 | -1,575.20 | Buy | | | | | | |
| | | | 25-Jan-24 | 1,551.00 | Sell | | | | | | |
| | | | 07-Feb-24 | -1,614.95 | Buy | | | | | | |
| | | | 21-Feb-24 | 1,635.65 | Sell | | | | | | |
| **XIRR** | **44%** | | **XIRR** | **36%** | | **XIRR** | **49%** | | **XIRR** | **41%** | |

The XIRR for Centre Line Crossover Strategy is 44% whereas the XIRR for Signal Line Crossover is 36%. For the Buy decision based on MACD Centre Line Crossover and then Hold yield a profit of 49% and the Random Buy on 3rd Apr'23 and then Hold yield 41% for the sample data of HCL Technologies Ltd.
For Wipro Ltd, the MACD graph has come as below in Graph 6.

*Graph 6*




2 Buy signals and 2 Sell signals are identified using Centre Line crossover strategy and placed in Table-1. 8 Buy signals and 8 Sell signals are identified using Signal Line crossover strategy and placed in Table-2. It is assumed that the buy/sell action based on signal is taken though the signal changes on the next day on 18th Oct'23 in

Table-2. For MACD Buy and Hold, the closing price of 6th July'23 i.e. the day on which the first Buy signal using Centre Line strategy is identified, is taken as Buy price. The closing price of the last trading day of sample period i.e. 28th Mar'24 is taken for Hold. Both are placed in Table-3. For Random Buy and Hold, the closing prices of the first trading day i.e. 3rd Apr'23 and the last trading day i.e. 28th Mar'24 of sample period are taken and placed in Table-4. All the 4 tables are given below in Result Table 4.

*Result Table 4*

| Wipro Ltd | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Table-1 (Centre Line Crossover) | | | Table-2 (Signal Line Crossover) | | | Table-3 (MACD Buy and Hold) | | | Table-4 (Random Buy and Hold) | | |
| Date | price | Signal | Date | price | Signal | Date | price | Signal | Date | price | Signal |
| 06-Jul-23 | -396.05 | Buy | 22-May-23 | -395.65 | Buy | 06-Jul-23 | -396.05 | Buy | 03-Apr-23 | -367.80 | Buy |
| 28-Sep-23 | 405.80 | Sell | 06-Jun-23 | 399.90 | Sell | 28-Mar-24 | 480.05 | Hold | 28-Mar-24 | 480.05 | Hold |
| 23-Nov-23 | -402.15 | Buy | 04-Jul-23 | -396.10 | Buy | | | | | | |
| 20-Mar-24 | 493.60 | Sell | 26-Jul-23 | 402.65 | Sell | | | | | | |
| | | | 08-Aug-23 | -416.55 | Buy | | | | | | |
| | | | 21-Aug-23 | 414.35 | Sell | | | | | | |
| | | | 04-Sep-23 | -434.05 | Buy | | | | | | |
| | | | 21-Sep-23 | 428.60 | Sell | | | | | | |
| | | | 17-Oct-23 | -411.25 | Buy | | | | | | |
| | | | 18-Oct-23 | 407.40 | Sell | | | | | | |
| | | | 07-Nov-23 | -383.10 | Buy | | | | | | |
| | | | 04-Jan-24 | 452.55 | Sell | | | | | | |
| | | | 16-Jan-24 | -485.00 | Buy | | | | | | |
| | | | 23-Jan-24 | 469.90 | Sell | | | | | | |
| | | | 06-Feb-24 | -499.60 | Buy | | | | | | |
| | | | 28-Feb-24 | 517.10 | Sell | | | | | | |
| XIRR | 50% | | XIRR | 45% | | XIRR | 30% | | XIRR | 31% | |

The XIRR for Centre Line Crossover Strategy is 50% whereas the XIRR for Signal Line Crossover is 45%. For the Buy decision based on MACD Centre Line Crossover and then Hold yield a profit of 30% and the Random Buy on 3rd Apr'23 and then Hold yield 31% for the sample data of Wipro Ltd.

## Profitability Consolidated

For comparison purpose, we have put the profitability i.e. XIRR% obtained through all the four strategies as below in Result Table 5.

*Result Table 5*

| Profitability | Centre Line Crossover | Signal Line Crossover | MACD Buy and Hold | Random Buy and Hold |
|---|---|---|---|---|
| Tata Consultancy Services Ltd | 20% | 20% | 22% | 20% |
| Infosys Ltd | 26% | 23% | 16% | 6% |
| HCL Technologies Ltd | 44% | 36% | 49% | 41% |
| Wipro Ltd | 50% | 45% | 30% | 31% |

The profitability of the Centre Line Crossover strategy is same as that of Signal Line Crossover Strategy for the stocks of Tata Consultancy Services Ltd. The profitability of the Centre Line Crossover strategy is higher than that of Signal Line Crossover Strategy for the stocks of Infosys Ltd, HCL Technologies Ltd and Wipro Ltd.
The profitability of Buy and Sell based on the signals of Centreline Crossover strategy is higher than Buy based on the signal of MACD Centreline Crossover and then hold strategy for the stocks of Infosys Ltd and Wipro Ltd. But the same is lower for the stocks of Tata Consultancy Services Ltd and HCL Technologies Ltd.
The profitability of Buy and Sell based on the signals of Centreline Crossover strategy is the same as that of Random Buy and then Hold strategy for the stock Tata Consultancy Services Ltd. But the same is higher for the stocks of Infosys Ltd, HCL Technologies Ltd and Wipro Ltd.

## Limitations of the Study

1. Four stocks alone from the same sector of Information Technology has been taken for analysis.
2. The closing price of the signal days are taken for calculating the profitability. In real life, opening price of next day need not be the same. So, the price may vary a little while implementing the decision.
3. The transactions costs are not considered for the calculation of profitability.
4. The Buy/ Sell signals are taken into effect even if these happen on the consecutive day.

## Conclusion

Based on the sample data for the population taken for analysis, Centre Line Crossover Strategy is same or more profitable than Signal Line Crossover Strategy and Random Buy and Hold strategy. But the Centre Line Crossover Strategy is lesser profitable than Buy based on MACD Centre Line Crossover and then Hold strategy for 50% of population and is more profitable for 50% of the population taken for study. But the result can be more effective to follow if the same analysis is done for more number of stocks from different sectors.

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