A TEST OF MACD TRADING STRATEGY

by

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ABSTRACT

From in-the-sample test, we found that by increasing flexibility of the parameter settings for standard MACDR2 trading strategy, we can create a very powerful tool that outperforms, or at least equal to, the performance of standard long or short MACD trading strategy. Out-of-sample tests enable us to measure the effectiveness of momentum trading strategy in a setting more close to real world. We confirmed that MACD trading can outperform buy-and-hold on NASDAQ, TSX, HSI, KOSPI, and TWSE if trading cost has been ignored.

When we scrutinize MACD trading returns over ten indices and DJIA stocks with paired comparison test, we found no evidence that MACD trading can outperform buy-and-hold with the presence of trading cost.

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1 INTRODUCTION

1.1 Purpose of the paper

The purpose of this paper is to test the profitability of technical analysis. To achieve this, we first review theoretical and empirical studies and then implement trading simulations that identify the timing of long and short in stock markets by using standard or customized trading strategies.

Technical analysis is the use of past price or volume relationships to forecast price movements. This type of analysis is particularly popular in the future markets, where high leverage, high liquidity, and low brokerage costs permit quick trading profits and losses [Murphy, 1986, pp 1]. Approximately 30% to 40% of practitioners, in the future markets and foreign currency markets, seem to believe that technical analysis is an important factor in determining price movement for shorter time horizons. However, no survey that focuses on stock market traders is available [Park, 2004, pp 1-3].

In order to determine the usefulness of technical analysis, the most straightforward measure is to compare the performance of active technical trading systems to that of buy-and-hold strategy.

1.2 Definition and trends of technical analysis

Technical analysis is a forecasting method of price movements using past prices or volume. Pring (2002) provides a more specific definition:

"The technical approach to investment is essentially a reflection of the idea that prices move in trends that are determined by the changing attitudes of investors toward a variety of economic, monetary, political, and psychological forces. The art of technical analysis, for it is an art, is to identify a trend reversal at a relatively early stage and ride on that trend until the weight of the evidence shows or proves that the trend has reversed." (p. 2)

According to Fama (1970), however, the capital markets are characterized by the weak form of the Efficient Market Hypothesis (EMH), a hypothesis which states that the *ex ante* expected return from a technical trading system cannot be greater than that from a naïve buy-and-hold strategy of equal risk.

The empirical literature has been categorized into two groups, "early" and "modern" studies, defined by the characteristics of testing procedures.

- Some early studies showed that technical trading strategies were profitable in foreign exchange markets and futures markets, but not in stock markets before the 1980s [Smidt (1965), Fama (1966, 1970), Bear (1970), Leuthold (1972), Sweeney (1986)].

- More recent studies indicated that technical trading strategies has consistently generated economic profits in certain markets at least until the early 1990s [Lukac, Brorsen, and Irwin (1988), Lukac and Brorsen (1990), Taylor (2000), Olsen (2004)].

In spite of the favourable evidence on the profitability of technical trading strategies, it seems that a majority of empirical studies are subject to various problems in testing procedures such as data snooping, *ex post* selection of trading rules, and improper treatment on risks or transaction costs [Park, 2004].

2 IDEA AND PHILOSOPHY OF THE TECHNICAL ANALYSIS

The first premise of technical analysis is that **market action discounts everything.** When prices are rising, technicians reckon that demand is stronger than supply and therefore the fundamental has to be bullish. In another word, a study of price action is all that is required [Murphy, 1999, pp. 2-3].

The second premise of technical analysis is the assumption that **prices move in trends.** This is an adaptation of Newton's first law of motion by assuming that a trend in motion is more likely to continue than to reverse. To identify and follow existing trend is probably one of the most basic technical strategies [Murphy, 1999, pp. 3-4].

The third premise of technical analysis is the belief that **history repeats itself.** Future is predictable; the key to see the future lies in the understanding of the past [Murphy, 1999, pp. 5].

2.1 Technical Trading and the Efficient Markets Hypothesis

Most economists have been sceptical of technical analysis because they argue that any discernible pattern in time-series price data would be exploited immediately by rational investors who would take advantage of the profit opportunities [Fyfe, 1999, pp. 1].

On the other hand, the EMH has also been criticized by practitioners. George Soros, one of the most successful traders, who stated that, '...this [efficient markets theory] interpretation of the way financial markets operate is severely distorted. ... It may seem strange that a patently false theory should gain such widespread acceptance.' [Soros, 1994].

In general, the efficient markets hypothesis is still dominant in the sense that financial economists have not yet reached a consensus on a better model of price formation. However, the efficient markets paradigm has been challenged by a growing number of alternative theories such as noisy rational expectations models and behavioural models. The disagreement in theoretical models has therefore made empirical evidence a key consideration in determining the profitability of technical trading strategies [Park, 2004, pp. 16].

2.2 Technical Indicators

Technical indicators can be classified into two major categories: trend followers and counter-trend indicators. In this section we will discuss briefly one of the most established trend followers, the Moving Average, and one of the most frequently used counter-trend indicator, the Relative Strength Index [Wong, 2003, pp. 545-546].

Moving average (MA)

The n-day simple MA is given by

$$M_{t,n} = \frac{1}{n}\sum_{i=t-n+1}^{t} C_i$$

$$= (C_t + C_{t-1} + \cdots + C_{t-n+2} + C_{t-n+1})/n$$

Where $M_{t,n}$ is the n-day simple moving average at period t and C_i is the closing price for period i. A buy signal is generated when the closing price rises above the MA and a sell signal is generated when the close falls below the MA.

The other use of moving average includes the dual moving average system, and the triple moving average system. The usefulness of a dual or triple moving average system is to provide explicit trading signals through the crossing of moving average lines.

Relative strength index (RSI)

The construction of $RSI_{t,p}$ at time t of period p uses closing prices to calculate the ratio of upward change U_i, to dowanward change D_i, over the selected time period p, expressed as an oscillator that has a range of 0 to 100. Given an index set $I_{t,p} = \{i : t - p \le i \le t\}$, for any $i \in I_{t,p}$ we have

$$U_i = \begin{cases} C_i - C_{i-1} & if \quad C_i > C_{i-1} \\ 0 & otherwise \end{cases}$$

$$D_i = \begin{cases} C_{i-1} - C_i & if \quad C_{i-1} > C_i \\ 0 & otherwise \end{cases}$$

where C_i is the closing price at time i, the next step is to calculate exponential moving average of U_i and D_i such that

$$\overline{U}_{t,p} = Exponential\_Moving\_Average\ of\ U_i\ over\ I_{t,p}$$

$$\overline{D}_{t,p} = Exponential\_Moving\_Average\ of\ D_i\ over\ I_{t,p}$$

the ratio of those two averages is the Relative Strength (RS)

$$RS_{t,p} = \frac{\overline{U}_{t,p}}{\overline{D}_{t,p}}$$

Finally, we can have RSI by plugging RS into the following formula:

$$RSI_{t,p} = 100 - \frac{100}{1 + RS_{t,p}}$$

For practitioners, a reading above 70 indicates an overbought market, while a reading below 30 indicates an oversold market.

2.3 A Skeletal Review of Literature

The feasibility of market timing has long been the subject of debate. Researchers question the usefulness of such techniques, arguing that such techniques usually cannot generate better returns than a buy-and-hold strategy [Wong, 2003, pp. 544]. Considering the presence of transaction costs, the returns could even be negative [Fama, 1966; Jensen, 1970]. These results are in line with the efficient market hypothesis - current price has already reflected all available information including the past history of prices and trading volume. Since investors compete with each other to exploit their knowledge on price history, they certainly will drive price level to where expected rate of return corresponds with risk. At that price level no one can expect abnormal returns [Fama, 1970].

Technicians may recognize the value of information on future economic prospects of the firm, however their belief is that such information is not vital for a successful trading strategy. Whatever the reason is that drives the change in the stock price, if the process takes time, technicians should be able to capture a trend and profit from it before the adjustment is completed. Therefore the critical factor to successful technical analysis is the slow response of stock prices to the fundamental demand-supply equilibrium [Wong, 2003, pp 544].

Early Studies (1960-1987)

Most early studies applied technical trading rules to examine price behaviour in various markets, along with standard statistical analyses such as serial correlation, runs analysis, and spectral analysis. However these statistical techniques have their limitations. Technical trading rules have been therefore considered as an alternative to avoid the weaknesses of statistical analyses [Park, 2004, pp. 20-21].

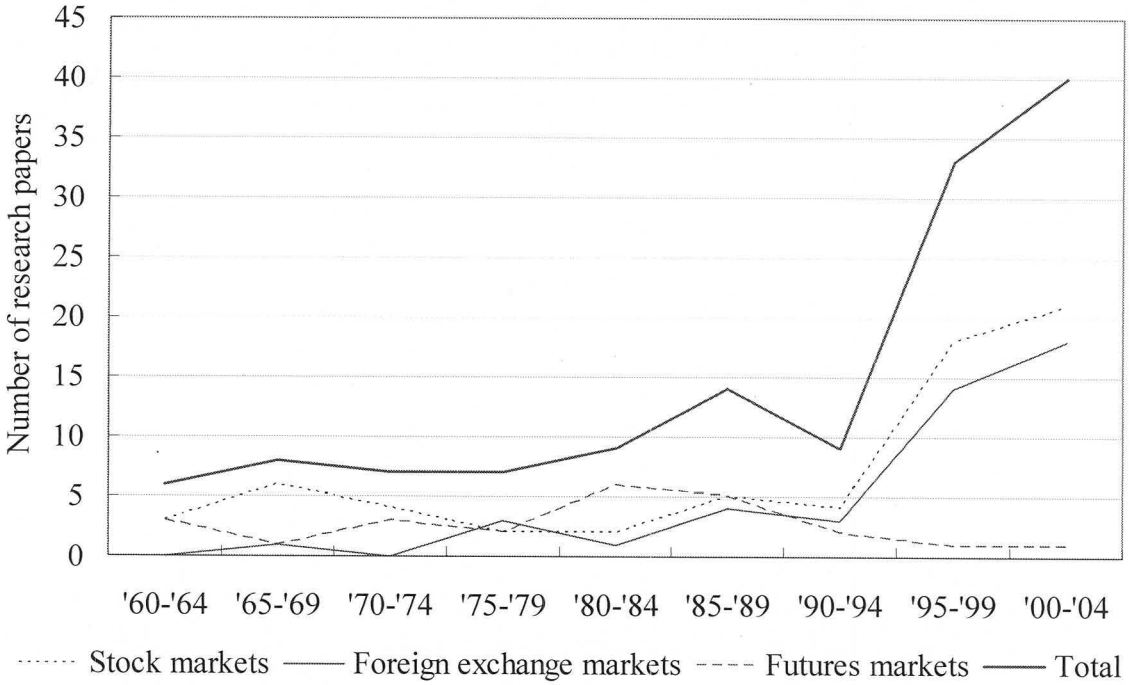
Modern Studies (1988-2004)

The most significant improvement in modern studies has been in the analytic techniques. The fast growing computing power has enabled researchers to apply more advanced theories and statistical methods [Park, 2004, pp.46]. Lukac, Brorsen and Irwin's (1988) work is probably one of the most important modern studies. They tested twelve technical trading systems, applied out-of-sample testing for optimized rules with a statistical test, and measured performance after adjusting for trading costs and risk. The results showed that four out of twelve systems produce significant net returns. Based on the findings, they concluded that "disequilibrium models are a better description of short-run futures price movements than the random walk model" [Lukac, Brorsen, & Irwin, 1988, pp. 623].

Pruitt and White (1988) have proposed a trading system CRISMA (Cumulative volume, Relative Strength, Moving Average) that attempted to forecast stock price by three filters, (1) moving average crossover, (2) relative strength of individual stock price performance against that of the market, and (3) the trend of cumulative volume. Even though they claimed that CRISMA can outperform buy-and-hold in US stock market, two subsequent researches that tested CRISMA in UK stock market [Goodacre, Bosher, & Dove, 1999] and HK stock market [Cheng, Cheung, & Yung, 2003] are quite disappointing. To everybody's surprise, Cheng, Cheung, and Yung discovered that two of the three filters - relative strength (RS) and cumulative volume (CV) are not useful. The only component that actually works is the moving average filter.

Figure 2-1 shows that in the last ten years the number of technical trading studies has been increased dramatically. With more researches, people may someday be able to delineate technical analysis in a more discreet manner.

Figure 2-1 Number of technical analysis trading studies (1960-2004)



Source: Park, 2004, pp.71

3 MOVING AVERAGE CONVERGENCE/DIVERGENCE (MACD) INDICATOR

3.1 Moving Average Convergence/Divergence (MACD) Indicator

Created by Gerald Appel in 1979, MACD is one of the most popular indicators in technical analysis. Its construction requires three exponential moving averages (EMA), which are lagging indicators, to identify the continuation or reversal of a trend. These lagging indicators are converted into a momentum oscillator by deducting the slow moving average from the fast moving average. Fast means shorter moving average and slow means longer moving average. In a standard setting the periods are 12 and 26 days for generating the first indicator:

$$MACD = EMA1\ (12\text{-}day\ closing\ prices) - EMA2\ (26\text{-}day\ closing\ prices)$$

The second indicator, called signal line, is once again applying EMA to smooth the first indicator. The standard day setting for signal line is 9:

$$Signal = EMA\ (9\text{-}day\ MACD)$$

To calculate EMA for both indicators, the following formula has been applied in our program.

$$EMA_t = \alpha\ *(closing\ price)_t + (1-\alpha)*\ EMA_{t-1}$$

Where $\alpha = \frac{2}{(N+1)}$, N: number of days.

The above formula shows that as long as the first EMA is known, any subsequent EMA could be derived from the closing price of that day and the EMA of previous day. For the first EMA, we apply the following formula:

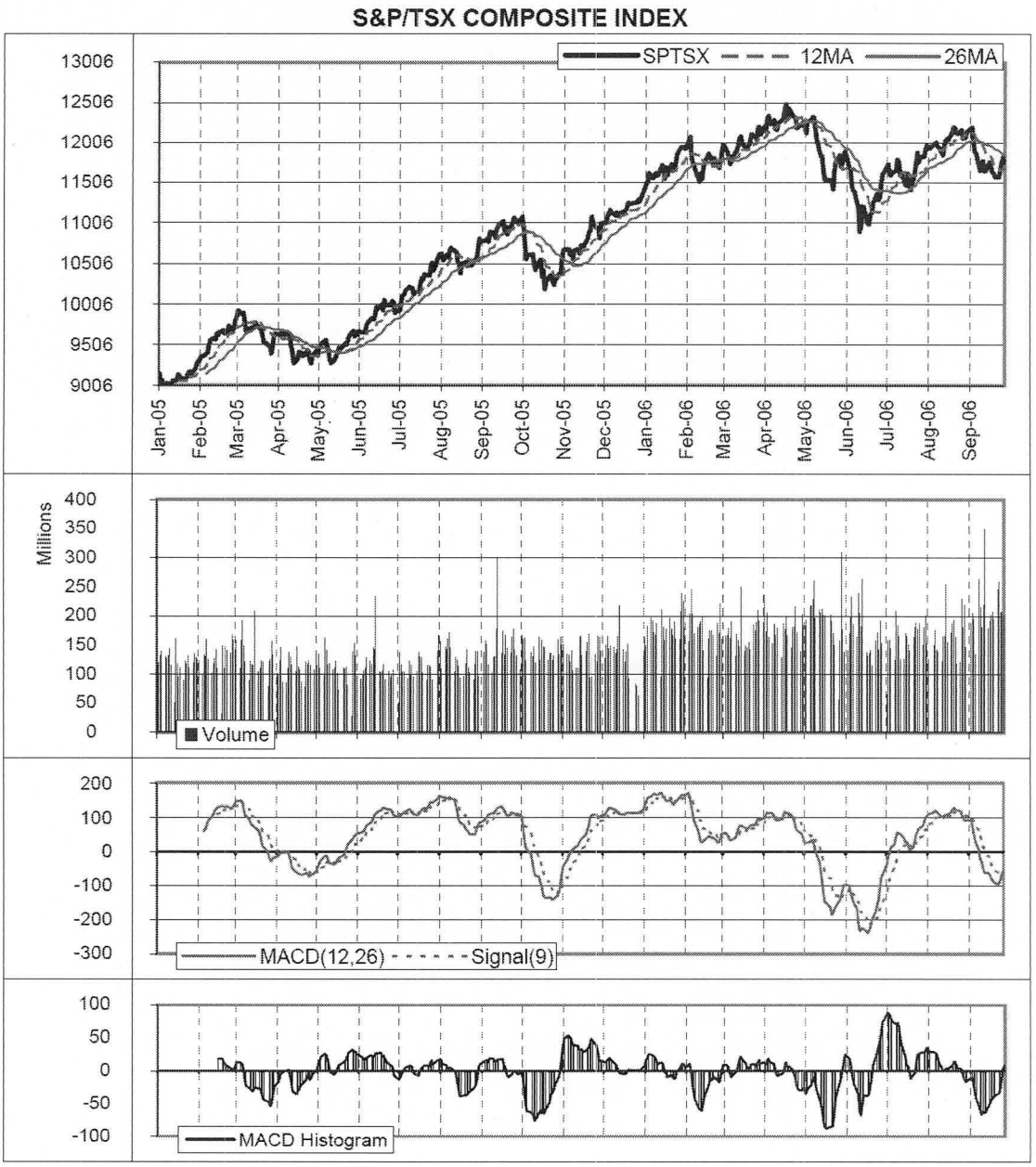
$$EMA_t = \frac{cp_1 + (1-\alpha)cp_2 + (1-\alpha)^2 cp_3 + ... + (1-\alpha)^{t-1} cp_t}{1 + (1-\alpha) + (1-\alpha)^2 + ... + (1-\alpha)^{t-1}}$$

Where cp_t stands for the closing price on day t.

Most technical analysis systems display an extra indicator that shows the difference between MACD and Signal by a solid block histogram. The MACD-Histogram is positive when MACD is above its 9-day EMA and negative when MACD is below its 9-day EMA. It was developed in 1986 by Thomas Aspray.

A buy signal is generated when the more volatile indicator (MACD) cross the less volatile one (Signal) from beneath. On the other hand, a sell signal is given when MACD indicator crosses Signal indicator from above. Figure 3-1 demonstrates how MACD looks like in a typical technical analysis system.

Figure 3-1 Typical technical analysis system using MACD



3.2 Usefulness and Criticism of Standard MACD

While myriads of technical indicators have been created in the past, MACD is one of the oscillators that have stood the test of time. The mechanism behind MACD is easy to comprehend and its construction rules are straightforward. Unlike Relative Strength Index (RSI), another highly popular oscillator provided by almost any existing technical analysis system, which only signals plausible status of overbought, oversold, or in between without unambiguous answer on where to buy or sell.

Due to the lagging feature of the MACD indicator, any buy or sell signals will be generated shortly after the bottom or top in the price movement. Standard MACD works well when there are clear upward and downward trends in price movement. However in a sideways market MACD crossovers may lead to whipsaws and false signals.

3.3 Refined MACD Indicator – MACDR1 and MACDR2

In order to improve the precision of MACD trading signal, Gunter, Albin, and Kai (2001) proposed extra decision rules when a standard MACD crossover has been identified. They pointed out that quite often a trend falters even though it might be strong in the beginning. Meanwhile since MACD is a lagging indicator, the timing to close an existing trade is often too late.

The first model, called MACDR1 (R: Refinement), attempts to ignore buy and sell signal if crossovers are too intensive in a short period of time. To accomplish this, the trading signal is given three days after the crossover, provided that no other crossing has appeared in between. To overcome the weakness of a lagging indicator that is not able to provide timely exit warning, they set a predetermined target at 3% or 5% for profit taking. Thus, the model will generate an exit signal to an existing position when a 3% or 5% target of gain has been reached, or if another

crossing occurs before the target is reached. The weakness in setting a predetermined profit level is that it might miss out the greater profit potential in a steady long trend.

The second model, MACDR2, is an enhancement from the first one. It inherits the same trading rules from MACDR1. The additional procedure is that when a buy or sell signal has been confirmed according to the aforementioned rules, it now further calculates the difference of MACD and Signal over closing price at the end of the third day after a crossing. Assuming closing price is $100, MACD=3 and Signal=1 on the third day after a crossing. If predetermined trigger level is 1%, by applying the following calculation a buy signal has been confirmed.

$$\text{Trading Signal: } \frac{3-1}{\$100} = 2\% \geq \text{Predetermined Trigger Level } 1\%$$

Gunter claimed that with this extra treatment, MACDR2 is able to capture a more significant trend in the beginning by avoiding random movement in a narrow trading range.

3.4 Research Model and Source Data

In order to study the effectiveness of MACD trading, the best way is to build a trading model that simulates trading activities according to a set of predefined trading rules. The program used in this research has been written in Microsoft Excel Visual Basic. We choose Excel because it owns two of the most convenient features – data input and portability.

Our Excel model contains two major parts. The first part is to provide MACD trading results and to search for the optimal combination of MACD parameters for each trading strategies. The criterion in searching for the optimized MACD parameters is to generate highest possible compounding return. Both functions in the first part use the whole time series as input and therefore the output here is purely in sample result. There are four available trading strategies in this part, which include:

Strategy 1: Long only trading strategy

A long position will be established while detecting the first buying signal. After the position is being sold it will hold nothing until seeing the next buying signal. It will close out existing position, if any, on the last trading day.

Strategy 2: Long or short trading strategy

A position, either long or short, will be established while detecting the first trading signal. Afterward it will keep holding either a long or short position until the last trading day.

Strategy 3: MACDR2 trading strategy

While detecting a trading signal, this strategy will hold trading decision after a certain days and then verify if the gap between MACD and Signal is sufficient to trigger a trade. It will close out a position under three conditions: (1) stock price has reached a specific profit taking or stop loss level, (2) a trading signal comes out, (3) last trading day.

Strategy 4: Short only trading strategy

The mechanism for this strategy is highly similar to that of Strategy 1 with one different rule: only short position is allowed.

It is worth noticing that Strategy 2 can be deemed as a special setting in Strategy 3 where all the three extra parameters (days delay, trigger gap, target profit/loss) are set to zero.

The second part of the model is designed for testing MACD out of sample trading capability. An explanation of how it works will be given in the later part of this research.

The historical data of US market are downloaded from Yahoo Finance, while indices outside the US are downloaded from Bloomberg. We use the adjusted daily closing price from Yahoo Finance for the thirty constituent stocks in Dow Jones Industrial Average Index (DJIA) for the reason that the adjusted closing price has followed CRSP standards in adjusting splits and

dividend distributions. Most of the time series start from the start of January 1980 to the end of September 2006 except some DJIA stocks that went IPO on a later date.

3.5 Effectiveness of in Sample MACD Trading

Before we apply MACD related trading rules to out of sample trading test, we believe it is worth going through in sample trading test to uncover certain unique characteristics in MACD. Ten major indices have been selected for in sample test, which include Dow Jones Industrial Average Index (DJIA), NASDAQ Composite Index (NASDAQ), S&P 500 Index (S&P500), S&P/TSX Composite (TSX), Deutsche Aktien Xchange (DAX), Financial Times Stock Exchange 100 Index (FTSE 100), Hang Seng Index (HSI), Korea Composite Stock Price Index (KOSPI), Nikkei-225 Stock Average (NIKKEI 225), Taiwan Stock Exchange Index (TWSE). All indices data start from January 1980 to September 2006 except FTSE 100, which starts from January 1984.

To conduct in sample test, we went through four trading strategies (long only, long or short, MACDR2, and short only). For each trading strategy, we first examine standard parameter setting (EMA1=12, EMA2=26, Signal=9) and compare them with the optimized parameter setting.

To search for the optimized MACD parameters, a set of upper bounds have to be assigned for searching. By definition EMA1 is shorter moving average and EMA2 is longer moving average, therefore EMA1 shall never be equal or greater than EMA2. Since Signal is the moving average of EMA1 - EMA2, if Signal equals to one day moving average the MACD indicator and Signal indicator will overlap and fails to generate crossover. Consequently the starting value of Signal has to be 2. The following upper bounds have been applied for in sample test.

Max EMA1 = 29

Max EMA2 = 30

Max Signal = 10

With the above setting, our program will search through 3,915 combinations starting from (1, 2, 2) to (29, 30, 10). For any given EMA1, EMA2, and Signal, the number of combinations can be calculated through the following formula:

$$\text{Number of combinations} = EMA2 * (EMA2 - 1) * (Signal - 1) / 2$$

Table 3-1 shows the performance of long only strategy based on standard MACD setting (12, 26, and 9). Even though these three parameters have been used as default MACD setting on almost every technical analysis platforms, probably no practitioner will be so naïve as to believe that there exists a common solution. The fact is, only four indices will allow superior trading results than buy-and-hold. Obviously for anyone who is interested in trading upon MACD signals should not take the standard setting as given. Moreover, there are two common characters that can be identified from the trading results in these indices. First, under standard MACD setting, the average holding period of a profitable trade is 30 days and the average holding period of a losing deal is 10 days. Second, even though on average MACD captures more from a winning trade than it gives out in a losing trade, it is quite a surprise that overall MACD trading signals generate more losing deals than winning deals.

Table 3-1 Strategy 1 with standard MACD parameters

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Index End Value	Index Start Value	Buy and Hold Return
DJIA	12	26	9	123	3.32%	28.0	155	-1.77%	9.1	224.22%	11679.07	824.57	1316.38%
NASDAQ	12	26	9	115	5.38%	31.0	137	-2.42%	10.3	1106.59%	2258.43	148.17	1424.22%
S&P500	12	26	9	103	3.78%	31.2	163	-1.72%	10.5	154.69%	1335.85	105.76	1163.10%
TSX	12	26	9	110	4.09%	32.7	132	-1.63%	10.1	773.74%	11761.27	1806.08	551.20%
DAX	12	26	9	127	3.87%	27.9	164	-2.09%	8.5	247.38%	6004.33	493.5	1116.68%
FTSE 100	12	26	9	89	3.63%	30.4	151	-1.68%	9.2	71.28%	5960.8	997.5	497.57%
HSI	12	26	9	110	7.75%	33.2	122	-2.66%	10.7	10974.47%	17543.05	889.13	1873.06%
KOSPI	12	26	9	119	6.73%	28.9	164	-3.31%	9.2	548.01%	1371.41	100	1271.41%
NIKKEI 225	12	26	9	104	4.41%	30.6	139	-2.32%	10.8	207.28%	16127.58	6560.16	145.84%
TWSE	12	26	9	108	9.90%	32.2	167	-2.79%	9.9	11886.38%	6883.05	562.65	1123.33%

Table 3-2 shows that with perfect hindsight, how amazing an optimized set of MACD parameters can be in certain markets. Since the in sample optimization process here ignores trading cost, it therefore makes perfect sense that the optimized parameters invariably generate larger amount of transactions in order to maximize compounding return. Even though all trading results are better than buy-and-hold, for certain indices it seems that a single set of optimized parameters may not be able to keep useful for more than 20 years. Apparently the unimpressive trading results in DJIA, S&P500, DAX, and FTSE 100 shows that in sample optimization have its limitation. One explanation is that these markets are more efficient and therefore no single set of MACD parameters can outperform for such a long period of time.

Table 3-2 Strategy 1 with optimized MACD parameters

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Index End Value	Index Start Value	Buy and Hold Return
DJIA	1	12	2	607	1.44%	5.2	783	-0.75%	2.1	1432.57%	11679.07	824.57	1316.38%
NASDAQ	1	2	7	699	1.83%	5.1	615	-1.11%	2.4	27479.68%	2258.43	148.17	1424.22%
S&P500	1	2	2	859	1.19%	3.5	891	-0.80%	1.9	1843.37%	1335.85	105.76	1163.10%
TSX	1	25	2	563	1.58%	6.5	587	-0.65%	2.4	13565.53%	11761.27	1806.08	551.20%
DAX	2	3	2	635	1.77%	5.1	722	-1.12%	2.3	1626.13%	6004.33	493.5	1116.68%
FTSE 100	1	15	5	368	1.64%	7.9	495	-0.83%	2.7	510.75%	5960.8	997.5	497.57%
HSI	1	19	6	361	3.55%	10.0	422	-1.27%	3.3	102863.26%	17543.05	889.13	1873.06%
KOSPI	1	2	2	906	2.05%	3.4	956	-1.15%	1.9	117632.86%	1371.41	100	1271.41%
NIKKEI 225	1	2	4	681	1.60%	4.4	855	-0.96%	2.1	1023.61%	16127.58	6560.16	145.84%
TWSE	1	29	8	337	4.04%	11.4	424	-1.38%	3.3	107317.83%	6883.05	562.65	1123.33%

Table 3-3 shows that in strategy 2 the transaction number doubles that of strategy 1. Notice that the proportion of losing trades has increased. In comparison with Table 3-1, the ratio of losing trades to winning trades is 1.35 to 1. Here the ratio has become 1.66 to 1. The consequence is a worse overall trading performance – even losing money in DJIA, S&P500, DAX, and FTSE 100. In comparison to the same parameter setting under strategy 1, only three indices (TSX, HSI, and TWSE) perform better than buy-and-hold under strategy 2. Among these three indices, TWSE is especially outstanding that has accumulated a compounding return four hundred times over initial investment.

Table 3-3 Strategy 2 with standard MACD parameters

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Index End Value	Index Start Value	Buy and Hold Return
DJIA	12	26	9	193	3.26%	28.8	362	-1.83%	11.4	-45.61%	11679.07	824.57	1316.38%
NASDAQ	12	26	9	200	5.04%	31.8	302	-2.61%	10.9	353.61%	2258.43	148.17	1424.22%
S&P500	12	26	9	181	3.29%	30.4	351	-1.88%	11.9	-60.87%	1335.85	105.76	1163.10%
TSX	12	26	9	199	3.78%	32.2	284	-1.72%	11.7	888.96%	11761.27	1806.08	551.20%
DAX	12	26	9	214	3.83%	28.6	369	-2.21%	9.7	-34.66%	6004.33	493.5	1116.68%
FTSE 100	12	26	9	157	3.41%	30.1	322	-1.85%	10.8	-58.67%	5960.8	997.5	497.57%
HSI	12	26	9	190	7.53%	33.1	274	-2.90%	12.5	19730.35%	17543.05	889.13	1873.06%
KOSPI	12	26	9	221	5.62%	29.0	345	-3.15%	9.6	72.58%	1371.41	100	1271.41%
NIKKEI 225	12	26	9	185	4.45%	32.0	301	-2.29%	12.5	140.79%	16127.58	6560.16	145.84%
TWSE	12	26	9	218	7.96%	28.9	331	-2.91%	10.4	40198.22%	6883.05	562.65	1123.33%

Table 3-4 shows that the compounding returns in seven indices have been improved if the restriction of short selling has been taken away. It is quite interesting that the enhancement in return can be more than ten times in five indices (see Table 3-5). On the other hand, this strategy is not dominating either. In comparison with optimized strategy 1, it generates less return on DAX, DJIA and FTSE 100.

Table 3-4 Strategy 2 with optimized MACD parameters

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Index End Value	Index Start Value	Buy and Hold Return
DJIA	1	12	2	1107	1.43%	5.3	1671	-0.78%	2.3	1149.48%	11679.07	824.57	1316.38%
NASDAQ	1	2	7	1232	1.86%	5.2	1400	-1.02%	2.4	293162.08%	2258.43	148.17	1424.22%
S&P500	1	3	3	1270	1.35%	4.6	1694	-0.81%	2.3	2045.83%	1335.85	105.76	1163.10%
TSX	1	25	2	1039	1.55%	6.4	1261	-0.63%	2.4	242709.51%	11761.27	1806.08	551.20%
DAX	2	3	2	1166	1.76%	5.1	1553	-1.11%	2.5	1411.12%	6004.33	493.5	1116.68%
FTSE 100	1	15	5	661	1.67%	8.0	1067	-0.86%	2.8	390.20%	5960.8	997.5	497.57%
HSI	1	19	6	657	3.46%	10.1	909	-1.30%	3.4	1938947.12%	17543.05	889.13	1873.06%
KOSPI	1	2	2	1762	1.93%	3.4	1959	-1.14%	1.9	4649405.16%	1371.41	100	1271.41%
NIKKEI 225	1	2	4	1286	1.64%	4.5	1785	-0.96%	2.2	2977.14%	16127.58	6560.16	145.84%
TWSE	1	29	8	617	3.95%	11.1	905	-1.41%	3.2	2812347.78%	6883.05	562.65	1123.33%

Table 3-5 Comparison of optimized strategy 2 versus strategy 1

Index	Optimized Strategy 2 (a)	Optimized Strategy 1 (b)	(a) / (b)
KOSPI	4649405.16%	117632.86%	39.5
TWSE	2812347.78%	107317.83%	26.2
HSI	1938947.12%	102863.26%	18.8
TSX	242709.51%	13565.53%	17.9
NASDAQ	293162.08%	27479.68%	10.7
NIKKEI 225	2977.14%	1023.61%	2.9
S&P500	2045.83%	1843.37%	1.1
DAX	1411.12%	1626.13%	0.9
DJIA	1149.48%	1432.57%	0.8
FTSE 100	390.20%	510.75%	0.8

Table 3-6 shows the results by combining standard MACD parameters with MACDR2 trading rules (3 days delay, trigger at 0.3%, and profit taking target at 5%). With these extra restrictions, the transaction number has reduced significantly. However it fails to improve the accuracy of trading signals. The losing deal number is still higher in most indices except for that of FTSE 100 and HSI.

Table 3-6 Strategy 3 with standard MACD parameters

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Index End Value	Index Start Value	Buy and Hold Return
DJIA	12	26	9	44	3.85%	20.2	79	-2.58%	16.2	-34.77%	11679.07	824.57	1316.38%
NASDAQ	12	26	9	77	4.41%	18.6	96	-4.07%	13.3	-51.80%	2258.43	148.17	1424.22%
S&P500	12	26	9	48	3.99%	20.4	71	-2.71%	13.9	-9.32%	1335.85	105.76	1163.10%
TSX	12	26	9	40	3.80%	26.7	55	-2.37%	17.2	16.70%	11761.27	1806.08	551.20%
DAX	12	26	9	72	4.50%	15.8	84	-2.88%	14.8	98.94%	6004.33	493.5	1116.68%
FTSE 100	12	26	9	45	4.21%	19.3	42	-2.69%	15.1	99.27%	5960.8	997.5	497.57%
HSI	12	26	9	122	5.56%	15.2	114	-3.78%	14.0	755.72%	17543.05	889.13	1873.06%
KOSPI	12	26	9	102	5.11%	14.1	122	-4.16%	11.7	-17.21%	1371.41	100	1271.41%
NIKKEI 225	12	26	9	68	4.76%	19.2	87	-3.24%	15.8	28.51%	16127.58	6560.16	145.84%
TWSE	12	26	9	112	5.48%	13.0	129	-4.29%	12.5	24.29%	6883.05	562.65	1123.33%

Table 3-7 shows that from a perfect hindsight, optimized MACDR2 is a strategy capable of reaching the greatest profit potential. Other than the search for the three MACD parameters, optimizer will do extra search for MACDR2 parameters shown below:

Days Delay: 0, 1, 2, 3

Trigger: 0, 0.1%, 0.2%, 0.3%

Target: -5%, 0, +5%

Even though the searching range of these extra parameters is very limited at the first glance, it requires much more calculations than in other strategies. As mentioned earlier, in order to search for the optimized MACD parameters, the program has to repeat 3,915 times of trading simulation on the same time series to sort out the one with maximum compounding return. Taking these three extra MACDR2 parameters into consideration, it will have to repeat 187,920 (= 4×4×3×3915) times of trading simulation. For a typical time serious applied in this research that starts from January 1980 to September 2006, the number of closing price is around 6,800.

The optimized results in strategy 3 are superior or at least equal to the results in strategy 2 because the latter is merely a special setting of the former where all MACDR2 parameters are set to zero. However the optimized parameters listed in Table 3-7 shows that parameters such as Days Delay and Trigger are mostly inactive in an optimized setting. Although Gunter has provided a very plausible reason on why should it be better to hold a trading decision three days after seeing traditional MACD signal, our in sample test shows that act immediately upon traditional signal leads to most favourable results.

Table 3-7 indicates that there are six optimized Target levels not equal to zero. It means that Gunter's idea of setting a predetermined profit target has actually worked. Even though Gunter's MACDR2 does not incorporate any predetermined stop loss decision, our optimizer is capable of testing either stop loss or profit taking level. For example, NASDAQ shows a Target of -5.0% in Table 3-7 means that optimizer has identified a better performance if there is a

predetermined stop level (-5.0%) in place.Table 3-8 shows that the compounding return for NASDAQ in strategy 3 is 10% higher than that of strategy 2. This 10% extra return can be fully attributed to the new stop loss setting because the rest parameters in strategy 2 and 3 are identical.

Table 3-7 Strategy 3 with optimized MACD parameters

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Days Delay	Trigger	Target
DJIA	1	12	2	1108	1.44%	5.2	1670	-0.77%	2.3	1394.69%	0	0.0%	5.0%
NASDAQ	1	2	7	1232	1.86%	5.2	1400	-1.02%	2.4	322203.76%	0	0.0%	-5.0%
S&P500	1	3	3	1271	1.36%	4.5	1693	-0.81%	2.2	2632.34%	0	0.0%	5.0%
TSX	1	25	2	1039	1.55%	6.4	1261	-0.63%	2.4	242709.51%	0	0.0%	0.0%
DAX	1	3	6	850	1.98%	5.2	1145	-1.15%	2.4	2583.47%	0	0.1%	5.0%
FTSE 100	1	15	5	661	1.70%	7.6	1067	-0.86%	2.8	500.67%	0	0.0%	5.0%
HSI	1	19	6	657	3.46%	10.1	909	-1.30%	3.4	1938947.12%	0	0.0%	0.0%
KOSPI	1	2	2	1762	1.93%	3.4	1959	-1.14%	1.9	4649405.16%	0	0.0%	0.0%
NIKKEI 225	1	2	4	1287	1.68%	4.3	1784	-0.96%	2.2	5125.86%	0	0.0%	5.0%
TWSE	1	29	8	617	3.95%	11.1	905	-1.41%	3.2	2812347.78%	0	0.0%	0.0%

Table 3-8 Comparison of optimized strategy 3 versus strategy 2

Index	Optimized Strategy 3 (a)	Optimized Strategy 2 (b)	(a) / (b)
DAX	2583.47%	1411.12%	1.8
NIKKEI 225	5125.86%	2977.14%	1.7
S&P500	2632.34%	2045.83%	1.3
FTSE 100	500.67%	390.20%	1.3
DJIA	1394.69%	1149.48%	1.2
NASDAQ	322203.76%	293162.08%	1.1
TSX	242709.51%	242709.51%	1.0
HSI	1938947.12%	1938947.12%	1.0
KOSPI	4649405.16%	4649405.16%	1.0
TWSE	2812347.78%	2812347.78%	1.0

Table 3-9 shows how disastrous it can be when applying short only strategy upon rising time series. Seven out of ten end up with damaging initial investment. Even though on average the standard MACD parameters are still able to grab more in a winning deal and give out less in a losing deal, the proportion of losing deals (67%) are simply too high.

Table 3-9 Strategy 4 with standard MACD parameters

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Index End Value	Index Start Value	Buy and Hold Return
DJIA	12	26	9	70	3.16%	30.1	207	-1.87%	13.1	-83.22%	11679.07	824.57	1316.38%
NASDAQ	12	26	9	85	4.58%	32.7	165	-2.77%	11.5	-62.41%	2258.43	148.17	1424.22%
S&P500	12	26	9	78	2.63%	29.3	188	-2.03%	13.1	-84.64%	1335.85	105.76	1163.10%
TSX	12	26	9	89	3.40%	31.5	152	-1.81%	13.0	13.19%	11761.27	1806.08	551.20%
DAX	12	26	9	87	3.77%	29.7	205	-2.31%	10.6	-81.19%	6004.33	493.5	1116.68%
FTSE 100	12	26	9	68	3.13%	29.8	171	-2.00%	12.2	-75.87%	5960.8	997.5	497.57%
HSI	12	26	9	80	7.23%	32.8	152	-3.09%	14.0	79.06%	17543.05	889.13	1873.06%
KOSPI	12	26	9	102	4.33%	29.1	181	-3.00%	9.9	-73.37%	1371.41	100	1271.41%
NIKKEI 225	12	26	9	81	4.50%	33.9	162	-2.26%	13.9	-21.64%	16127.58	6560.16	145.84%
TWSE	12	26	9	110	6.05%	25.7	164	-3.03%	10.9	236.20%	6883.05	562.65	1123.33%

Table 3-10 shows the optimized results for short only strategy is still disappointing. Six out of ten compounding return are still lag behind buy-and-hold return. Table 3-11 shows that the optimized results in the last strategy are merely tiny fractions of the optimized results in strategy 1.

Table 3-10 Strategy 4 with optimized MACD parameters

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Index End Value	Index Start Value	Buy and Hold Return
DJIA	1	12	2	500	1.42%	5.4	888	-0.80%	2.5	-18.47%	11679.07	824.57	1316.38%
NASDAQ	1	2	7	533	1.90%	5.2	785	-0.95%	2.4	963.33%	2258.43	148.17	1424.22%
S&P500	1	3	3	575	1.34%	4.8	908	-0.82%	2.5	12.52%	1335.85	105.76	1163.10%
TSX	1	25	2	476	1.51%	6.3	674	-0.62%	2.5	1676.80%	11761.27	1806.08	551.20%
DAX	2	3	2	531	1.75%	5.1	831	-1.11%	2.6	-12.46%	6004.33	493.5	1116.68%
FTSE 100	1	15	5	293	1.71%	8.1	572	-0.89%	2.9	-19.74%	5960.8	997.5	497.57%
HSI	1	19	6	296	3.34%	10.1	487	-1.33%	3.5	1783.24%	17543.05	889.13	1873.06%
KOSPI	1	2	2	856	1.80%	3.3	1003	-1.13%	2.0	3849.20%	1371.41	100	1271.41%
NIKKEI 225	1	2	4	605	1.68%	4.6	930	-0.96%	2.4	173.86%	16127.58	6560.16	145.84%
TWSE	1	26	8	288	3.80%	10.6	483	-1.48%	3.1	2546.70%	6883.05	562.65	1123.33%

Table 3-11 Comparison of optimized strategy 4 versus strategy 1

Index	Optimized Strategy 4 (a)	Optimized Strategy 1 (b)	(a) / (b)
DJIA	-18.47%	1432.57%	-1%
NASDAQ	963.33%	27479.68%	4%
S&P500	12.52%	1843.37%	1%
TSX	1676.80%	13565.53%	12%
DAX	-12.46%	1626.13%	-1%
FTSE 100	-19.74%	510.75%	-4%
HSI	1783.24%	102863.26%	2%
KOSPI	3849.20%	117632.86%	3%
NIKKEI 225	173.86%	1023.61%	17%
TWSE	2546.70%	107317.83%	2%

3.6 In Sample MACD Trading With Trading Cost

In the previous section we have identified certain indices that generate hundreds or even thousands times of trading return comparing to buy-and-hold results. Without considering trading cost, optimizer invariably favours MACD parameters that generate more trading activities. Even though this will inevitably invite more losing trades, it doesn't really matter as long as these trades maintain a positive average return. Through the power of compounding, myriad of insignificant winning trades keep magnifying the investment for hundreds of times until the final figure becomes too good to be true. Impose trading cost can force the optimizer to search for more realistic solutions. More importantly, if MACD can not outperform in sample with the presence of trading cost, it probably won't get any chance to outperform in real life situation.

First we assume one-way trading cost is 0.25% for either buying or selling. Then we optimize MACD parameters for trading strategy 2. With the presence of trading cost the optimized parameters hit upper bound much more often now. If more than one parameter has reached the upper limit, we relax the upper bound from (29, 30, 10) to (49, 50, 20). The detail of trading results is demonstrated in Table 3-12.

Without surprise, trading cost is a real issue that brings devastating results in four indices (DJIA, S&P 500, FTSE 100, NIKKEI 225). On the other hand, MACD has survived in sample trial in HSI, KOSPI, and TWSE. A further investigation shows that MACD trading strategy 2 can outperform buy-and-hold on TWSE with trading cost up to 0.40%. Coincidentally the three indices all reside in Asia Pacific and none of these countries impose capital gain tax on equity investment.

Noticeably, trading activity has withered in every index. To be more precise, total deal number in Table 3-12 is only 16.2% of that number in Table 3-4.

Table 3-12 Strategy 2 with optimized MACD parameters, one-way trading cost 0.25%

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Index End Value	Index Start Value	Buy and Hold Return
DJIA	32	41	13	87	4.92%	58.1	194	-2.67%	23.8	-69.30%	11679.07	824.57	1316.38%
NASDAQ	46	49	20	72	10.96%	87.4	117	-3.96%	28.7	966.53%	2258.43	148.17	1424.22%
S&P500	34	50	19	69	5.31%	71.1	176	-3.05%	27.0	-86.63%	1335.85	105.76	1163.10%
TSX	25	30	2	211	3.56%	29.3	431	-1.51%	8.2	95.37%	11761.27	1806.08	551.20%
DAX	23	24	19	118	6.07%	50.9	180	-3.15%	20.5	156.20%	6004.33	493.5	1116.68%
FTSE 100	18	43	20	75	5.73%	59.1	200	-2.40%	18.9	-54.78%	5960.8	997.5	497.57%
HSI	27	28	2	214	6.81%	29.6	412	-2.25%	8.2	6878.49%	17543.05	889.13	1873.06%
KOSPI	48	49	17	86	10.95%	77.5	125	-4.06%	24.2	2307.45%	1371.41	100	1271.41%
NIKKEI 225	11	29	9	168	4.41%	32.9	320	-2.58%	13.0	-72.70%	16127.58	6560.16	145.84%
TWSE	17	30	2	286	6.48%	22.4	519	-2.31%	6.4	12495.74%	6883.05	562.65	1123.33%

We have demonstrated in the last section that strategy 3 (MACDR2 trading strategy) can marginally improve trading results of strategy 2 (either long or short) without considering trading cost. Table 3-13 shows that strategy 3 is even more useful while facing trading cost. In comparison with the results in Table 3-7, more MACDR2 parameters have been set active. Instead of only three out performance in strategy 2, here we have five winners (NASDAQ, HSI, KOSPI, NIKKEI 225, and TWSE).

Perhaps the most important contribution of MACDR2 is to protect downside loss instead of boosting further profit for front runners. The trading results are all positive now but the optimized trading performance of previous winners (HSI, KOSPI, and TWSE) is still identical. In another word, the extra efforts in searching for MACDR2 specific parameters on these three indices have not led to better results previously identified by strategy 2.

Table 3-13 Strategy 3 with optimized MACD parameters, one-way trading cost 0.25%

Index	EMA1	EMA2	Signal	Profit Deal	Average P/L	Average Holding Period	Loss Deal	Average P/L	Average Holding Period	Compounding Return	Days Delay	Trigger	Target
DJIA	17	24	7	20	5.68%	32.7	14	-2.92%	19.3	94.01%	1	0.1%	0.0%
NASDAQ	47	48	20	69	11.03%	84.8	114	-3.40%	25.0	1779.90%	2	0.0%	-5.0%
S&P500	5	6	7	9	4.82%	8.4	2	-3.52%	5.0	41.89%	1	0.2%	5.0%
TSX	25	30	2	211	3.56%	29.3	431	-1.50%	8.2	101.70%	0	0.0%	-5.0%
DAX	23	30	9	47	5.04%	25.0	34	-4.48%	22.9	106.63%	3	0.1%	5.0%
FTSE 100	18	28	13	22	5.22%	23.7	8	-3.57%	23.7	128.34%	2	0.2%	5.0%
HSI	27	28	2	214	6.81%	29.6	412	-2.25%	8.2	6878.49%	0	0.0%	0.0%
KOSPI	48	49	17	86	10.95%	77.5	125	-4.06%	24.2	2307.45%	0	0.0%	0.0%
NIKKEI 225	11	29	6	64	4.98%	17.8	64	-2.98%	14.2	214.11%	0	0.1%	5.0%
TWSE	17	30	2	286	6.48%	22.4	519	-2.31%	6.4	12495.74%	0	0.0%	0.0%

With the help of in sample test, we have identified the possibility for MACD trading to outperform buy-and-hold strategy in some markets from a hindsight perspective. The finding here also shows that even if a trader can get the optimized parameters in advance, the chance that overall MACD trading performance lags behind buy-and-hold is still high if the trader keeps using the same parameters in certain developed markets (DJIA, S&P 500, TSX, DAX, FTSE 100).

3.7 Effectiveness of Out of Sample MACD Trading

In sample test may not be able to answer the true effectiveness of MACD trading strategy because (1) optimized parameters can only be observed ex post, (2) it is possible that the optimized parameters are changing through time. An out of sample test should be able to clarify these concerns.

Zitzlsperger (2002) has tested S&P 500 by continuous searching for the optimized MACD parameters for two years and then apply in trading for the subsequent year. He claimed that, without considering trading cost, the training-applying strategy will be able to generate 17710% of total return from 1970 to 2001.

The second part of our model has been designed to perform out of sample test. The program for learning-applying methodology is similar to the functions in the first part. For example, learning function is working in the same way as optimization. The difference is that learning is an on going process that only focuses on a shorter period of time. The parameters identified in the learning process will be applied at once in the adjacent trading period.

The rationale behind learning and applying is straightforward, there might exist certain parameters that are capable of capturing price momentum in a finite period of time. Several different learning and applying period will be tested to increase the chance of recognizing such a relationship.

In order to provide comparable benchmarks, for each applying period a buy-and-hold return will be calculated. Right before the start of an applying period we assume that there is no

position for either MACD trader or buy-and-hold investor. When an applying period starts, MACD trader will act upon the first trading signal while buy-and-hold investor will long index or stock immediately. Existing position will be closed out on the last day of the applying period for both MACD trader and buy-and-hold investor. Under this setting the compounding return of a series buy-and-hold results will be different from general buy-and-hold definition. This discrepancy comes from the repetitive liquidating on the last applying day and repurchasing on the next day, the beginning of the next applying period.

We have predetermined several different learning and applying period to perform out of sample test. For simplicity, we will express a learning-applying setting by this notation: learning months – applying months. For example, 12-6 means training 12 months and applying 6 months. All the predetermined combinations are listed below (Table 3-14).

Table 3-14 Combinations of learning period and applying period

	Learning Period	Applying Period	Abbreviation
1	12-month	12-month	12-12
2	24-month	12-month	24-12
3	36-month	12-month	36-12
4	48-month	12-month	48-12
5	12-month	6-month	12-6
6	12-month	3-month	12-3
7	6-month	6-month	6-6
8	6-month	3-month	6-3
9	3-month	3-month	3-3

Next, we will revisit DJIA, NASDAQ, S&P 500, TSX, DAX, FTSE 100, HSI, KOSPI, NIKKEI 225, and TWSE by applying MACD trading strategy 2. All indices data start from January 1980 to September 2006 except FTSE 100, which starts from January 1984. None of the applying period will start from January 1980 because learning period has to come first. For

example, a 48-12 setting means that the first 48 month data (from January 1980 to December 1983) have been treated as known data and will not be traded upon.

Table 3-15 exhibits the out of sample trading results of MACD strategy 2. It shows that without considering trading cost, MACD is able to outperform buy-and-hold on most indices except DJIA. This may be a useful finding for anyone who wants to trade DJIA index by using moving average indicators. If MACD can't work on DJIA in a frictionless setting, it doesn't stand a chance with the presence of trading cost.

It also shows that 24-12 is probably the most useful one among nine different settings. This learning-applying combination has generated the best performance in four indices (S&P 500, DAX, FTSE 100, and TWSE) and is the only setting that enables out performance in nine indices except in DJIA.

The performance figures presented in Table 3-15 are similar to the concept of compounding returns with certain different settings. Since no position exists right before the beginning of an applying period and any existing position must be closed out on the last day of the applying period, the compounding return for buy-and-hold here is actually the compounding return of a series of buy-and-hold. The reason for this setting is to create a comparable benchmark in each applying period that will enable us to critically verify the statistical meaning of trading results in the later stage.

Table 3-15 Strategy 2 learning-applying on ten indices

Index	Strategy	12-12	24-12	36-12	48-12	12-6	12-3	6-6	6-3	3-3
DJIA	Strategy 2	224.7%	357.2%	281.3%	392.6%	598.4%	609.2%	138.6%	616.0%	292.9%
	Buy and Hold	1028.5%	1154.6%	958.0%	763.3%	942.0%	791.1%	1051.6%	877.5%	981.4%
NASDAQ	Strategy 2	22153.1%	42162.8%	57809.8%	51111.3%	22479.8%	8911.6%	19468.5%	35029.0%	24438.8%
	Buy and Hold	1007.3%	1050.8%	868.2%	701.4%	996.0%	1120.8%	1302.0%	1446.4%	1732.6%
S&P 500	Strategy 2	1355.6%	1888.2%	483.4%	598.9%	1332.1%	539.2%	158.8%	221.6%	445.3%
	Buy and Hold	860.7%	968.8%	832.8%	682.4%	797.8%	683.6%	960.6%	813.5%	921.3%
TSX	Strategy 2	58587.0%	40769.2%	19135.7%	20870.3%	25967.3%	52655.9%	30941.9%	52160.7%	174476.7%
	Buy and Hold	423.0%	513.0%	512.4%	367.8%	383.8%	388.2%	425.5%	424.9%	498.6%
DAX	Strategy 2	111.7%	1116.8%	10.6%	17.0%	138.0%	68.3%	538.8%	302.8%	-26.0%
	Buy and Hold	1019.7%	1018.8%	906.1%	629.3%	898.9%	714.2%	821.3%	645.4%	703.7%
FTSE 100	Strategy 2	32.1%	453.0%	96.4%	97.1%	117.2%	228.6%	88.6%	121.9%	312.3%
	Buy and Hold	385.2%	319.0%	252.6%	246.1%	326.1%	294.5%	401.1%	369.2%	340.9%
HSI	Strategy 2	30644.8%	60976.3%	80490.7%	170185.6%	37489.1%	29565.6%	35931.8%	13550.7%	9327.2%
	Buy and Hold	1131.9%	1236.2%	2246.9%	1954.6%	1045.6%	1234.5%	1526.8%	1753.9%	2419.7%
KOSPI	Strategy 2	245715.9%	92339.7%	418372.7%	90975.9%	171330.2%	46199.0%	70810.0%	43594.3%	157966.8%
	Buy and Hold	1243.5%	901.8%	859.9%	870.3%	939.0%	902.8%	891.0%	860.8%	926.3%
NIKKEI 225	Strategy 2	30.2%	172.2%	74.1%	488.0%	332.5%	736.1%	1032.3%	806.2%	331.1%
	Buy and Hold	104.6%	90.4%	83.3%	48.6%	78.0%	96.8%	84.2%	102.4%	113.8%
TWSE	Strategy 2	205811.2%	393224.4%	311788.3%	132449.1%	47402.9%	27193.4%	59909.8%	12403.1%	43893.8%
	Buy and Hold	1155.5%	1162.4%	1454.5%	804.3%	1238.3%	1204.0%	1451.7%	1410.0%	1276.6%

The next question is, can strategy 3 (MACDR2) provide any enhancement to those highest strategy 2 results for each index? We have demonstrated during in sample test that MACDR2 can outperform strategy 2 or at least guarantee an equal performance. Unfortunately, it is not true anymore for out of sample test. Table 3-16 shows that MACDR2 can only outperform strategy 2 in three indices (NASDAQ, KOSPI, and NIKKEI 225). And the rest seven MACDR2 trading performances are behind strategy 2 performance. Optimized setting for DJIA has been market as 'n/a' because neither strategy 2 nor MACDR2 can outperform buy-and-hold strategy.

We have calculated the statistical significance for each index by applying one-tailed pared comparisons test. The assumptions and formulas are listed below:

$$H_0 : \mu_d \leq 0,\ H_a : \mu_d > 0$$

μ_d = Mean of the paired differences (MACD return – Buy-and-Hold return)

$t = \dfrac{\bar{d} - 0}{s_{\bar{d}}}$ ... t-statistic with n – 1 degree of freedom

$\bar{d}$ = Sample mean difference

$s_{\bar{d}} = \dfrac{s_d}{\sqrt{n}}$ ... Standard error of the mean difference

s_d = Sample standard deviation

n = Number of applying period

The p-values listed in Table 3-16 indicate that five MACD trading performances are significantly outperform buy-and-hold return with a five percent level of significance. The results imply that a MACD trader may have a chance to outperform buy-and-hold on NASDAQ, TSX, HSI, KOSPI, and TWSE if trading cost has been ignored.

Table 3-16 Optimized strategy and learning-applying setting for each index

Index	Strategy 2 (zero cost)	MACDR2 (zero cost)	Optimized Strategy	Optimized Setting	Compounding Return v.s. Buy-and-Hold	d.f.	t-stat	p-value
DJIA	616.0%	352.0%	Strategy 2	n/a				
NASDAQ	57809.8%	79363.3%	MACDR2	36-12	79363.3% 868.2%	23	2.6474	0.0072
S&P 500	1888.2%	1782.0%	Strategy 2	24-12	1888.2% 968.8%	24	0.7360	0.2344
TSX	174476.7%	74815.3%	Strategy 2	3-3	174476.7% 498.6%	106	4.6695	4.5E-06
DAX	1116.8%	394.7%	Strategy 2	24-12	1116.8% 1018.8%	24	-0.1737	0.4318
FTSE 100	453.0%	361.3%	Strategy 2	24-12	453.0% 319.0%	20	0.3763	0.3553
HSI	170185.6%	71012.3%	Strategy 2	48-12	170185.6% 1954.6%	22	2.4755	0.0107
KOSPI	418372.7%	522626.9%	MACDR2	36-12	522626.9% 859.9%	23	2.4863	0.0103
NIKKEI 225	1032.3%	1337.1%	MACDR2	6-6	1032.3% 84.2%	52	1.1060	0.1369
TWSE	393224.4%	102610.0%	Strategy 2	24-12	393224.4% 1162.4%	24	2.0218	0.0272

The real challenge of MACD trading strategy is to face the trial with the presence of trading cost. Since it requires much more execution time for a learning-applying simulation than that of an in sample test, the search for sustainable trading cost has to be confined to certain predetermined values. We will test the following one-way trading costs: 0.25%, 0.125%, 0.0625%, 0.03125%, and 0.01%.

Table 3-17 displays the sustainable trading costs for each index. We use the term "sustainable" to refer to the highest trading cost that MACD can still outperform. With the presence of trading cost, MACD can no longer outperform buy-and-hold on DAX even if the

trading cost is as low as 1 basis point. A slightly better result can be found in S&P 500 and FTSE 100, where the sustainable trading cost is merely 1 basis point and the performance is slightly above buy-and-hold. MACD can still outperform in NASDAQ, HSI, KOSPI, and NIKKEI 225 with trading cost 6.25 basis points. It is quite a surprise that MACD can still outperform in TSX with trading cost as high as 12.5 basis points. Finally, our model shows that MACD trading can outperform in TWSE with one-way trading cost as high as 25 basis points.

However under the scrutiny of paired comparison test, none of the result can be confirmed as statistically significant. Therefore we are unable to prove whether out of sample MACD trading can outperform buy-and-hold with the presence of trading costs listed in Table 3-17.

Table 3-17 Sustainable level of trading cost for ten indices

Index	Strategy	Optimized Setting	One way trading cost	Compounding Return v.s. Buy-and-Hold	d.f.	t-stat	p-value
DJIA	Strategy 2	n/a					
NASDAQ	MACDR2	36-12	0.0625%	2546.3% 839.6%	23	0.5032	0.3098
S&P 500	Strategy 2	24-12	0.01%	975.0% 963.5%	24	0.1013	0.4601
TSX	Strategy 2	3-3	0.125%	967.4% 359.2%	105	0.6431	0.2608
DAX	Strategy 2	n/a					
FTSE 100	Strategy 2	24-12	0.01%	321.2% 317.3%	20	0.0977	0.4616
HSI	Strategy 2	48-12	0.0625%	19177.9% 1896.4%	22	1.2023	0.1210
KOSPI	MACDR2	36-12	0.0625%	8719.9% 831.5%	23	0.9240	0.1825
NIKKEI 225	MACDR2	6-6	0.0625%	119.1% 72.4%	52	-0.1426	0.4436
TWSE	Strategy 2	24-12	0.25%	2514.8% 1014.0%	24	0.6322	0.2666

So far we have tested both in sample and out of sample on ten indices. From Table 3-15 we know that even ignoring the trading cost, learning and applying still can not outperform buy-and-hold on DJIA. How about applying out of sample test on those 30 constituents of DJIA?

Table 3-18 shows that without considering trading cost, MACD trading strategy 2 can outperform in twelve DJIA stocks, which includes Alcoa Inc. (AA), American International Group Inc. (AIG), Boeing Co. (BA), Citigroup Inc. (C), Caterpillar Inc. (CAT), El DuPont de Nemours & Co. (DD), Walt Disney Co. (DIS), General Motors Corporation (GM), Honeywell International Inc. (HON), International Business Machines Corp. (IBM), Intel Corp. (INTC), JP Morgan Chase & Co. (JPM).

There is no superior learning-applying setting that can be identified in Table 3-18. However it seems apparent that if we can capture one setting that outperform on a certain stock, the chance that different settings might work as well is quite high. Or, to put it another way: MACD only works on certain stocks. When that stock has been identified, very likely the number of outperforming setting on that stock is more than one. The only exception is INTC, for which we have identified only one setting that can outperform buy-and-hold.

Even though we have identified that by ignoring trading cost, MACD trading is capable of outperforming buy-and-hold in twelve stocks. We have also noticed a dismal fact that no matter under which learning-applying setting, MACD trading inevitably leads to the destruction of value in three stocks: Hewlett-Packard Co. (HPQ), Verizon Communication Inc. (VZ), and Exxon Mobil Corp. (XOM). A possible explanation is that the market has completely exploited any price signal revealed by them, i.e. market is extremely efficient on these stocks. Whenever our model has figured out the optimal parameters for a certain period, the market has already identified the same information and therefore that knowledge is completely useless. Nevertheless, we don't have an explanation on why it only happens to these three stocks.

Table 3-18 Strategy 2 learning-applying on DJIA component stocks

Ticker	Strategy	12-12	24-12	36-12	48-12	12-6	12-3	6-6	6-3	3-3	No. of setting that outperforms	Optimized Setting
AA	Strategy 2	2401.7%	4059.0%	20853.8%	5107.2%	6306.4%	1931.7%	7390.2%	24812.5%	2761.1%	9	6-3
	Buy and Hold	1259.5%	1422.3%	1091.0%	659.6%	1046.2%	1091.1%	1078.4%	1141.5%	1141.5%		
AIG	Strategy 2	3460.2%	984.1%	3188.7%	2044.4%	2744.4%	1898.9%	3824.3%	1797.6%	2439.5%	8	6-6
	Buy and Hold	1404.3%	1188.0%	1240.5%	1136.6%	1223.5%	1068.8%	1560.5%	1361.9%	1607.3%		
AXP	Strategy 2	-69.4%	-86.9%	-72.6%	-97.3%	-9.1%	94.6%	-80.7%	-27.8%	-88.8%		
	Buy and Hold	11871.8%	9713.0%	6180.3%	5298.9%	10013.3%	6079.7%	12480.0%	7586.9%	9748.9%		
BA	Strategy 2	693.7%	1747.1%	2096.2%	4097.7%	906.4%	265.8%	2492.1%	427.4%	21.9%	2	48-12
	Buy and Hold	2234.0%	4183.0%	2645.5%	1936.1%	1912.0%	2080.5%	2462.7%	2599.6%	2571.2%		
C	Strategy 2	864.6%	839.5%	5460.9%	11694.9%	1330.7%	1827.3%	1129.1%	1416.8%	5860.8%	3	48-12
	Buy and Hold	5260.0%	4718.0%	5440.7%	3517.5%	4171.2%	3398.0%	3773.9%	3033.9%	3634.9%		
CAT	Strategy 2	13859.2%	28607.7%	3530.8%	2135.8%	6352.0%	7695.5%	8499.2%	9374.1%	21771.6%	9	24-12
	Buy and Hold	1431.1%	1499.3%	1951.1%	1601.9%	1332.1%	1003.5%	1469.7%	1094.8%	1226.1%		
DD	Strategy 2	25.2%	148.0%	92.1%	38.1%	1854.3%	2731.2%	621.0%	2358.0%	1164.4%	4	12-3
	Buy and Hold	1294.3%	1378.6%	1372.8%	864.3%	1160.0%	840.9%	1225.5%	889.8%	1087.8%		
DIS	Strategy 2	10193.9%	7761.1%	5936.5%	7210.1%	3226.6%	1063.2%	641.7%	852.0%	177.1%	5	12-12
	Buy and Hold	2677.7%	2677.7%	2189.1%	2537.4%	3093.1%	2679.0%	3250.8%	2816.3%	3010.7%		
GE	Strategy 2	-39.0%	130.2%	-21.4%	55.5%	-84.3%	-78.4%	-91.0%	-41.3%	-35.9%		
	Buy and	5612.3%	5799.6%	3350.7%	2513.4%	5365.2%	4186.9%	6543.9%	5211.8%	5789.2%		

Ticker	Strategy	12-12	24-12	36-12	48-12	12-6	12-3	6-6	6-3	3-3	No. of setting that outperforms	Optimized Setting
	Hold											
GM	Strategy 2	2512.5%	2876.2%	137.1%	336.0%	1780.0%	1209.5%	3053.0%	1023.4%	57.0%	7	6-6
	Buy and Hold	351.3%	408.6%	206.8%	141.9%	314.6%	260.7%	307.2%	259.9%	272.2%		
HD	Strategy 2	298.8%	946.8%	2757.0%	927.0%	651.7%	351.2%	-73.3%	-33.7%	-73.5%		
	Buy and Hold	15394.6%	10660.1%	6817.2%	4268.8%	14507.9%	12364.1%	13946.0%	11363.6%	8666.3%		
HON	Strategy 2	641.1%	507.1%	3784.9%	1462.2%	-30.1%	251.9%	-13.5%	35.8%	-10.8%	2	36-12
	Buy and Hold	817.4%	978.0%	1311.6%	680.6%	820.8%	660.7%	940.2%	724.2%	788.2%		
HPQ	Strategy 2	-99.0%	-95.5%	-94.2%	-42.5%	-98.6%	-96.8%	-99.2%	-94.1%	-84.2%		
	Buy and Hold	1824.8%	2040.1%	1061.1%	880.6%	1787.6%	2605.7%	2589.9%	3702.4%	3702.4%		
IBM	Strategy 2	47.7%	2228.8%	711.2%	1383.0%	63.7%	338.3%	186.0%	44.8%	154.6%	3	24-12
	Buy and Hold	663.9%	774.5%	403.5%	271.5%	611.6%	539.1%	733.0%	641.9%	706.2%		
INTC	Strategy 2	487.3%	-93.4%	54.4%	162.5%	131.3%	756.6%	521.2%	1810.7%	5893.3%	1	3-3
	Buy and Hold	2024.7%	1683.9%	2124.7%	1238.0%	1353.6%	1257.4%	2949.0%	2640.5%	2856.8%		
JNJ	Strategy 2	109.1%	89.3%	54.7%	119.6%	597.4%	469.2%	26.2%	100.1%	136.6%		
	Buy and Hold	5626.7%	4900.7%	3490.3%	4147.0%	5752.0%	5348.7%	7380.9%	6796.4%	7509.8%		
JPM	Strategy 2	6208.4%	2223.4%	1237.0%	715.3%	9991.8%	5199.2%	2134.0%	2797.2%	1919.4%	9	12-6
	Buy and Hold	267.1%	178.2%	202.0%	506.0%	260.9%	241.3%	411.0%	403.7%	299.3%		
KO	Strategy 2	54.0%	-39.2%	-64.4%	-38.6%	188.0%	130.9%	2037.1%	758.4%	-8.7%		
	Buy and Hold	6174.7%	5632.4%	3471.7%	3117.1%	5026.2%	3337.4%	5323.4%	3385.2%	3653.3%		

Ticker	Strategy	12-12	24-12	36-12	48-12	12-6	12-3	6-6	6-3	3-3	No. of setting that outperforms	Optimized Setting
MCD	Strategy 2	470.8%	96.5%	253.5%	754.0%	690.2%	216.8%	1062.5%	96.9%	738.3%		
	Buy and Hold	5439.4%	4013.4%	2745.6%	2179.7%	4668.1%	3679.0%	4734.3%	3731.5%	4433.9%		
MMM	Strategy 2	-86.4%	-73.1%	-29.1%	-93.5%	-34.1%	-0.1%	74.3%	825.9%	241.6%		
	Buy and Hold	2095.6%	2160.2%	1444.0%	1216.5%	1885.4%	1676.5%	2151.6%	1927.6%	2111.9%		
MO	Strategy 2	-71.1%	-73.1%	169.3%	78.9%	6.9%	-71.6%	-73.0%	107.8%	32.1%		
	Buy and Hold	11037.9%	9708.0%	7791.5%	6126.3%	9557.2%	6658.6%	10286.1%	7038.9%	8499.1%		
MRK	Strategy 2	67.4%	33.1%	-7.5%	117.9%	606.5%	31.7%	554.4%	-12.4%	-57.7%		
	Buy and Hold	2971.1%	2918.6%	2843.8%	2536.2%	2731.2%	1715.0%	3297.5%	2078.0%	2175.9%		
MSFT	Strategy 2	84.6%	-16.0%	-33.3%	-3.3%	138.5%	181.8%	-84.5%	-78.8%	-96.9%		
	Buy and Hold	8427.1%	6508.5%	8367.1%	2877.4%	7182.6%	6985.1%	16025.7%	16750.6%	31494.8%		
PFE	Strategy 2	11.9%	403.1%	598.6%	1235.0%	30.3%	25.3%	18.8%	-70.7%	-78.3%		
	Buy and Hold	3486.9%	3198.3%	2612.6%	2000.7%	3326.0%	2534.1%	4289.6%	3155.8%	3369.3%		
PG	Strategy 2	-16.0%	1.5%	-86.1%	-77.1%	-7.0%	94.3%	-76.7%	-36.9%	7.3%		
	Buy and Hold	5998.7%	4788.3%	3070.1%	3007.3%	5499.7%	4465.4%	5247.5%	4181.2%	4605.1%		
T	Strategy 2	150.8%	-30.4%	-64.3%	-7.3%	-57.9%	-51.4%	-4.4%	-67.6%	511.4%		
	Buy and Hold	1008.2%	698.8%	562.4%	517.9%	821.1%	633.6%	1035.2%	796.8%	883.0%		
UTX	Strategy 2	305.6%	2040.4%	468.4%	503.4%	1577.3%	1406.7%	553.3%	201.7%	63.4%		
	Buy and Hold	3600.8%	5070.3%	3559.0%	2527.7%	4029.5%	3840.3%	5997.5%	5608.9%	5842.9%		
VZ	Strategy 2	-67.5%	-62.9%	-67.1%	-67.5%	-46.8%	-69.0%	-84.8%	-80.3%	-79.5%		
	Buy and	750.5%	500.5%	346.0%	353.3%	697.1%	549.5%	877.3%	703.0%	700.5%		

Ticker	Strategy	12-12	24-12	36-12	48-12	12-6	12-3	6-6	6-3	3-3	No. of setting that outperforms	Optimized Setting
	Hold											
WMT	Strategy 2	480.8%	746.2%	656.7%	249.8%	52.1%	448.3%	-9.3%	196.7%	-29.5%		
	Buy and Hold	22913.2%	16564.7%	7113.1%	4323.1%	23695.3%	20815.4%	39558.9%	32708.5%	42551.1%		
XOM	Strategy 2	-96.7%	-94.4%	-75.8%	-91.0%	-99.1%	-97.9%	-99.1%	-99.0%	-98.5%		
	Buy and Hold	4328.8%	5159.2%	4705.2%	3296.3%	3930.0%	3104.9%	4929.1%	3778.3%	4553.9%		

Table 3-19 shows that time consuming MACDR2 performs worse than strategy 2 in most of the stocks except for DD. This should not be a surprise because we have already identified this phenomenon from Table 3-16. Apparently the advantage of those three extra parameters unique to MACDR2 has disappeared while dealing with out of sample data. In comparison to strategy 2 that simply relies on three moving average parameters, MACDR2 is inherently more susceptible to the problem of over training.

Table 3-19 also shows that at the five percent level of significance, only one trading result (CAT) has significantly outperformed buy-and-hold. Even though we have observed in Table 3-18 that MACD outperforms buy-and-hold in all nine settings on three stocks (AA, CAT, and JPM), the test result shows that only CAT has a p-value lower than 5%.

Table 3-19 Optimized strategy and learning-applying setting for 12 DJIA stocks

Index	Strategy 2 (zero cost)	MACDR2 (zero cost)	Optimized Strategy	Optimized Setting	Compounding Return v.s. Buy-and-Hold	d.f.	t-stat	p-value
AA	24812.5%	15186.60%	Strategy 2	6-3	24812.5% 1141.5%	104	1.4780	0.0712
AIG	3824.3%	532.60%	Strategy 2	6-6	3824.3% 1560.5%	42	0.8248	0.2071
BA	4097.7%	4013.30%	Strategy 2	48-12	4097.7% 1936.1%	22	0.4056	0.3445
C	11694.9%	7666.30%	Strategy 2	48-12	11694.9% 3517.5%	22	0.6196	0.2710
CAT	28607.7%	11569.30%	Strategy 2	24-12	28607.7% 1499.3%	24	1.7277	0.0485
DD	2731.2%	5067.20%	MACDR2	12-3	5067.20% 840.9%	102	0.9084	0.1829
DIS	10193.9%	6900.40%	Strategy 2	12-12	10193.9% 2677.7%	25	1.0864	0.1438
GM	3053.0%	1265.40%	Strategy 2	6-6	3053.0% 307.2%	52	0.9480	0.1738
HON	3784.9%	2531.10%	Strategy 2	36-12	3784.9% 1311.6%	23	0.4785	0.3184
IBM	2228.8%	668.40%	Strategy 2	24-12	2228.8% 774.5%	24	0.2521	0.4016
INTC	5893.3%	2211.50%	Strategy 2	3-3	5893.3% 2856.8%	79	0.00346	0.49862
JPM	9991.8%	4802.10%	Strategy 2	12-6	9991.8% 260.9%	43	1.6293	0.0553

Finally, we implement different trading costs (0.25%, 0.125%, 0.0625%, 0.03125%, and 0.01%) on each optimized settings and record the highest cost level that MACD trading can still outperform buy-and-hold. Table 3-20 shows that both IBM and JPM can tolerate the highest one-way trading cost at 12.5 basis points. However the results from paired comparison test shows that none of the out-performances in this table is statistically significant. That is to say, no matter in ten indices or in DJIA stocks, we don't find any statistical evidence to show that MACD trading can outperform buy-and-hold with the presence of trading cost.

Table 3-20 Sustainable level of trading cost for 12 DJIA stocks

Index	Strategy 2	Optimized Setting	One way trading cost	Compounding Return v.s. Buy-and-Hold	d.f.	t-stat	p-value
AA	Strategy 2	6-3	0.0625%	2396.10% 988.8%	104	0.3626	0.3588
AIG	Strategy 2	6-6	0.01%	2710.40% 1546.3%	42	0.5739	0.2846
BA	Strategy 2	48-12	0.01%	3469.70% 1926.8%	22	0.2654	0.3966
C	Strategy 2	48-12	0.01%	7589.70% 3500.9%	22	0.4283	0.3363
CAT	Strategy 2	24-12	0.0625%	2442.80% 1450.1%	24	0.7059	0.2435
DD	MACDR2	12-3	0.01%	2252.50% 821.7%	102	0.4779	0.3169
DIS	Strategy 2	12-12	0.01%	3449.80% 2663.3%	25	0.6767	0.2524
GM	Strategy 2	6-6	0.0625%	388.80% 281.1%	52	0.1675	0.4338
HON	Strategy 2	n/a					
IBM	Strategy 2	24-12	0.125%	757.30% 721.6%	24	-0.2204	0.4137
INTC	Strategy 2	n/a					
JPM	Strategy 2	12-6	0.125%	414.10% 223.3%	43	-0.0263	0.4896

4 CONCLUSION

Derived from the concept of exponential moving average, MACD has already become one of the most studied technical indicators and is available in almost every technical analysis system. One of the reasons that MACD is so popular is because its trading signals are unambiguous. This can be valuable if a trader is looking for clear definition of trading rules in order to construct an automatic trading system. Other than MACD, many other indicators are in fact quite ambiguous. For example, another popular technical indicator RSI measures market sentiment without answering when to initiate trading activities. For trading rules or indicators that leave too much room for interpretations, the challenge of testing their effectiveness is probably similar to the challenge of testing the effectiveness of art.

The unambiguous nature of MACD enables us to construct a testing model that includes both in sample and out of sample test functions. The function of in sample test treats the whole time series as given data. It searches for the optimized MACD parameters that generate highest compounding return. The function of out of sample test only treats learning period as given data. With the optimized parameters identified from learning period, the program will be able to trade ahead and compare results to buy-and-hold strategy in the same applying period.

From the in sample test we found that by increasing flexibility to the parameter settings for standard MACDR2 trading strategy, we have created a very powerful tool that outperforms, or at least equal to, the performance of standard long or short MACD trading strategy. From a hindsight perspective, there exist certain parameters that enable a trader to outperform buy-and-hold in certain indices even with the presence of trading cost.

Out of sample tests enable us to measure the effectiveness of momentum trading strategy in a setting more close to real world. We confirmed that MACD trading can outperform buy-and-

hold on NASDAQ, TSX, HSI, KOSPI, and TWSE if trading cost has been ignored. Our test on DJIA stocks shows that, without considering trading cost, only the trading result on CAT outperforms buy-and-hold.

Even though our model has identified that, with the presence of trading cost, MACD trading on certain indices and DJIA stocks can outperform buy-and-hold. When we scrutinize these trading returns by paired comparison test, none of the results are statistically significant.

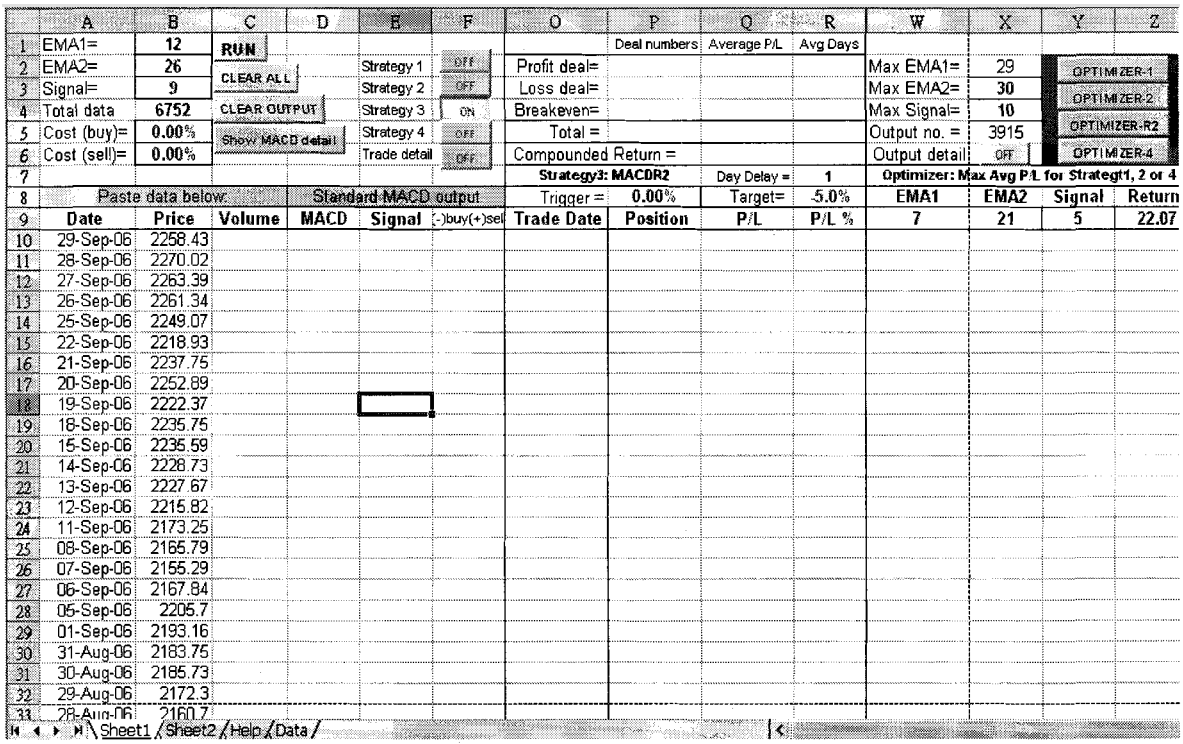
Tons of research papers claimed that they can successfully challenge weak form EMH by providing abnormal trading results. Our research shows that, as long as the settings are away from reality, we can demonstrate some fantastic returns as well. For example, ignoring trading cost, our in sample test shows that MACDR2 can generate compounding return of 4649405.16% on KOSPI starting from 1980 to 2006. Some results can still be astonishing if our setting is a step closer to reality. We have demonstrated in Table 3-16 that by a 36-12 (36-month training and 12-month applying) MACDR2 trading strategy, we can achieve 522626.9% of compounding return from 1983 to 2006.

Our research shows that with the presence of trading cost, all those exciting results seem vanished. Let us once again take KOSPI as an example. By assigning merely 6.25 basis point of one-way trading cost, the aforementioned 36-12 out of sample test result has slumped to 8719.9%. Even worse, we are now even unable to reject the null hypothesis that MACD trading result is no better than buy-and-hold result.

In conclusion, our test over ten indices and DJIA stocks shows that technical analysis performed by MACD trading strategies can not outperform buy-and-hold strategy with the presence of trading cost.

APPENDICES

Appendix A Interface of trading model



	A	B	C	D	E	F	O	P	Q	R	W	X	Y	Z
1	EMA1=	12	RUN					Deal numbers	Average P/L	Avg Days				
2	EMA2=	26	CLEAR ALL		Strategy 1	OFF	Profit deal=				Max EMA1=	29	OPTIMIZER-1	
3	Signal=	9			Strategy 2	OFF	Loss deal=				Max EMA2=	30	OPTIMIZER-2	
4	Total data	6752	CLEAR OUTPUT		Strategy 3	ON	Breakeven=				Max Signal=	10	OPTIMIZER-R2	
5	Cost (buy)=	0.00%	Show MACD detail		Strategy 4	OFF	Total =				Output no. =	3915	OPTIMIZER-4	
6	Cost (sell)=	0.00%			Trade detail	OFF	Compounded Return =				Output detail	OFF		
7							Strategy3: MACDR2		Day Delay =	1	Optimizer: Max Avg P/L for Strategt1, 2 or 4			
8	Paste data below:			Standard MACD output			Trigger =	0.00%	Target=	-5.0%	EMA1	EMA2	Signal	Return
9	Date	Price	Volume	MACD	Signal	(-)buy(+)sell	Trade Date	Position	P/L	P/L %	7	21	5	22.07
10	29-Sep-06	2258.43												
11	28-Sep-06	2270.02												
12	27-Sep-06	2263.39												
13	26-Sep-06	2261.34												
14	25-Sep-06	2249.07												
15	22-Sep-06	2218.93												
16	21-Sep-06	2237.75												
17	20-Sep-06	2252.89												
18	19-Sep-06	2222.37												
19	18-Sep-06	2235.75												
20	15-Sep-06	2235.59												
21	14-Sep-06	2228.73												
22	13-Sep-06	2227.67												
23	12-Sep-06	2215.82												
24	11-Sep-06	2173.25												
25	08-Sep-06	2165.79												
26	07-Sep-06	2155.29												
27	06-Sep-06	2167.84												
28	05-Sep-06	2205.7												
29	01-Sep-06	2193.16												
30	31-Aug-06	2183.75												
31	30-Aug-06	2185.73												
32	29-Aug-06	2172.3												
33	28-Aug-06	2160.7												

Sheet1 / Sheet2 / Help / Data /

Appendix B Interface of Learning/Applying Model

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1		Learning period:	3	months		STRATEGY 1		STRATEGY 2		STRATEGY 3											
2		Applying period:	3	months																	
3		Cost (buy)=	0.00%																		
4		Cost (sell)=	0.00%		Fm	To	Step														
5		Max EMA1=	29	DayDealy	0	3	1														
6		Max EMA2=	30	Trigger	0.00%	0.30%	0.10%														
7		Max Signal=	10	Target	-5%	5%	5%														
8			Learning Period (searching optimized parameters)										Applying Period						Single period buy and hold		
9		From	To	EMA1	EMA2	Signal	Return	Delay	Trigger	Target		1st data	From	To	Deal No.	Avg Prifit	Return		Begin	End	Return
90		01-Apr-86	30-Jun-86	3	4	2	15.1%					24-Jun-86	01-Jul-86	30-Sep-86	17	0.7%	12.4%		407.6	350.7	-14.0%
91		02-Jan-86	31-Mar-86	1	2	2	10.3%					26-Mar-86	01-Apr-86	30-Jun-86	27	0.1%	3.6%		374.2	405.5	8.4%
92		01-Oct-85	31-Dec-85	1	2	2	6.3%					27-Dec-85	02-Jan-86	31-Mar-86	26	0.3%	8.7%		325	374.7	15.3%
93		01-Jul-85	30-Sep-85	1	3	4	9.5%					20-Sep-85	01-Oct-85	31-Dec-85	20	0.2%	4.9%		281.8	324.9	15.3%
94		01-Apr-85	28-Jun-85	1	2	4	13.5%					24-Jun-85	01-Jul-85	30-Sep-85	22	0.4%	8.8%		296.5	280.3	-5.5%
95		02-Jan-85	29-Mar-85	2	3	2	10.3%					26-Mar-85	01-Apr-85	28-Jun-85	16	0.6%	10.7%		280.3	296.2	5.7%
96		01-Oct-84	31-Dec-84	1	2	4	13.3%					24-Dec-84	02-Jan-85	29-Mar-85	24	0.4%	10.3%		245.9	279.2	13.5%
97		02-Jul-84	28-Sep-84	2	8	2	15.5%					18-Sep-84	01-Oct-84	31-Dec-84	17	0.5%	7.9%		247.86	247.1	-0.3%
98		02-Apr-84	29-Jun-84	1	4	5	19.3%					20-Jun-84	02-Jul-84	28-Sep-84	20	0.7%	14.1%		237.91	249.94	5.1%
99		03-Jan-84	30-Mar-84	4	10	3	11.1%					15-Mar-84	02-Apr-84	29-Jun-84	9	1.5%	14.1%		249.8	239.65	-4.1%
100		03-Oct-83	30-Dec-83	1	17	4	9.7%					02-Dec-83	03-Jan-84	30-Mar-84	12	0.7%	8.0%		277.63	250.78	-9.7%
101		01-Jul-83	30-Sep-83	2	3	4	22.0%					23-Sep-83	03-Oct-83	30-Dec-83	21	0.0%	-0.1%		294.64	278.6	-5.4%
102		04-Apr-83	30-Jun-83	1	2	2	14.5%					28-Jun-83	01-Jul-83	30-Sep-83	28	0.4%	11.6%		321.58	296.65	-7.8%
103		03-Jan-83	31-Mar-83	1	2	4	10.4%					25-Mar-83	04-Apr-83	30-Jun-83	26	0.5%	13.6%		268.73	318.7	18.6%
104		01-Oct-82	31-Dec-82	2	3	2	23.0%					28-Dec-82	03-Jan-83	31-Mar-83	24	0.2%	5.5%		230.59	270.8	17.4%
105		01-Jul-82	30-Sep-82	13	15	4	17.7%					07-Sep-82	01-Oct-82	31-Dec-82	9	0.7%	5.9%		188.7	232.41	23.2%
106		01-Apr-82	30-Jun-82	8	15	10	11.7%					27-May-82	01-Jul-82	30-Sep-82	5	2.5%	12.5%		170.6	187.65	10.0%
107		04-Jan-82	31-Mar-82	1	9	10	12.5%					08-Mar-82	01-Apr-82	30-Jun-82	19	0.1%	1.5%		177.31	171.3	-3.4%
108		01-Oct-81	31-Dec-81	1	2	2	9.3%					29-Dec-81	04-Jan-82	31-Mar-82	25	0.5%	12.9%		195.53	175.65	-10.2%
109		01-Jul-81	30-Sep-81	1	2	2	17.9%					28-Sep-81	01-Oct-81	31-Dec-81	27	0.3%	8.5%		181.09	195.84	8.1%
110		01-Apr-81	30-Jun-81	1	2	2	11.0%					26-Jun-81	01-Jul-81	30-Sep-81	27	0.7%	19.5%		214.63	180.03	-16.1%
111		02-Jan-81	31-Mar-81	1	2	3	10.9%					26-Mar-81	01-Apr-81	30-Jun-81	27	0.4%	10.5%		211.34	215.75	2.1%
112		01-Oct-80	31-Dec-80	6	7	5	17.6%					16-Dec-80	02-Jan-81	31-Mar-81	11	-0.2%	-2.6%		203.55	210.18	3.3%
113		01-Jul-80	30-Sep-80	1	2	4	11.9%					24-Sep-80	01-Oct-80	31-Dec-80	29	-0.1%	-3.5%		189.62	202.34	6.7%
114		01-Apr-80	30-Jun-80	1	11	4	11.9%					11-Jun-80	01-Jul-80	30-Sep-80	22	0.2%	5.1%		158.17	187.76	18.7%
115		02-Jan-80	31-Mar-80	7	21	5	22.1%					26-Feb-80	01-Apr-80	30-Jun-80	6	1.6%	9.1%		133.14	157.78	18.5%
116														Strategy 2	Compounded Rtn =		24438.8%		Compounded Rtn		1732.6%
117																					

Appendix C Visual Basic Code

Declaration

```
Option Explicit
Option Base 1
Const MaxDays = 10000
Const MaxTrades = 7000

Public Price(MaxDays) As Double
Public PDate(MaxDays) As Date
Public MACD(MaxDays) As Single
Public EMA(MaxDays, 2) As Single 'EMA1 and EMA2
Public Signal(MaxDays) As Single
Public Trading(MaxDays) As Integer 'record buy/sell trading signal according to MACD rule
Public TotalDay As Integer
Public AllMACD As Integer 'total number of MACD value
Public AllSigl As Integer 'total number of Signal value
Public CopyPriceOK As Boolean
Public LearningMode As Boolean 'TRUE: we are in Learning mode, a signal for optimizer
Public LearnDay1 As Integer 'for Learning() to tell optimizer which time period to learn (or to apply)
Public LearnDay2 As Integer
Public Optimized(6) As Single  '1:EMA1  2:EMA2  3:Signal 4:DayDelay 5:Trigger 6:Target
Public OptimizedRtn As Single 'Max return found by optimizer
Public Performance(4) '1:AllDealNo 2:DealAvgProfit% 3:CompoundedReturn 4: FarDay(for internal
check)
```

CopyPrice

```
Sub CopyPrice()
'the 1st preparation work
'copy price and date to Price( ) and PDate( )

ClearPublicMatrix

Dim i As Integer

TotalDay = Sheet1.Cells(4, 2)

For i = 1 To TotalDay
  PDate(i) = Sheet1.Cells(9 + i, 1)
  Price(i) = Sheet1.Cells(9 + i, 2)
Next i

End Sub
```

MACDinitiate

```
Sub MACDinitiate()
'must execute CopyPrice in advance
'calculate value of MACD and Singal

Dim Avg As Single
Dim Power As Integer
Dim Alpha As Single
Dim Denominator As Single
Dim EMA1 As Integer
```

```
Dim EMA2 As Integer
Dim Sigl As Integer
Dim i As Integer

TotalDay = Sheet1.Cells(4, 2)
If TotalDay = 0 Then Exit Sub

EMA1 = Sheet1.Cells(1, 2)
EMA2 = Sheet1.Cells(2, 2)
Sigl = Sheet1.Cells(3, 2)

If EMA2 <= EMA1 Or EMA1 < 1 Or Sigl <= 1 Then 'Invalid initial parameters
  MsgBox "Be sure that (1) EMA2 > EMA1, (2) EMA1 >= 1, (3) Signal >1 "
  End
End If

If EMA2 + Sigl - 2 >= TotalDay Then 'no sufficient data to generate Signal
  MsgBox "Insufficient data to generate MACD trading signal "
  End
End If

Avg = 0
Alpha = 2 / (1 + EMA1)
Power = 0
Denominator = 0
For i = TotalDay - EMA1 + 1 To TotalDay 'to get initial EMA1
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(TotalDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
For i = TotalDay - EMA1 To 1 Step -1 'fill the rest EMA1
  EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
Next i

Avg = 0
Alpha = 2 / (1 + EMA2)
Power = 0
Denominator = 0
For i = TotalDay - EMA2 + 1 To TotalDay 'to get initial EMA2
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(TotalDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
For i = TotalDay - EMA2 To 1 Step -1 'fill the rest EMA2
  EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
Next i

AllMACD = TotalDay - EMA2 + 1

For i = 1 To AllMACD
  MACD(i) = EMA(i, 1) - EMA(i, 2)
Next i
```

```
'Signal = EMA of MACD
Avg = 0
Alpha = 2 / (1 + Sigl)
Power = 0
Denominator = 0
For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
  Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator

AllSigl = AllMACD - Sigl + 1
Signal(AllSigl) = Avg 'first Signal

For i = AllSigl - 1 To 1 Step -1 'fill the rest Signal
  Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
Next i

End Sub
```

MACDtradingsignal

```
Sub MACDtradingsignal()
'must execute MACDiniciate in advance
'Trading signals are stored in Trading( )
'The calculation follows standard MACD rules

If TotalDay = 0 Then Exit Sub

Dim i As Integer

For i = AllSigl - 1 To 1 Step -1
  If MACD(i) > Signal(i) Then
    If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
  ElseIf MACD(i) < Signal(i) Then
    If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
  End If
Next i
'While inspecting myriads of output the chance that MACD=Signal does exist but quite rare,
'therefore the code here ignores a very unlikely situation: MACD(i+1)=Signal(i+1) happens
'right in the beginning when i=AllSigl-1. No value has yet been assigned to Signal(i+2), i.e. =0
End Sub
```

MACDoutput

```
Sub MACDoutput()
'display MACD detail in Sheet1, this process is very slow
'must execute (1) MACDiniciate and (2)MACDtradingsignal in advance

Dim i As Integer

Sheets("Sheet1").Select
Range("D10:F65536").Select
Selection.ClearContents
```

```
If AllMACD = 0 Then End
If MACD(1) = 0 And MACD(AllMACD) = 0 And Signal(1) = 0 And Signal(AllSigl) = 0 Then End

For i = 1 To AllMACD 'this value has been assigned already
  Sheet1.Cells(9 + i, 4) = MACD(i)
Next i
For i = 1 To AllSigl 'this value has been assigned already
  Sheet1.Cells(9 + i, 5) = Signal(i)
Next i

'Output MACD trading signal: (-)buy(+)sell
For i = 1 To AllSigl - 1
  If Trading(i) <> 0 Then
    Sheet1.Cells(i + 9, 6) = Trading(i)
  End If
Next i

End Sub

Sub MACDoutput()
'display MACD detail in Sheet1, this process is very slow
'must execute (1) MACDiniciate and (2)MACDtradingsignal in advance

Dim i As Integer

Sheets("Sheet1").Select
Range("D10:F65536").Select
Selection.ClearContents

If AllMACD = 0 Then End
If MACD(1) = 0 And MACD(AllMACD) = 0 And Signal(1) = 0 And Signal(AllSigl) = 0 Then End

For i = 1 To AllMACD 'this value has been assigned already
  Sheet1.Cells(9 + i, 4) = MACD(i)
Next i
For i = 1 To AllSigl 'this value has been assigned already
  Sheet1.Cells(9 + i, 5) = Signal(i)
Next i

'Output MACD trading signal: (-)buy(+)sell
For i = 1 To AllSigl - 1
  If Trading(i) <> 0 Then
    Sheet1.Cells(i + 9, 6) = Trading(i)
  End If
Next i

End Sub
```

MACDtrading1

```
Sub MACDtrading1()
'Trade Stragegy 1 starts here

Dim i As Integer

Dim JustStarted As Boolean
```

```
Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 3) As Single 'Profit/Loss for a round trip (1:amount 2: percentage 3:days)
Dim TradeDate(MaxTrades) As Date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade
Dim WinDeal As Integer
Dim LossDeal As Integer
Dim WinAvgPct As Single 'average percentage in a winning deal
Dim LossAvgPct As Single
Dim WinAvgDay As Single
Dim LossAvgDay As Single
Dim CompoundedReturn As Double

If TotalDay = 0 Or Sheet1.ToggleButton1.Caption = "OFF" Then Exit Sub

JustStarted = True
AllTrade = 0

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL
'no need to define Cost(2)

'Buy and sell based on the signal we stored in Trading( )
'Here we only allow long position, no short sell allowed
For i = AllSigl - 1 To 1 Step -1
 If Trading(i) <> 0 Then
  If JustStarted And Trading(i) = 1 Then
   'do nothing because the 1st signal is a SELL (don't allow short selling)
  Else
   If i = 1 And Trading(1) = -1 Then 'last day shows BUY signal => we won't allow this happen
    'do nothing (we are sure the last day will not have a BUY decision)
   Else
    TradePos(i) = Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i))
    AllTrade = AllTrade + 1
    TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
    TradeDate(AllTrade) = PDate(i)
   End If
  End If
  JustStarted = False
 End If
Next i

'Force sell on the last day (if we still have position)
If AllTrade > 0 Then
 If TradeRecord(AllTrade) < 0 Then 'Your last trade is BUY, i.e. you have a long position need to close
out
  TradePos(1) = Price(1) * 1 * (1 - Cost(1 + 2) * 1) 'in this formula, 1 = the signal generate by a sell
decision
  AllTrade = AllTrade + 1
  TradeRecord(AllTrade) = TradePos(1) 'complete the record of this final force deal
  TradeDate(AllTrade) = PDate(1)
 End If
End If
```

```
'we are sure now AllTrade will be an even number

RoundTrip = AllTrade / 2  'the number of complete BUY and SELL transactions

CompoundedReturn = 1
For i = 1 To RoundTrip   'Count Profit/Loss for each round trip
  TradePL(i, 1) = TradeRecord(i * 2) + TradeRecord(i * 2 - 1)
  TradePL(i, 2) = TradePL(i, 1) / (-TradeRecord(i * 2 - 1))
  TradePL(i, 3) = TradeDate(i * 2) - TradeDate(i * 2 - 1)
  CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
Next i
CompoundedReturn = CompoundedReturn - 1

WinDeal = 0
LossDeal = 0
WinAvgPct = 0
LossAvgPct = 0
WinAvgDay = 0
LossAvgDay = 0

For i = 1 To RoundTrip
  If TradePL(i, 1) > 0 Then 'a deal with profit
     WinDeal = WinDeal + 1
     WinAvgPct = WinAvgPct + TradePL(i, 2)
     WinAvgDay = WinAvgDay + TradePL(i, 3)
  End If
  If TradePL(i, 1) < 0 Then 'a deal with loss
     LossDeal = LossDeal + 1
     LossAvgPct = LossAvgPct + TradePL(i, 2)
     LossAvgDay = LossAvgDay + TradePL(i, 3)
  End If
Next i
If WinDeal > 0 Then
  WinAvgPct = WinAvgPct / WinDeal
  WinAvgDay = WinAvgDay / WinDeal
End If

If LossDeal > 0 Then
  LossAvgPct = LossAvgPct / LossDeal
  LossAvgDay = LossAvgDay / LossDeal
End If

'Output trading position to Sheet1

Sheet1.Cells(2, 8) = WinDeal
Sheet1.Cells(3, 8) = LossDeal
Sheet1.Cells(4, 8) = RoundTrip - WinDeal - LossDeal
Sheet1.Cells(5, 8) = RoundTrip

Sheet1.Cells(2, 9) = WinAvgPct
Sheet1.Cells(3, 9) = LossAvgPct
Sheet1.Cells(4, 9) = 0
Sheet1.Cells(5, 9) = 0
If RoundTrip > 0 Then Sheet1.Cells(5, 9) = (WinDeal * WinAvgPct + LossDeal * LossAvgPct) /
RoundTrip
Sheet1.Cells(6, 9) = CompoundedReturn
```

```
Sheet1.Cells(2, 10) = WinAvgDay
Sheet1.Cells(3, 10) = LossAvgDay

If Sheet1.ToggleButton6.Caption = "OFF" Then Exit Sub

For i = 1 To AllTrade  'display a continuous list of trading history
  Sheet1.Cells(i + 9, 8) = TradeRecord(AllTrade - i + 1) 'start from the last entry
  Sheet1.Cells(i + 9, 7) = TradeDate(AllTrade - i + 1)
Next i

For i = 1 To RoundTrip 'display profit/loss for each round trip
  Sheet1.Cells(i * 2 + 8, 9) = TradePL(RoundTrip - i + 1, 1) 'start from the last entry
  Sheet1.Cells(i * 2 + 8, 10) = TradePL(RoundTrip - i + 1, 2) ' profit/loss in terms of %
Next i

End Sub
```

MACDtrading2

```
Sub MACDtrading2()
'Trade Stragegy 2 starts here

Dim i As Integer

Dim JustStarted As Boolean
Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 3) As Single 'Profit/Loss for a round trip (1:amount 2: percentage 3:days)
Dim TradeDate(MaxTrades) As Date
'Dim TradeTrigger(MaxTrades) As Single '[TEST] to observe the magnitude of Trigger (definition see
MACDR2)
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be only 1 less than AllTrade
Dim WinDeal As Integer
Dim LossDeal As Integer
Dim WinAvgPct As Single 'average percentage in a winning deal
Dim LossAvgPct As Single
Dim WinAvgDay As Single
Dim LossAvgDay As Single
Dim CompoundedReturn As Double

If TotalDay = 0 Or Sheet1.ToggleButton2.Caption = "OFF" Then Exit Sub

JustStarted = True
AllTrade = 0

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL
'no need to define Cost(2)

'Buy and sell based on the signal we stored in Trading( )
'Here we allow either long or short position
For i = AllSigl - 1 To 2 Step -1  'skip the final day (i=1) and deal with it later
  If Trading(i) <> 0 Then
    If JustStarted Then 'very first trade - for one unit only, no matter long or short
```

```
    TradePos(i) = Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i))
    AllTrade = AllTrade + 1
    TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
    TradeDate(AllTrade) = PDate(i)
    'TradeTrigger(AllTrade) = -Trading(i) * (MACD(i) - Signal(i)) / Price(i)       '[TEST]
   Else
    TradePos(i) = 2 * (Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i)))
    'double in order to close out original position and simultaneously open new position
    AllTrade = AllTrade + 1
    TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
    TradeDate(AllTrade) = PDate(i)
    'TradeTrigger(AllTrade) = -Trading(i) * (MACD(i) - Signal(i)) / Price(i)       '[TEST]
   End If
   JustStarted = False
  End If
Next i

'Force close out existing position on the last day. Unless no trade at all, we must have position before the
last day
If AllTrade > 0 Then

  If TradeRecord(AllTrade) < 0 Then 'Your last trade is BUY, i.e. you have a long position need to close
out
    TradePos(1) = Price(1) * 1 * (1 - Cost(1 + 2) * 1) 'in this formula, 1 = the signal generate by a sell
decision
  Else  'Your last trade is SELL, i.e. you have a short position need to close out
    TradePos(1) = Price(1) * (-1) * (1 - Cost(-1 + 2) * (-1)) 'in this formula, -1 = the signal generate by a buy
decision
  End If

  AllTrade = AllTrade + 1
  TradeRecord(AllTrade) = TradePos(1) 'complete the record of this final force deal
  TradeDate(AllTrade) = PDate(1)

  RoundTrip = AllTrade - 1 'the number of complete BUY and SELL transactions
  CompoundedReturn = 1

  If RoundTrip = 1 Then
    i = 1 'special process for the only trade
    TradePL(i, 1) = TradeRecord(i + 1) + TradeRecord(i)
    TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i))
    TradePL(i, 3) = TradeDate(i + 1) - TradeDate(i)
    CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
  Else
    i = 1 'special process for 1st trade
    TradePL(i, 1) = TradeRecord(i + 1) / 2 + TradeRecord(i)
    TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i))
    TradePL(i, 3) = TradeDate(i + 1) - TradeDate(i)
    CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))

    i = RoundTrip 'special process for last trade
    TradePL(i, 1) = TradeRecord(i + 1) + TradeRecord(i) / 2
    TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i) / 2)
    TradePL(i, 3) = TradeDate(i + 1) - TradeDate(i)
```

```
    CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))

    For i = 2 To RoundTrip - 1 'Count Profit/Loss for the rest round trips
      TradePL(i, 1) = TradeRecord(i + 1) / 2 + TradeRecord(i) / 2
      TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i) / 2)
      TradePL(i, 3) = TradeDate(i + 1) - TradeDate(i)
      CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
    Next i
  End If
  CompoundedReturn = CompoundedReturn - 1

End If

WinDeal = 0
LossDeal = 0
WinAvgPct = 0
LossAvgPct = 0
WinAvgDay = 0
LossAvgDay = 0

For i = 1 To RoundTrip
  If TradePL(i, 1) > 0 Then 'a deal with profit
     WinDeal = WinDeal + 1
     WinAvgPct = WinAvgPct + TradePL(i, 2)
     WinAvgDay = WinAvgDay + TradePL(i, 3)
  End If
  If TradePL(i, 1) < 0 Then 'a deal with loss
     LossDeal = LossDeal + 1
     LossAvgPct = LossAvgPct + TradePL(i, 2)
     LossAvgDay = LossAvgDay + TradePL(i, 3)
  End If
Next i

If WinDeal > 0 Then
  WinAvgPct = WinAvgPct / WinDeal
  WinAvgDay = WinAvgDay / WinDeal
End If

If LossDeal > 0 Then
  LossAvgPct = LossAvgPct / LossDeal
  LossAvgDay = LossAvgDay / LossDeal
End If

'Output trading position to Sheet1

Sheet1.Cells(2, 12) = WinDeal
Sheet1.Cells(3, 12) = LossDeal
Sheet1.Cells(4, 12) = RoundTrip - WinDeal - LossDeal
Sheet1.Cells(5, 12) = RoundTrip

Sheet1.Cells(2, 13) = WinAvgPct
Sheet1.Cells(3, 13) = LossAvgPct
Sheet1.Cells(4, 13) = 0
Sheet1.Cells(5, 13) = 0
If RoundTrip > 0 Then Sheet1.Cells(5, 13) = (WinDeal * WinAvgPct + LossDeal * LossAvgPct) /
RoundTrip
```

```
Sheet1.Cells(6, 13) = CompoundedReturn

Sheet1.Cells(2, 14) = WinAvgDay
Sheet1.Cells(3, 14) = LossAvgDay

If Sheet1.ToggleButton6.Caption = "OFF" Then Exit Sub

For i = 1 To AllTrade  'display a continuous list of trading history
  Sheet1.Cells(i + 9, 12) = TradeRecord(AllTrade - i + 1) 'start from the last entry
  Sheet1.Cells(i + 9, 11) = TradeDate(AllTrade - i + 1)

Next i

For i = 1 To RoundTrip 'display profit/loss for each round trip
  Sheet1.Cells(i + 9, 13) = TradePL(RoundTrip - i + 1, 1)  'start from the last entry
  Sheet1.Cells(i + 9, 14) = TradePL(RoundTrip - i + 1, 2) ' profit/loss in terms of %
  'Sheet1.Cells(i + 10, 13) = 1 + TradeTrigger(RoundTrip - i + 1) '[TEST] has to turn off p/l output
Next i

End Sub
```

MACDR2trading

```
Sub MACDR2trading()

Dim i As Integer

Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 3) As Single 'Profit/Loss for a round trip (1:amount 2: percentage 3: days)
Dim TradeDate(MaxTrades) As Date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade (like strategy 1)
Dim WinDeal As Integer
Dim LossDeal As Integer
Dim WinAvgPct As Single 'average percentage in a winning deal
Dim LossAvgPct As Single
Dim WinAvgDay As Single
Dim LossAvgDay As Single
Dim CompoundedReturn As Double

Dim DayDelay As Byte '=3 in standard MACDR2
Dim Trigger As Single
Dim Target As Single
Dim TargetReached As Boolean 'true if it's time to take profit or stop loss
Dim TradeNow As Boolean
Dim CurrentPos As Single
Dim CurrentTrade As Integer 'same value as in Trading( ), only have +1,  -1, or 0
Dim ClosingTrade As Integer
Dim Profit As Single

If TotalDay = 0 Or Sheet1.ToggleButton3.Caption = "OFF" Then Exit Sub

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL
'no need to define Cost(2)
```

```
DayDelay = Sheet1.Cells(7, 18) '3 for standard MACDR2, 0 for Strategy2 (when Trigger=0, Target=no limit, such as 99%)
Trigger = Sheet1.Cells(8, 16) 'Trade trigger level (for example 1%)
Target = Sheet1.Cells(8, 18) ' Trade profit target level (for example 3%)

AllTrade = 0
CurrentPos = 0
CurrentTrade = 0

For i = AllSigl - 1 - DayDelay To 2 Step -1

 'the 1st possible MACD trading signal will start from Trading(AllSigl-1)
 'first possible trading will be 3(=DayDelay) days after seeing that signal
 'therefore the starting point is AllSigl-4
 'since we will close out position on the last day, we will process the last day separately

 TradeNow = False 'should we do trade today?

 If Trading(i + DayDelay) <> 0 Then 'There's MACD trading signal 3(=DayDelay) days ago
  If -Trading(i + DayDelay) * (MACD(i) - Signal(i)) / Price(i) >= Trigger Then TradeNow = True
  '3 days later the gap between MACD and Signal is large enough
 End If

 If TradeNow = True Then
  If Not (CurrentTrade = Trading(i + DayDelay)) Then 'do nothing if the signal is identical to the existing position

    If CurrentTrade <> 0 Then 'new trade certainly has different signal versus existing position
     'close out existing position
     ClosingTrade = -CurrentTrade
     TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
     AllTrade = AllTrade + 1
     TradeRecord(AllTrade) = TradePos(i)
     TradeDate(AllTrade) = PDate(i)
    End If
    'no need to worry any pending position now

    'open new position here
    TradePos(i) = TradePos(i) + Price(i) * Trading(i + DayDelay) * (1 - Cost(Trading(i + DayDelay) + 2) * Trading(i + DayDelay))
    'in case we have a close out deal and a new trade in same day, TradePos( ) will record total amount

    AllTrade = AllTrade + 1
    TradeRecord(AllTrade) = Price(i) * Trading(i + DayDelay) * (1 - Cost(Trading(i + DayDelay) + 2) * Trading(i + DayDelay))
    'record new trade amount (while TradePos(i) might accumulate 2 same way trades in same day)
    TradeDate(AllTrade) = PDate(i)

    CurrentPos = TradeRecord(AllTrade)
    CurrentTrade = Trading(i + DayDelay)
  End If 'Not (CurrentTrade = trade(i + DayDelay))

 Else 'no new trade for this day

  If CurrentTrade <> 0 Then 'is it time for profit-taking or cutting-loss?
```

```
    ClosingTrade = -CurrentTrade
    Profit = CurrentPos + ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
    Profit = Profit / Abs(CurrentPos) 'convert into %
    TargetReached = False
    If Profit > 0 And Target > 0 And Profit >= Target Then TargetReached = True 'confirm to take profit
    If Profit < 0 And Target < 0 And Profit <= Target Then TargetReached = True 'confirm to stop loss
    If TargetReached Or Trading(i) = ClosingTrade Then 'close out because of (1) TakeProfit or StopLoss,
(2) MACD signal said so
      TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
      AllTrade = AllTrade + 1
      TradeRecord(AllTrade) = TradePos(i)
      TradeDate(AllTrade) = PDate(i)
      CurrentPos = 0
      CurrentTrade = 0
    End If
  End If

 End If 'TradeNow=True

Next i

'it's time to deal with the last working day
i = 1
If CurrentTrade <> 0 Then 'after running through the for-next loop, we still have position
 ClosingTrade = -CurrentTrade
 TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
 AllTrade = AllTrade + 1
 TradeRecord(AllTrade) = TradePos(i)
 TradeDate(AllTrade) = PDate(i)
 CurrentPos = 0 'in fact it won't do any harm if we don't reset them
 CurrentTrade = 0
End If

RoundTrip = AllTrade / 2

CompoundedReturn = 1
For i = 1 To RoundTrip   'Count Profit/Loss for each round trip
 TradePL(i, 1) = TradeRecord(i * 2) + TradeRecord(i * 2 - 1)
 TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i * 2 - 1))
 TradePL(i, 3) = TradeDate(i * 2) - TradeDate(i * 2 - 1)
 CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
Next i
CompoundedReturn = CompoundedReturn - 1

WinDeal = 0
LossDeal = 0
WinAvgPct = 0
LossAvgPct = 0
WinAvgDay = 0
LossAvgDay = 0

For i = 1 To RoundTrip
 If TradePL(i, 1) > 0 Then 'a deal with profit
    WinDeal = WinDeal + 1
    WinAvgPct = WinAvgPct + TradePL(i, 2)
    WinAvgDay = WinAvgDay + TradePL(i, 3)
```

```
  End If
  If TradePL(i, 1) < 0 Then 'a deal with loss
     LossDeal = LossDeal + 1
     LossAvgPct = LossAvgPct + TradePL(i, 2)
     LossAvgDay = LossAvgDay + TradePL(i, 3)
  End If
Next i

If WinDeal > 0 Then
  WinAvgPct = WinAvgPct / WinDeal
  WinAvgDay = WinAvgDay / WinDeal
End If

If LossDeal > 0 Then
  LossAvgPct = LossAvgPct / LossDeal
  LossAvgDay = LossAvgDay / LossDeal
End If

'Output trading position to Sheet1

Sheet1.Cells(2, 16) = WinDeal
Sheet1.Cells(3, 16) = LossDeal
Sheet1.Cells(4, 16) = RoundTrip - WinDeal - LossDeal
Sheet1.Cells(5, 16) = RoundTrip

Sheet1.Cells(2, 17) = WinAvgPct
Sheet1.Cells(3, 17) = LossAvgPct
Sheet1.Cells(4, 17) = 0
Sheet1.Cells(5, 17) = 0
If RoundTrip > 0 Then Sheet1.Cells(5, 17) = (WinDeal * WinAvgPct + LossDeal * LossAvgPct) /
RoundTrip

Sheet1.Cells(6, 17) = CompoundedReturn

Sheet1.Cells(2, 18) = WinAvgDay
Sheet1.Cells(3, 18) = LossAvgDay

If Sheet1.ToggleButton6.Caption = "OFF" Then Exit Sub

For i = 1 To AllTrade  'display a continuous list of trading history
  Sheet1.Cells(i + 9, 16) = TradeRecord(AllTrade - i + 1) 'start from the last entry
  Sheet1.Cells(i + 9, 15) = TradeDate(AllTrade - i + 1)
Next i

For i = 1 To RoundTrip 'display profit/loss for each round trip
  Sheet1.Cells(i * 2 + 8, 17) = TradePL(RoundTrip - i + 1, 1) 'start from the last entry
  Sheet1.Cells(i * 2 + 8, 18) = TradePL(RoundTrip - i + 1, 2) ' profit/loss in terms of %
Next i

End Sub
```

MACDtrading4

```
Sub MACDtrading4()
'Trade Stragegy 4 starts here (we don't use sub name MACDtrading3)
'Only short sell allowed
```

```
Dim i As Integer

Dim JustStarted As Boolean
Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 3) As Single 'Profit/Loss for a round trip (1:amount 2: percentage 3:days)
Dim TradeDate(MaxTrades) As Date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade
Dim WinDeal As Integer
Dim LossDeal As Integer
Dim WinAvgPct As Single 'average percentage in a winning deal
Dim LossAvgPct As Single
Dim WinAvgDay As Single
Dim LossAvgDay As Single
Dim CompoundedReturn As Double

If TotalDay = 0 Or Sheet1.ToggleButton4.Caption = "OFF" Then Exit Sub

JustStarted = True
AllTrade = 0

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL
'no need to define Cost(2)

'Buy and sell based on the signal we stored in Trading( )
'Here we only allow SHORT position, no long position allowed
For i = AllSigl - 1 To 1 Step -1
 If Trading(i) <> 0 Then
  If JustStarted And Trading(i) = -1 Then
   'do nothing because the 1st signal is a BUY
  Else
   If i = 1 And Trading(1) = 1 Then  'last day shows SELL signal => we won't allow this happen
    'do nothing (we are sure the last day will not have a SELL decision)
   Else
    TradePos(i) = Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i))
    AllTrade = AllTrade + 1
    TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
    TradeDate(AllTrade) = PDate(i)
   End If
  End If
  JustStarted = False
 End If
Next i

'Force buy on the last day (if we still have position)
If AllTrade > 0 Then
 If TradeRecord(AllTrade) > 0 Then 'Your last trade is SELL, i.e. you have a short position need to close
out
  TradePos(1) = Price(1) * (-1) * (1 - Cost((-1) + 2) * (-1)) 'in this formula, -1 = the signal generate by a
sell decision
  AllTrade = AllTrade + 1
  TradeRecord(AllTrade) = TradePos(1) 'complete the record of this final force deal
```

```
    TradeDate(AllTrade) = PDate(1)
  End If
End If
'we are sure now AllTrade will be an even number

RoundTrip = AllTrade / 2  'the number of complete BUY and SELL transactions

CompoundedReturn = 1
For i = 1 To RoundTrip   'Count Profit/Loss for each round trip
  TradePL(i, 1) = TradeRecord(i * 2) + TradeRecord(i * 2 - 1)
  TradePL(i, 2) = TradePL(i, 1) / TradeRecord(i * 2 - 1) 'denominator is always positive
  TradePL(i, 3) = TradeDate(i * 2) - TradeDate(i * 2 - 1)
  CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
Next i
CompoundedReturn = CompoundedReturn - 1

WinDeal = 0
LossDeal = 0
WinAvgPct = 0
LossAvgPct = 0
WinAvgDay = 0
LossAvgDay = 0

For i = 1 To RoundTrip
  If TradePL(i, 1) > 0 Then 'a deal with profit
     WinDeal = WinDeal + 1
     WinAvgPct = WinAvgPct + TradePL(i, 2)
     WinAvgDay = WinAvgDay + TradePL(i, 3)
  End If
  If TradePL(i, 1) < 0 Then 'a deal with loss
     LossDeal = LossDeal + 1
     LossAvgPct = LossAvgPct + TradePL(i, 2)
     LossAvgDay = LossAvgDay + TradePL(i, 3)
  End If
Next i
If WinDeal > 0 Then
  WinAvgPct = WinAvgPct / WinDeal
  WinAvgDay = WinAvgDay / WinDeal
End If

If LossDeal > 0 Then
  LossAvgPct = LossAvgPct / LossDeal
  LossAvgDay = LossAvgDay / LossDeal
End If

'Output trading position to Sheet1

Sheet1.Cells(2, 20) = WinDeal
Sheet1.Cells(3, 20) = LossDeal
Sheet1.Cells(4, 20) = RoundTrip - WinDeal - LossDeal
Sheet1.Cells(5, 20) = RoundTrip

Sheet1.Cells(2, 21) = WinAvgPct
Sheet1.Cells(3, 21) = LossAvgPct
Sheet1.Cells(4, 21) = 0
Sheet1.Cells(5, 21) = 0
```

```
If RoundTrip > 0 Then Sheet1.Cells(5, 21) = (WinDeal * WinAvgPct + LossDeal * LossAvgPct) /
RoundTrip
Sheet1.Cells(6, 21) = CompoundedReturn

Sheet1.Cells(2, 22) = WinAvgDay
Sheet1.Cells(3, 22) = LossAvgDay

If Sheet1.ToggleButton6.Caption = "OFF" Then Exit Sub

For i = 1 To AllTrade  'display a continuous list of trading history
  Sheet1.Cells(i + 9, 20) = TradeRecord(AllTrade - i + 1) 'start from the last entry
  Sheet1.Cells(i + 9, 19) = TradeDate(AllTrade - i + 1)
Next i

For i = 1 To RoundTrip 'display profit/loss for each round trip
  Sheet1.Cells(i * 2 + 8, 21) = TradePL(RoundTrip - i + 1, 1) 'start from the last entry
  Sheet1.Cells(i * 2 + 8, 22) = TradePL(RoundTrip - i + 1, 2) ' profit/loss in terms of %
Next i

End Sub
```

Optimizer1

```
Sub Optimizer1()
'Find the best combination of EMA1, EMA2, and Signal for Strategy1
'use same code as in MACDinitiate, MACDtradingsignal, MACDtrading1

If CopyPriceOK = False Then Call CopyPrice

Dim i As Integer
Dim j As Long 'output pointer

Dim MaxEMA1 As Integer 'Max EMA1
Dim MaxEMA2 As Integer 'Max EMA2
Dim MaxSigl As Integer 'Max Signal

Dim Avg As Single
Dim Power As Integer
Dim Alpha As Single
Dim Denominator As Single
Dim EMA1 As Integer
Dim EMA2 As Integer
Dim Sigl As Integer

Dim JustStarted As Boolean
Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 2) As Single 'Profit/Loss for a round trip (1:amount 2: percentage) .. don't need
3: date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade
Dim CompoundedReturn As Double 'To search for MACD parameters that maximize this value
Dim MaxPL As Double

Dim NearDay As Integer  'The day range for optimizer to work
Dim FarDay As Integer
```

```
TotalDay = Sheet1.Cells(4, 2)
If TotalDay = 0 Then Exit Sub

If LearningMode = True Then 'Learning mode only require optimizer to work on a specific time period
  NearDay = LearnDay1
  FarDay = LearnDay2
Else  'By default, optimizer will go through the whole time period
  NearDay = 1
  FarDay = TotalDay
End If
'Once the Learning Mode is on, AllMACD and AllSigl no longer stand for the whole time period

MaxEMA2 = Sheet1.Cells(3, 24)
MaxEMA1 = MaxEMA2 - 1
MaxSigl = Sheet1.Cells(4, 24)

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL

j = 0 'counter for displaying all combinations
MaxPL = -999

'Total loops = MaxEMA2 * (MaxEMA2 - 1) / 2 * (MaxSigl - 1)
For EMA1 = 1 To MaxEMA1
  For EMA2 = EMA1 + 1 To MaxEMA2
    For Sigl = 2 To MaxSigl

      'These must reset first, or they will keep filling more and more entries
      Erase Trading
      Erase TradePos

      Avg = 0
      Alpha = 2 / (1 + EMA1)
      Power = 0
      Denominator = 0
      For i = FarDay - EMA1 + 1 To FarDay 'to get initial EMA1
        Avg = Avg + Price(i) * (1 - Alpha) ^ Power
        Denominator = Denominator + (1 - Alpha) ^ Power
        Power = Power + 1
      Next i
      Avg = Avg / Denominator
      EMA(FarDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
      For i = FarDay - EMA1 To NearDay Step -1 'fill the rest EMA1
        EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
      Next i

      Avg = 0
      Alpha = 2 / (1 + EMA2)
      Power = 0
      Denominator = 0
      For i = FarDay - EMA2 + 1 To FarDay 'to get initial EMA2
        Avg = Avg + Price(i) * (1 - Alpha) ^ Power
        Denominator = Denominator + (1 - Alpha) ^ Power
        Power = Power + 1
      Next i
```

```
    Avg = Avg / Denominator
    EMA(FarDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
    For i = FarDay - EMA2 To NearDay Step -1 'fill the rest EMA2
      EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
    Next i

    AllMACD = FarDay - EMA2 + 1

    For i = NearDay To AllMACD
      MACD(i) = EMA(i, 1) - EMA(i, 2)
    Next i

    'Signal = EMA of MACD
    Avg = 0
    Alpha = 2 / (1 + Sigl)
    Power = 0
    Denominator = 0
    For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
      Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
      Denominator = Denominator + (1 - Alpha) ^ Power
      Power = Power + 1
    Next i
    Avg = Avg / Denominator

    AllSigl = AllMACD - Sigl + 1
    Signal(AllSigl) = Avg 'first Signal

    For i = AllSigl - 1 To NearDay Step -1 'fill the rest Signal
      Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
    Next i

    For i = AllSigl - 1 To NearDay Step -1
      If MACD(i) > Signal(i) Then
        If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
      ElseIf MACD(i) < Signal(i) Then
        If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
      End If
    Next i

    JustStarted = True 'Strategy1 starts here (no need to record TradeDate)
    AllTrade = 0

    'Buy and sell based on the signal we stored in Trading( )
    'Here we only allow long position, no short sell allowed
    For i = AllSigl - 1 To NearDay Step -1
      If Trading(i) <> 0 Then
        If JustStarted And Trading(i) = 1 Then
          'do nothing because the 1st signal is a SELL (don't allow short selling)
        Else
          If i = NearDay And Trading(NearDay) = -1 Then 'last day shows BUY signal => we won't allow
this happen
            'do nothing (we are sure the last day will not have a BUY decision)
          Else
            TradePos(i) = Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i))
```

```
          AllTrade = AllTrade + 1
          TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
        End If
       End If
       JustStarted = False
      End If
    Next i

    'Force sell on the last day (if we still have position)
    If AllTrade > 0 Then
     If TradeRecord(AllTrade) < 0 Then 'Your last trade is BUY, i.e. you have a long position need to
close out
      TradePos(NearDay) = Price(NearDay) * 1 * (1 - Cost(1 + 2) * 1) 'in this formula, 1 = the signal
generate by a sell decision
      AllTrade = AllTrade + 1
      TradeRecord(AllTrade) = TradePos(NearDay) 'complete the record of this final force deal
     End If
    End If
    'we are sure now AllTrade will be an even number

    RoundTrip = AllTrade / 2  'the number of complete BUY and SELL transactions

    CompoundedReturn = 1
    For i = 1 To RoundTrip   'Count Profit/Loss for each round trip
     TradePL(i, 1) = TradeRecord(i * 2) + TradeRecord(i * 2 - 1)
     TradePL(i, 2) = TradePL(i, 1) / (-TradeRecord(i * 2 - 1))
     CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
    Next i
    CompoundedReturn = CompoundedReturn - 1

    'Output to Sheet1
    If CompoundedReturn > MaxPL Then 'keep updating the best solution
     MaxPL = CompoundedReturn
     Sheet1.Cells(9, 23) = EMA1
     Sheet1.Cells(9, 24) = EMA2
     Sheet1.Cells(9, 25) = Sigl
     Sheet1.Cells(9, 26) = MaxPL
     Optimized(1) = EMA1 'stored in public variables for further usage in Learning()
     Optimized(2) = EMA2
     Optimized(3) = Sigl
     OptimizedRtn = MaxPL
    End If

    If Sheet1.ToggleButton5.Caption = "ON" And j <= 65526 Then 'output should not exceed Excel row
65536
     j = j + 1
     Sheet1.Cells(j + 9, 23) = EMA1
     Sheet1.Cells(j + 9, 24) = EMA2
     Sheet1.Cells(j + 9, 25) = Sigl
     Sheet1.Cells(j + 8, 26) = CompoundedReturn
    End If

   Next Sigl
  Next EMA2
Next EMA1
```

```
End Sub
```

Optimizer2

```
Sub Optimizer2()
'Find the best combination of EMA1, EMA2, and Signal for Strategy2
'The code in this sub is highly similar to Optimizer1

If CopyPriceOK = False Then Call CopyPrice

Dim i As Integer
Dim j As Long 'output pointer

Dim MaxEMA1 As Integer 'Max EMA1
Dim MaxEMA2 As Integer 'Max EMA2
Dim MaxSigl As Integer 'Max Signal

Dim Avg As Single
Dim Power As Integer
Dim Alpha As Single
Dim Denominator As Single
Dim EMA1 As Integer
Dim EMA2 As Integer
Dim Sigl As Integer

Dim JustStarted As Boolean
Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 2) As Single 'Profit/Loss for a round trip (1:amount 2: percentage) .. don't need
3: date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade
Dim CompoundedReturn As Double 'To search for MACD parameters that maximize this value
Dim MaxPL As Double

Dim NearDay As Integer  'The day range for optimizer to work
Dim FarDay As Integer

TotalDay = Sheet1.Cells(4, 2)
If TotalDay = 0 Then Exit Sub

If LearningMode = True Then 'Learning mode only require optimizer to work on a specific time period
  NearDay = LearnDay1
  FarDay = LearnDay2
Else  'By default, optimizer will go through the whole time period
  NearDay = 1
  FarDay = TotalDay
End If
'Once the Learning Mode is on, AllMACD and AllSigl no longer stand for the whole time period

MaxEMA2 = Sheet1.Cells(3, 24)
MaxEMA1 = MaxEMA2 - 1
MaxSigl = Sheet1.Cells(4, 24)

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
```

```
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL

j = 0 'counter for displaying all combinations
MaxPL = -999

'Total loops = MaxEMA2 * (MaxEMA2 - 1) / 2 * (MaxSigl - 1)
For EMA1 = 1 To MaxEMA1
  For EMA2 = EMA1 + 1 To MaxEMA2
    For Sigl = 2 To MaxSigl

      'These must reset first, or they will keep filling more and more entries
      Erase Trading
      Erase TradePos

      Avg = 0
      Alpha = 2 / (1 + EMA1)
      Power = 0
      Denominator = 0
      For i = FarDay - EMA1 + 1 To FarDay 'to get initial EMA1
        Avg = Avg + Price(i) * (1 - Alpha) ^ Power
        Denominator = Denominator + (1 - Alpha) ^ Power
        Power = Power + 1
      Next i
      Avg = Avg / Denominator
      EMA(FarDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
      For i = FarDay - EMA1 To NearDay Step -1 'fill the rest EMA1
        EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
      Next i

      Avg = 0
      Alpha = 2 / (1 + EMA2)
      Power = 0
      Denominator = 0
      For i = FarDay - EMA2 + 1 To FarDay 'to get initial EMA2
        Avg = Avg + Price(i) * (1 - Alpha) ^ Power
        Denominator = Denominator + (1 - Alpha) ^ Power
        Power = Power + 1
      Next i
      Avg = Avg / Denominator
      EMA(FarDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
      For i = FarDay - EMA2 To NearDay Step -1 'fill the rest EMA2
        EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
      Next i

      AllMACD = FarDay - EMA2 + 1

      For i = NearDay To AllMACD
        MACD(i) = EMA(i, 1) - EMA(i, 2)
      Next i

      'Signal = EMA of MACD
      Avg = 0
      Alpha = 2 / (1 + Sigl)
      Power = 0
      Denominator = 0
      For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
```

```
    Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
    Denominator = Denominator + (1 - Alpha) ^ Power
    Power = Power + 1
  Next i
  Avg = Avg / Denominator

  AllSigl = AllMACD - Sigl + 1
  Signal(AllSigl) = Avg 'first Signal

  For i = AllSigl - 1 To NearDay Step -1 'fill the rest Signal
    Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
  Next i

  For i = AllSigl - 1 To NearDay Step -1
    If MACD(i) > Signal(i) Then
      If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
    ElseIf MACD(i) < Signal(i) Then
      If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
    End If
  Next i

  JustStarted = True 'Strategy2 starts here (no need to record TradeDate)
  AllTrade = 0

  'Buy and sell based on the signal we stored in Trading( )
  'Here we allow either long or short position
  For i = AllSigl - 1 To NearDay + 1 Step -1 'skip the final day (i=1 or NearDay) and deal with it later
    If Trading(i) <> 0 Then
      If JustStarted Then 'very first trade - for one unit only, no matter long or short
        TradePos(i) = Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i))
        AllTrade = AllTrade + 1
        TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
      Else
        TradePos(i) = 2 * (Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i)))
        'double in order to close out original position and simultaneously open new position
        AllTrade = AllTrade + 1
        TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
      End If
      JustStarted = False
    End If
  Next i

  'Force close out existing position on the last day (It is certain that we still have position before the last
day)
  If AllTrade > 0 Then

    If TradeRecord(AllTrade) < 0 Then 'Your last trade is BUY, i.e. you have a long position need to
close out
      TradePos(NearDay) = Price(NearDay) * 1 * (1 - Cost(1 + 2) * 1) 'in this formula, 1 = the signal
generate by a sell decision
    Else  'Your last trade is SELL, i.e. you have a short position need to close out
```

```
      TradePos(NearDay) = Price(NearDay) * (-1) * (1 - Cost(-1 + 2) * (-1)) 'in this formula, -1 = the
signal generate by a buy decision
    End If

    AllTrade = AllTrade + 1
    TradeRecord(AllTrade) = TradePos(NearDay) 'complete the record of this final force deal

    RoundTrip = AllTrade - 1 'the number of complete BUY and SELL transactions

    CompoundedReturn = 1

    If RoundTrip = 1 Then
     i = 1 'special process for the only trade
     TradePL(i, 1) = TradeRecord(i + 1) + TradeRecord(i)
     TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i))
     CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
    Else
     i = 1 'special process for 1st trade
     TradePL(i, 1) = TradeRecord(i + 1) / 2 + TradeRecord(i)
     TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i))
     CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))

     i = RoundTrip 'special process for last trade
     TradePL(i, 1) = TradeRecord(i + 1) + TradeRecord(i) / 2
     TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i) / 2)
     CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))

     For i = 2 To RoundTrip - 1 'Count Profit/Loss for the rest round trips
      TradePL(i, 1) = TradeRecord(i + 1) / 2 + TradeRecord(i) / 2
      TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i) / 2)
      CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
     Next i
    End If
    CompoundedReturn = CompoundedReturn - 1

   End If

   'Output to Sheet1

   If CompoundedReturn > MaxPL Then
    MaxPL = CompoundedReturn
    Sheet1.Cells(9, 23) = EMA1
    Sheet1.Cells(9, 24) = EMA2
    Sheet1.Cells(9, 25) = Sigl
    Sheet1.Cells(9, 26) = MaxPL
    Optimized(1) = EMA1 'stored in public variables for further usage in Learning()
    Optimized(2) = EMA2
    Optimized(3) = Sigl
    OptimizedRtn = MaxPL
   End If

   If Sheet1.ToggleButton5.Caption = "ON" And j <= 65526 Then 'output should not exceed Excel row
65536
    j = j + 1
    Sheet1.Cells(j + 9, 23) = EMA1
    Sheet1.Cells(j + 9, 24) = EMA2
```

```
      Sheet1.Cells(j + 9, 25) = Sigl
      Sheet1.Cells(j + 9, 26) = CompoundedReturn
    End If

  Next Sigl
 Next EMA2
Next EMA1

End Sub
```

Optimizer3

```
Sub Optimizer3()
'Find the best combination of EMA1, EMA2, and Signal for MACDR2
'The code in this sub is modified from Optimizer2

If CopyPriceOK = False Then Call CopyPrice

Dim i As Integer
Dim j As Long 'output pointer


Dim MaxEMA1 As Integer 'Max EMA1
Dim MaxEMA2 As Integer 'Max EMA2
Dim MaxSigl As Integer 'Max Signal

Dim Avg As Single
Dim Power As Integer
Dim Alpha As Single
Dim Denominator As Single
Dim EMA1 As Integer
Dim EMA2 As Integer
Dim Sigl As Integer

Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 2) As Single 'Profit/Loss for a round trip (1:amount 2: percentage) .. don't need
3: date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade
Dim CompoundedReturn As Double 'To search for MACD parameters that maximize this value
Dim MaxPL As Double

Dim DayDelay As Byte '=3 in standard MACDR2
Dim Trigger As Single
Dim Target As Single
Dim TargetReached As Boolean 'true if it's time to take profit or stop loss
Dim TradeNow As Boolean
Dim CurrentPos As Single
Dim CurrentTrade As Integer 'same value as in Trading( ), only have +1,  -1, or 0
Dim ClosingTrade As Integer
Dim Profit As Single

Dim NearDay As Integer  'The day range for optimizer to work
Dim FarDay As Integer
```

```
TotalDay = Sheet1.Cells(4, 2)
If TotalDay = 0 Then Exit Sub

If LearningMode = True Then 'Learning mode only require optimizer to work on a specific time period
  NearDay = LearnDay1
  FarDay = LearnDay2
Else  'By default, optimizer will go through the whole time period
  NearDay = 1
  FarDay = TotalDay
End If
'Once the Learning Mode is on, AllMACD and AllSigl no longer stand for the whole time period

MaxEMA2 = Sheet1.Cells(3, 24)
MaxEMA1 = MaxEMA2 - 1
MaxSigl = Sheet1.Cells(4, 24)

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL

'DayDelay = Sheet1.Cells(7, 18) '3 for standard MACDR2, 0 for Strategy2 (when Trigger=0, Target=no
limit, such as 99%)
'Trigger = Sheet1.Cells(8, 16) 'Trade trigger level (for example 1%)
'Target = Sheet1.Cells(8, 18) ' Trade profit target level (for example 3%)

Dim DayDelay1 As Integer
Dim DayDelay2 As Integer
Dim DayDelayStep As Integer
Dim Trigger1 As Single
Dim Trigger2 As Single
Dim TriggerStep As Single
Dim Target1 As Single
Dim Target2 As Single
Dim TargetStep As Single

DayDelay1 = Sheet1.Cells(2, 28)
DayDelay2 = Sheet1.Cells(2, 29)
DayDelayStep = Sheet1.Cells(2, 30)
Trigger1 = Sheet1.Cells(3, 28)
Trigger2 = Sheet1.Cells(3, 29)
TriggerStep = Sheet1.Cells(3, 30)
Target1 = Sheet1.Cells(4, 28)
Target2 = Sheet1.Cells(4, 29)
TargetStep = Sheet1.Cells(4, 30)

j = 0 'counter for displaying all combinations
MaxPL = -999

'Total loops = MaxEMA2 * (MaxEMA2 - 1) / 2 * (MaxSigl - 1)
For EMA1 = 1 To MaxEMA1
 For EMA2 = EMA1 + 1 To MaxEMA2
  For Sigl = 2 To MaxSigl
   For DayDelay = DayDelay1 To DayDelay2 Step DayDelayStep
    For Trigger = Trigger1 To Trigger2 Step TriggerStep
     For Target = Target1 To Target2 Step TargetStep

      'These must reset first, or they will keep filling more and more entries
```

```
Erase Trading
Erase TradePos

Avg = 0
Alpha = 2 / (1 + EMA1)
Power = 0
Denominator = 0
For i = FarDay - EMA1 + 1 To FarDay 'to get initial EMA1
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
For i = FarDay - EMA1 To NearDay Step -1 'fill the rest EMA1
  EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
Next i

Avg = 0
Alpha = 2 / (1 + EMA2)
Power = 0
Denominator = 0
For i = FarDay - EMA2 + 1 To FarDay 'to get initial EMA2
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
For i = FarDay - EMA2 To NearDay Step -1 'fill the rest EMA2
  EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
Next i

AllMACD = FarDay - EMA2 + 1

For i = NearDay To AllMACD
  MACD(i) = EMA(i, 1) - EMA(i, 2)
Next i

'Signal = EMA of MACD
Avg = 0
Alpha = 2 / (1 + Sigl)
Power = 0
Denominator = 0
For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
  Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator

AllSigl = AllMACD - Sigl + 1
Signal(AllSigl) = Avg 'first Signal

For i = AllSigl - 1 To NearDay Step -1 'fill the rest Signal
  Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
```

```
    Next i

    For i = AllSigl - 1 To NearDay Step -1
      If MACD(i) > Signal(i) Then
        If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
      ElseIf MACD(i) < Signal(i) Then
        If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
      End If
    Next i

    AllTrade = 0
    CurrentPos = 0
    CurrentTrade = 0

    For i = AllSigl - 1 - DayDelay To NearDay + 1 Step -1 'skip the final day (i=1 or NearDay) and deal
with it later

      'the 1st possible MACD trading signal will start from Trading(AllSigl-1)
      'first possible trading will be 3(=DayDelay) days after seeing that signal
      'therefore the starting point is AllSigl-4
      'since we will close out position on the last day, we will process the last day separately

      TradeNow = False 'should we do trade today?

      If Trading(i + DayDelay) <> 0 Then 'There's MACD trading signal 3(=DayDelay) days ago
        If -Trading(i + DayDelay) * (MACD(i) - Signal(i)) / Price(i) >= Trigger Then TradeNow = True
        '3 days later the gap between MACD and Signal is large enough
      End If

      If TradeNow = True Then
        If Not (CurrentTrade = Trading(i + DayDelay)) Then 'do nothing if the signal is identical to the
existing position

          If CurrentTrade <> 0 Then 'new trade certainly has different signal versus existing position
            'close out existing position
            ClosingTrade = -CurrentTrade
            TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
            AllTrade = AllTrade + 1
            TradeRecord(AllTrade) = TradePos(i)
          End If
          'no need to worry any pending position now

          'open new position here
          TradePos(i) = TradePos(i) + Price(i) * Trading(i + DayDelay) * (1 - Cost(Trading(i + DayDelay) +
2) * Trading(i + DayDelay))
          'in case we have a close out deal and a new trade in same day, TradePos( ) will record total amount

          AllTrade = AllTrade + 1
          TradeRecord(AllTrade) = Price(i) * Trading(i + DayDelay) * (1 - Cost(Trading(i + DayDelay) + 2)
* Trading(i + DayDelay))
          'record new trade amount (while TradePos(i) might accumulate 2 same way trades in same day)

          CurrentPos = TradeRecord(AllTrade)
          CurrentTrade = Trading(i + DayDelay)
```

```
        End If 'Not (CurrentTrade = trade(i + DayDelay))

      Else 'no new trade for this day

        If CurrentTrade <> 0 Then 'is it time for profit-taking?
          ClosingTrade = -CurrentTrade
          Profit = CurrentPos + ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
          Profit = Profit / Abs(CurrentPos) 'convert into %
          TargetReached = False
          If Profit > 0 And Target > 0 And Profit >= Target Then TargetReached = True 'confirm to take
profit
          If Profit < 0 And Target < 0 And Profit <= Target Then TargetReached = True 'confirm to stop loss
          If TargetReached Or Trading(i) = ClosingTrade Then 'close out because of (1) TakeProfit or
StopLoss, (2) MACD signal said so
            TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
            AllTrade = AllTrade + 1
            TradeRecord(AllTrade) = TradePos(i)
            CurrentPos = 0
            CurrentTrade = 0
          End If
        End If

      End If 'TradeNow=True

    Next i

    i = NearDay  'to deal with the last working day
    If CurrentTrade <> 0 Then 'after running through the for-next loop, we still have position
      ClosingTrade = -CurrentTrade
      TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
      AllTrade = AllTrade + 1
      TradeRecord(AllTrade) = TradePos(i)
      CurrentPos = 0 'in fact it won't do any harm if we don't reset them
      CurrentTrade = 0
    End If

    RoundTrip = AllTrade / 2

    CompoundedReturn = 1
    For i = 1 To RoundTrip   'Count Profit/Loss for each round trip
      TradePL(i, 1) = TradeRecord(i * 2) + TradeRecord(i * 2 - 1)
      TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i * 2 - 1))
      CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
    Next i
    CompoundedReturn = CompoundedReturn - 1

    'Output to Sheet1

    If CompoundedReturn > MaxPL Then
      MaxPL = CompoundedReturn
      Sheet1.Cells(9, 23) = EMA1
      Sheet1.Cells(9, 24) = EMA2
      Sheet1.Cells(9, 25) = Sigl
      Sheet1.Cells(9, 26) = MaxPL
      Sheet1.Cells(9, 27) = DayDelay
      Sheet1.Cells(9, 28) = Trigger
```

```
        Sheet1.Cells(9, 29) = Target
        Optimized(1) = EMA1 'stored in public variables for further usage in Learning()
        Optimized(2) = EMA2
        Optimized(3) = Sigl
        Optimized(4) = DayDelay 'only for MACDR2
        Optimized(5) = Trigger 'only for MACDR2
        Optimized(6) = Target 'only for MACDR2
        OptimizedRtn = MaxPL
      End If

    If Sheet1.ToggleButton5.Caption = "ON" And j <= 65526 Then 'output should not exceed Excel row
65536
        j = j + 1
        Sheet1.Cells(j + 9, 23) = EMA1
        Sheet1.Cells(j + 9, 24) = EMA2
        Sheet1.Cells(j + 9, 25) = Sigl
        Sheet1.Cells(j + 9, 26) = CompoundedReturn
        Sheet1.Cells(j + 9, 27) = DayDelay
        Sheet1.Cells(j + 9, 28) = Trigger
        Sheet1.Cells(j + 9, 29) = Target
      End If

    Next Target
   Next Trigger
  Next DayDelay
 Next Sigl
Next EMA2
Next EMA1

End Sub
```

Optimizer4

```
Sub Optimizer4()
'Find the best combination of EMA1, EMA2, and Signal for Strategy4 (short only)
'use same code as in Optimizer1

If CopyPriceOK = False Then Call CopyPrice
'apply same arrangement in every optimizer even though Learnin() does not cite Optimizer4

Dim i As Integer
Dim j As Long 'output pointer

Dim MaxEMA1 As Integer 'Max EMA1
Dim MaxEMA2 As Integer 'Max EMA2
Dim MaxSigl As Integer 'Max Signal

Dim Avg As Single
Dim Power As Integer
Dim Alpha As Single
Dim Denominator As Single
Dim EMA1 As Integer
Dim EMA2 As Integer
Dim Sigl As Integer

Dim JustStarted As Boolean
Dim Cost(1 To 3) As Single
```

```
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 2) As Single 'Profit/Loss for a round trip (1:amount 2: percentage) .. don't need
3: date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade
Dim CompoundedReturn As Double 'To search for MACD parameters that maximize this value
Dim MaxPL As Double

TotalDay = Sheet1.Cells(4, 2)
If TotalDay = 0 Then Exit Sub

MaxEMA2 = Sheet1.Cells(3, 24)
MaxEMA1 = MaxEMA2 - 1
MaxSigl = Sheet1.Cells(4, 24)

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL

j = 0 'counter for displaying all combinations
MaxPL = -999

'Total loops = MaxEMA2 * (MaxEMA2 - 1) / 2 * (MaxSigl - 1)
For EMA1 = 1 To MaxEMA1
  For EMA2 = EMA1 + 1 To MaxEMA2
    For Sigl = 2 To MaxSigl

      'These must reset first, or they will keep filling more and more entries
      Erase Trading
      Erase TradePos

      Avg = 0
      Alpha = 2 / (1 + EMA1)
      Power = 0
      Denominator = 0
      For i = TotalDay - EMA1 + 1 To TotalDay 'to get initial EMA1
        Avg = Avg + Price(i) * (1 - Alpha) ^ Power
        Denominator = Denominator + (1 - Alpha) ^ Power
        Power = Power + 1
      Next i
      Avg = Avg / Denominator
      EMA(TotalDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
      For i = TotalDay - EMA1 To 1 Step -1 'fill the rest EMA1
        EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
      Next i

      Avg = 0
      Alpha = 2 / (1 + EMA2)
      Power = 0
      Denominator = 0
      For i = TotalDay - EMA2 + 1 To TotalDay 'to get initial EMA2
        Avg = Avg + Price(i) * (1 - Alpha) ^ Power
        Denominator = Denominator + (1 - Alpha) ^ Power
        Power = Power + 1
      Next i
      Avg = Avg / Denominator
```

```
EMA(TotalDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
For i = TotalDay - EMA2 To 1 Step -1 'fill the rest EMA2
  EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
Next i

AllMACD = TotalDay - EMA2 + 1

For i = 1 To AllMACD
  MACD(i) = EMA(i, 1) - EMA(i, 2)
Next i

'Signal = EMA of MACD
Avg = 0
Alpha = 2 / (1 + Sigl)
Power = 0
Denominator = 0
For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
  Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator

AllSigl = AllMACD - Sigl + 1
Signal(AllSigl) = Avg 'first Signal

For i = AllSigl - 1 To 1 Step -1 'fill the rest Signal
  Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
Next i

For i = AllSigl - 1 To 1 Step -1
  If MACD(i) > Signal(i) Then
    If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
  ElseIf MACD(i) < Signal(i) Then
    If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
  End If
Next i

JustStarted = True 'Strategy4 starts here (no need to record TradeDate)
AllTrade = 0

'Buy and sell based on the signal we stored in Trading( )
'Here we only allow SHORT position, no long position allowed
For i = AllSigl - 1 To 1 Step -1
  If Trading(i) <> 0 Then
    If JustStarted And Trading(i) = -1 Then
      'do nothing because the 1st signal is a BUY
    Else
      If i = 1 And Trading(1) = 1 Then 'last day shows SELL signal => we won't allow this happen
        'do nothing (we are sure the last day will not have a SELL decision)
      Else
        TradePos(i) = Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i))
        AllTrade = AllTrade + 1
```

```
        TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
         End If
        End If
        JustStarted = False
       End If
     Next i

     'Force buy on the last day (if we still have position)
     If AllTrade > 0 Then
      If TradeRecord(AllTrade) > 0 Then 'Your last trade is SELL, i.e. you have a short position need to
close out
        TradePos(1) = Price(1) * (-1) * (1 - Cost((-1) + 2) * (-1)) 'in this formula, -1 = the signal generate by
a sell decision
        AllTrade = AllTrade + 1
        TradeRecord(AllTrade) = TradePos(1) 'complete the record of this final force deal
       End If
     End If
     'we are sure now AllTrade will be an even number

     RoundTrip = AllTrade / 2  'the number of complete BUY and SELL transactions

     CompoundedReturn = 1
     For i = 1 To RoundTrip   'Count Profit/Loss for each round trip
      TradePL(i, 1) = TradeRecord(i * 2) + TradeRecord(i * 2 - 1)
      TradePL(i, 2) = TradePL(i, 1) / TradeRecord(i * 2 - 1) 'denominator is always positive
      CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
     Next i
     CompoundedReturn = CompoundedReturn - 1

     'Output to Sheet1
     If CompoundedReturn > MaxPL Then 'keep updating the best solution
      MaxPL = CompoundedReturn
      Sheet1.Cells(9, 23) = EMA1
      Sheet1.Cells(9, 24) = EMA2
      Sheet1.Cells(9, 25) = Sig1
      Sheet1.Cells(9, 26) = MaxPL
     End If

     If Sheet1.ToggleButton5.Caption = "ON" And j <= 65526 Then 'output should not exceed Excel row
65536
       j = j + 1
       Sheet1.Cells(j + 9, 23) = EMA1
       Sheet1.Cells(j + 9, 24) = EMA2
       Sheet1.Cells(j + 9, 25) = Sig1
       Sheet1.Cells(j + 9, 26) = CompoundedReturn
     End If

   Next Sig1
  Next EMA2
Next EMA1

End Sub
```

Learning

```
Sub Learning(WhichOne As Byte) 'Learn and trade, WhichOne=1 or 2 (Strategy1 or 2)

Dim i As Integer
Dim j As Integer
Dim CompoundedReturn As Double
Dim Cost(1 To 3) As Single
Dim Months(500) As Byte 'Trade days in each month
Dim Learn(500, 2) As Integer 'Schedule of each learning period 1:Last Day 2:First Day
Dim Apply(500, 2) As Integer 'Schedule of each applying period 1:Last Day 2:First Day
Dim ApplyRtn(500) As Single 'Compounded return in each apply period
Dim BuyAndHold(500, 3) As Double '1:EndPrice 2:BeginPrice 3:NetReturn
Dim Apply1 As Byte 'Total months in the nearest applying period (probably shorter than the rest)
Dim AllApply As Integer 'how many times to perform actual trading (Each time will last: ApplyMonth)
Dim CountedMth As Integer 'months already counted in preparing Apply() and Learn()
Dim AllMonth As Integer 'total months in source data
Dim LearnMonth As Integer 'assigned in Sheet2 by user
Dim ApplyMonth As Integer 'assigned in Sheet2 by user

CopyPrice
CopyPriceOK = True 'Tell optimizer to skip this procedure

If TotalDay = 0 Then Exit Sub

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL

LearnMonth = Sheet2.Cells(1, 3)
ApplyMonth = Sheet2.Cells(2, 3)

AllMonth = 1
Months(AllMonth) = 1

For i = 2 To TotalDay
 If Month(PDate(i)) = Month(PDate(i - 1)) Then 'still counting days in the same month
  Months(AllMonth) = Months(AllMonth) + 1
 Else
  AllMonth = AllMonth + 1
  Months(AllMonth) = 1
 End If
Next i  'Months() is ready

AllApply = AllMonth - LearnMonth 'covering full applying period
If AllApply <= 0 Then
 MsgBox "No sufficient data to apply trading simulation."
 End
End If

If AllApply Mod ApplyMonth = 0 Then 'perfect, every apply period euqals to ApplyMonth
 Apply1 = ApplyMonth
 AllApply = AllApply / ApplyMonth
Else
  Apply1 = AllApply Mod ApplyMonth
  AllApply = Int(AllApply / ApplyMonth) + 1
End If
```

```
Apply(1, 1) = 1 'the nearest day in source data
For i = 1 To Apply1 'go through each month in Apply1 period
  Apply(1, 2) = Apply(1, 2) + Months(i)
Next i

CountedMth = Apply1
For i = 2 To AllApply
  Apply(i, 1) = Apply(i - 1, 2) + 1 'the last day in previous period plus 1
  Apply(i, 2) = Apply(i - 1, 2)       'in Apply() the day count is accumulating
  For j = 1 To ApplyMonth
    Apply(i, 2) = Apply(i, 2) + Months(CountedMth + j)
  Next j
  CountedMth = CountedMth + ApplyMonth
Next i  'Apply() is ready

CountedMth = Apply1 'use the same methodology again
For i = 1 To AllApply   'no need to assign AllLearn because for Learn() and Apply(), this counter has to be
identical
  Learn(i, 1) = Apply(i, 2) + 1 'the day before the first apply (trade) day is the last learning day
  Learn(i, 2) = Apply(i, 2)       'use the first trade day as a starting point
  For j = 1 To LearnMonth
    Learn(i, 2) = Learn(i, 2) + Months(CountedMth + j)
  Next j
  CountedMth = CountedMth + ApplyMonth
Next i 'Learn() is ready

'Output Learning and Applying schedule

For i = 1 To AllApply
  Sheet2.Cells(i + 9, 2) = PDate(Learn(i, 2))
  Sheet2.Cells(i + 9, 3) = PDate(Learn(i, 1))
Next i

For i = 1 To AllApply
  Sheet2.Cells(i + 9, 13) = PDate(Apply(i, 2))
  Sheet2.Cells(i + 9, 14) = PDate(Apply(i, 1))
  BuyAndHold(i, 2) = Price(Apply(i, 2)) 'BeginPrice
  BuyAndHold(i, 1) = Price(Apply(i, 1)) 'EndPrice
  BuyAndHold(i, 3) = (BuyAndHold(i, 1) * (1 - Cost(3)) - BuyAndHold(i, 2) * (1 + Cost(1))) /
(BuyAndHold(i, 2) * (1 + Cost(1)))
  'Return = (EndPx(1-SellingCost) - BeginPx(1+BuyingCost)) / BeginPx(1+BuyingCost)
  Sheet2.Cells(i + 9, 19) = BuyAndHold(i, 2)
  Sheet2.Cells(i + 9, 20) = BuyAndHold(i, 1)
  Sheet2.Cells(i + 9, 21) = BuyAndHold(i, 3)
Next i

CompoundedReturn = 1
For i = 1 To AllApply
  CompoundedReturn = CompoundedReturn * (1 + BuyAndHold(i, 3))
Next i
CompoundedReturn = CompoundedReturn - 1
Sheet2.Cells(i + 9, 21) = CompoundedReturn 'here i = AllApply+1
Sheet2.Cells(i + 9, 19) = " Compounded Rtn ="

LearningMode = True 'turn on the signal, prepare to call optimizer
For i = 1 To AllApply
```

```
LearnDay1 = Learn(i, 1) 'optimizer will catch these two dates
LearnDay2 = Learn(i, 2)

Select Case WhichOne
Case 1
  Call Optimizer1
Case 2
  Call Optimizer2
Case 3
  Call Optimizer3
End Select

Sheet2.Cells(i + 9, 4) = Optimized(1) 'Output EMA1 from optimizer
Sheet2.Cells(i + 9, 5) = Optimized(2) 'Output EMA2
Sheet2.Cells(i + 9, 6) = Optimized(3) 'Output Signal
Sheet2.Cells(i + 9, 7) = OptimizedRtn 'Output Max return
If WhichOne = 3 Then
  Sheet2.Cells(i + 9, 8) = Optimized(4) 'Output DayDelay
  Sheet2.Cells(i + 9, 9) = Optimized(5) 'Output Trigger
  Sheet2.Cells(i + 9, 10) = Optimized(6) 'Output Target
End If

'Transferring Apply schedule to ApplyStrategy (the variable names may look confusing)
LearnDay1 = Apply(i, 1) 'ApplyStrategy will catch these two dates
LearnDay2 = Apply(i, 2)
If WhichOne = 1 Then Call ApplyStrategy1
If WhichOne = 2 Then Call ApplyStrategy2

Select Case WhichOne
Case 1
  Call ApplyStrategy1
Case 2
  Call ApplyStrategy2
Case 3
  Call ApplyStrategy3
End Select

'Output apply results
Sheet2.Cells(i + 9, 15) = Performance(1) 'Deal No.
Sheet2.Cells(i + 9, 16) = Performance(2) 'Avg Profit
ApplyRtn(i) = Performance(3)
Sheet2.Cells(i + 9, 17) = ApplyRtn(i) 'Compounded Return for this apply period
Sheet2.Cells(i + 9, 12) = PDate(Performance(4)) '1st data - enable user to manually varify the results

Next i

CompoundedReturn = 1
For i = 1 To AllApply
  CompoundedReturn = CompoundedReturn * (1 + ApplyRtn(i))
Next i
CompoundedReturn = CompoundedReturn - 1
Sheet2.Cells(i + 9, 17) = CompoundedReturn 'here i=AllApply+1
Sheet2.Cells(i + 9, 15) = " Compounded Rtn ="
Sheet2.Cells(i + 9, 14) = "Strategy" & Str(WhichOne)
LearningMode = False 'turn off the signal
```

```
End Sub
```

ApplyStrategy1

```
Sub ApplyStrategy1()
'Apply the optimized parameters to trade and report profit/loss
'Learning() calls this sub immediately after it calls Optimizer1
'code is very similar to Optimizer1

Dim i As Integer

Dim Avg As Single
Dim Power As Integer
Dim Alpha As Single
Dim Denominator As Single
Dim EMA1 As Integer
Dim EMA2 As Integer
Dim Sigl As Integer

Dim JustStarted As Boolean
Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 2) As Single 'Profit/Loss for a round trip (1:amount 2: percentage) .. don't need
3: date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade

Dim AvgPL As Single 'a simple average for reference only

Dim NearDay As Integer  'The day range for optimizer to work
Dim FarDay As Integer
Dim PreparingPeriod As Integer '= EMA2+Signal-2+1 (the minimum days required to generate the 1st
trading signal)
Dim CompoundedReturn As Double

EMA1 = Optimized(1)
EMA2 = Optimized(2)
Sigl = Optimized(3)

PreparingPeriod = EMA2 + Sigl - 2 + 1
NearDay = LearnDay1
FarDay = LearnDay2 + PreparingPeriod 'to ensure system is ready to general trading signal when entering
Apply period

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL

Avg = 0
Alpha = 2 / (1 + EMA1)
Power = 0
Denominator = 0
For i = FarDay - EMA1 + 1 To FarDay 'to get initial EMA1
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
```

```
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
For i = FarDay - EMA1 To NearDay Step -1 'fill the rest EMA1
  EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
Next i

Avg = 0
Alpha = 2 / (1 + EMA2)
Power = 0
Denominator = 0
For i = FarDay - EMA2 + 1 To FarDay 'to get initial EMA2
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
For i = FarDay - EMA2 To NearDay Step -1 'fill the rest EMA2
  EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
Next i

AllMACD = FarDay - EMA2 + 1

For i = NearDay To AllMACD
  MACD(i) = EMA(i, 1) - EMA(i, 2)
Next i

'Signal = EMA of MACD
Avg = 0
Alpha = 2 / (1 + Sigl)
Power = 0
Denominator = 0
For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
  Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator

AllSigl = AllMACD - Sigl + 1
Signal(AllSigl) = Avg 'first Signal

For i = AllSigl - 1 To NearDay Step -1 'fill the rest Signal
  Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
Next i

'Learning() fist call optimizer that will write something into Trading(),
'they should still exist in "learning period" and will not contaminate the following area (applying period)
For i = AllSigl - 1 To NearDay Step -1
  If MACD(i) > Signal(i) Then
    If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
  ElseIf MACD(i) < Signal(i) Then
    If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
```

```
  End If
Next i

JustStarted = True 'Strategy1 starts here (no need to record TradeDate)
AllTrade = 0

'Buy and sell based on the signal we stored in Trading( )
'Here we only allow long position, no short sell allowed
'Even though the code here is almost identical to MACDtrading1 or Optimizer1,
'those subs can't trade on the 1st available set of data (1st MACD and Signal)
'because the trading signal in Trading() will come into existence after that day.
'This loop is ready to trade exactly from the first apply day (AllSig1 - 1 =  1st day of apply period)

For i = AllSig1 - 1 To NearDay Step -1
  If Trading(i) <> 0 Then
    If JustStarted And Trading(i) = 1 Then
'do nothing because the 1st signal is a SELL (don't allow short selling)
    Else
If i = NearDay And Trading(NearDay) = -1 Then 'last day shows BUY signal => we won't allow this
happen
  'do nothing (we are sure the last day will not have a BUY decision)
Else
  TradePos(i) = Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i))
  AllTrade = AllTrade + 1
  TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are different
End If
    End If
    JustStarted = False
  End If
Next i

'Force sell on the last day (if we still have position)
If AllTrade > 0 Then
  If TradeRecord(AllTrade) < 0 Then 'Your last trade is BUY, i.e. you have a long position need to close
out
    TradePos(NearDay) = Price(NearDay) * 1 * (1 - Cost(1 + 2) * 1) 'in this formula, 1 = the signal generate
by a sell decision
    AllTrade = AllTrade + 1
    TradeRecord(AllTrade) = TradePos(NearDay) 'complete the record of this final force deal
  End If
End If
'we are sure now AllTrade will be an even number

RoundTrip = AllTrade / 2  'the number of complete BUY and SELL transactions

CompoundedReturn = 1
For i = 1 To RoundTrip   'Count Profit/Loss for each round trip
  TradePL(i, 1) = TradeRecord(i * 2) + TradeRecord(i * 2 - 1)
  TradePL(i, 2) = TradePL(i, 1) / (-TradeRecord(i * 2 - 1))
  CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
Next i
CompoundedReturn = CompoundedReturn - 1

AvgPL = 0

For i = 1 To RoundTrip
```

```
  AvgPL = AvgPL + TradePL(i, 2)
Next i

If RoundTrip > 0 Then AvgPL = AvgPL / RoundTrip

'Transferring results back to sub Learning()
Performance(1) = RoundTrip
Performance(2) = AvgPL
Performance(3) = CompoundedReturn
Performance(4) = FarDay 'with this info user is able to verify results manually

End Sub
```

ApplyStrategy2

```
Sub ApplyStrategy2()
'Apply the optimized parameters to trade and report profit/loss
'Learning() calls this sub immediately after it calls Optimizer2
'code is very similar to ApplyStrategy1

Dim i As Integer

Dim Avg As Single
Dim Power As Integer
Dim Alpha As Single
Dim Denominator As Single
Dim EMA1 As Integer
Dim EMA2 As Integer
Dim Sigl As Integer

Dim JustStarted As Boolean
Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 2) As Single 'Profit/Loss for a round trip (1:amount 2: percentage) .. don't need
3: date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade

Dim AvgPL As Single 'a simple average for reference only

Dim NearDay As Integer  'The day range for optimizer to work
Dim FarDay As Integer
Dim PreparingPeriod As Integer '= EMA2+Signal-2+1 (the minimum days required to generate the 1st
trading signal)
Dim CompoundedReturn As Double

EMA1 = Optimized(1)
EMA2 = Optimized(2)
Sigl = Optimized(3)

PreparingPeriod = EMA2 + Sigl - 2 + 1

NearDay = LearnDay1
FarDay = LearnDay2 + PreparingPeriod 'to ensure system is ready to general trading signal when entering
Apply period
```

```
Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL

Avg = 0
Alpha = 2 / (1 + EMA1)
Power = 0
Denominator = 0
For i = FarDay - EMA1 + 1 To FarDay 'to get initial EMA1
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
For i = FarDay - EMA1 To NearDay Step -1 'fill the rest EMA1
  EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
Next i

Avg = 0
Alpha = 2 / (1 + EMA2)
Power = 0
Denominator = 0
For i = FarDay - EMA2 + 1 To FarDay 'to get initial EMA2
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
For i = FarDay - EMA2 To NearDay Step -1 'fill the rest EMA2
  EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
Next i

AllMACD = FarDay - EMA2 + 1

For i = NearDay To AllMACD
  MACD(i) = EMA(i, 1) - EMA(i, 2)
Next i

'Signal = EMA of MACD
Avg = 0
Alpha = 2 / (1 + Sigl)
Power = 0
Denominator = 0
For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
  Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator

AllSigl = AllMACD - Sigl + 1
Signal(AllSigl) = Avg 'first Signal

For i = AllSigl - 1 To NearDay Step -1 'fill the rest Signal
  Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
```

```
Next i

For i = AllSigl - 1 To NearDay Step -1
 If MACD(i) > Signal(i) Then
  If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
 ElseIf MACD(i) < Signal(i) Then
  If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
 End If
Next i

JustStarted = True 'Strategy1 starts here (no need to record TradeDate)
AllTrade = 0

'Buy and sell based on the signal we stored in Trading( )
'Here we allow either long or short position
'More information, see comments in ApplyStrategy1
For i = AllSigl - 1 To NearDay + 1 Step -1 'skip the final day (i=1 or NearDay) and deal with it later
 If Trading(i) <> 0 Then
  If JustStarted Then 'very first trade - for one unit only, no matter long or short
   TradePos(i) = Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i))
   AllTrade = AllTrade + 1
   TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
  Else
   TradePos(i) = 2 * (Price(i) * Trading(i) * (1 - Cost(Trading(i) + 2) * Trading(i)))
   'double in order to close out original position and simultaneously open new position
   AllTrade = AllTrade + 1
   TradeRecord(AllTrade) = TradePos(i)  'Be careful the indexing in TradePos and TradeRecord are
different
  End If
  JustStarted = False
 End If
Next i

'Force close out existing position on the last day (It is certain that we still have position before the last day)
If AllTrade > 0 Then

 If TradeRecord(AllTrade) < 0 Then 'Your last trade is BUY, i.e. you have a long position need to close
out
  TradePos(NearDay) = Price(NearDay) * 1 * (1 - Cost(1 + 2) * 1) 'in this formula, 1 = the signal generate
by a sell decision
 Else  'Your last trade is SELL, i.e. you have a short position need to close out
  TradePos(NearDay) = Price(NearDay) * (-1) * (1 - Cost(-1 + 2) * (-1)) 'in this formula, -1 = the signal
generate by a buy decision
 End If

 AllTrade = AllTrade + 1
 TradeRecord(AllTrade) = TradePos(NearDay) 'complete the record of this final force deal

 RoundTrip = AllTrade - 1 'the number of complete BUY and SELL transactions

 CompoundedReturn = 1

 If RoundTrip = 1 Then
```

```
    i = 1 'special process for the only trade
    TradePL(i, 1) = TradeRecord(i + 1) + TradeRecord(i)
    TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i))
    CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
   Else
    i = 1 'special process for 1st trade
    TradePL(i, 1) = TradeRecord(i + 1) / 2 + TradeRecord(i)
    TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i))
    CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))

    i = RoundTrip 'special process for last trade
    TradePL(i, 1) = TradeRecord(i + 1) + TradeRecord(i) / 2
    TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i) / 2)
    CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))

    For i = 2 To RoundTrip - 1 'Count Profit/Loss for the rest round trips
      TradePL(i, 1) = TradeRecord(i + 1) / 2 + TradeRecord(i) / 2
      TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i) / 2)
      CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
    Next i
   End If
   CompoundedReturn = CompoundedReturn - 1

End If

AvgPL = 0

For i = 1 To RoundTrip
  AvgPL = AvgPL + TradePL(i, 2)
Next i

If RoundTrip > 0 Then AvgPL = AvgPL / RoundTrip

'Transferring results back to sub Learning()
Performance(1) = RoundTrip
Performance(2) = AvgPL
Performance(3) = CompoundedReturn
Performance(4) = FarDay 'with this info user is able to verify results manually

End Sub
```

ApplyStrategy3

```
Sub ApplyStrategy3()
'Apply the optimized parameters to trade and report profit/loss
'Learning() calls this sub immediately after it calls Optimizer3
'code is very similar to ApplyStrategy2

Dim i As Integer

Dim Avg As Single
Dim Power As Integer
Dim Alpha As Single
Dim Denominator As Single
Dim EMA1 As Integer
Dim EMA2 As Integer
Dim Sigl As Integer
```

```
Dim Cost(1 To 3) As Single
Dim TradePos(MaxDays) As Single 'record buy/sell position
Dim TradeRecord(MaxTrades) As Single
Dim TradePL(MaxTrades, 2) As Single 'Profit/Loss for a round trip (1:amount 2: percentage) .. don't need
3: date
Dim AllTrade As Integer
Dim RoundTrip As Integer 'should be half the number of AllTrade

Dim AvgPL As Single 'a simple average for reference only

Dim NearDay As Integer  'The day range for optimizer to work
Dim FarDay As Integer
Dim PreparingPeriod As Integer '= EMA2+Signal-2+1 (the minimum days required to generate the 1st
trading signal)
Dim CompoundedReturn As Double

Dim DayDelay As Byte '=3 in standard MACDR2
Dim Trigger As Single
Dim Target As Single
Dim TargetReached As Boolean 'true if it's time to take profit or stop loss
Dim TradeNow As Boolean
Dim CurrentPos As Single
Dim CurrentTrade As Integer 'same value as in Trading( ), only have +1,  -1, or 0
Dim ClosingTrade As Integer
Dim Profit As Single

EMA1 = Optimized(1)
EMA2 = Optimized(2)
Sigl = Optimized(3)
DayDelay = Optimized(4)
Trigger = Optimized(5)
Target = Optimized(6)

PreparingPeriod = EMA2 + Sigl - 2 + 1

NearDay = LearnDay1
FarDay = LearnDay2 + PreparingPeriod 'to ensure system is ready to general trading signal when entering
Apply period

Cost(1) = Sheet1.Cells(5, 2) 'Trading cost for BUY
Cost(3) = Sheet1.Cells(6, 2) 'Trading cost for SELL

Avg = 0
Alpha = 2 / (1 + EMA1)
Power = 0
Denominator = 0
For i = FarDay - EMA1 + 1 To FarDay 'to get initial EMA1
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
For i = FarDay - EMA1 To NearDay Step -1 'fill the rest EMA1
  EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
```

```
Next i

Avg = 0
Alpha = 2 / (1 + EMA2)
Power = 0
Denominator = 0
For i = FarDay - EMA2 + 1 To FarDay 'to get initial EMA2
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
For i = FarDay - EMA2 To NearDay Step -1 'fill the rest EMA2
  EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
Next i

AllMACD = FarDay - EMA2 + 1

For i = NearDay To AllMACD
  MACD(i) = EMA(i, 1) - EMA(i, 2)
Next i

'Signal = EMA of MACD
Avg = 0
Alpha = 2 / (1 + Sigl)
Power = 0
Denominator = 0
For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
  Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator

AllSigl = AllMACD - Sigl + 1
Signal(AllSigl) = Avg 'first Signal

For i = AllSigl - 1 To NearDay Step -1 'fill the rest Signal
  Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
Next i

For i = AllSigl - 1 To NearDay Step -1
  If MACD(i) > Signal(i) Then
    If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
  ElseIf MACD(i) < Signal(i) Then
    If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
  End If
Next i

Avg = 0
Alpha = 2 / (1 + EMA1)
Power = 0
Denominator = 0
```

```
For i = FarDay - EMA1 + 1 To FarDay 'to get initial EMA1
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA1 + 1, 1) = Avg 'first EMA1 ready
For i = FarDay - EMA1 To NearDay Step -1 'fill the rest EMA1
  EMA(i, 1) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 1)
Next i

Avg = 0
Alpha = 2 / (1 + EMA2)
Power = 0
Denominator = 0
For i = FarDay - EMA2 + 1 To FarDay 'to get initial EMA2
  Avg = Avg + Price(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator
EMA(FarDay - EMA2 + 1, 2) = Avg 'first EMA2 ready
For i = FarDay - EMA2 To NearDay Step -1 'fill the rest EMA2
  EMA(i, 2) = Alpha * Price(i) + (1 - Alpha) * EMA(i + 1, 2)
Next i

AllMACD = FarDay - EMA2 + 1

For i = NearDay To AllMACD
  MACD(i) = EMA(i, 1) - EMA(i, 2)
Next i

'Signal = EMA of MACD
Avg = 0
Alpha = 2 / (1 + Sigl)
Power = 0
Denominator = 0
For i = AllMACD - Sigl + 1 To AllMACD 'to get initial Signal
  Avg = Avg + MACD(i) * (1 - Alpha) ^ Power
  Denominator = Denominator + (1 - Alpha) ^ Power
  Power = Power + 1
Next i
Avg = Avg / Denominator

AllSigl = AllMACD - Sigl + 1
Signal(AllSigl) = Avg 'first Signal

For i = AllSigl - 1 To NearDay Step -1 'fill the rest Signal
  Signal(i) = Alpha * MACD(i) + (1 - Alpha) * Signal(i + 1)
Next i

For i = AllSigl - 1 To NearDay Step -1
  If MACD(i) > Signal(i) Then
    If (MACD(i + 1) < Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) < Signal(i +
2))) Then Trading(i) = -1
  ElseIf MACD(i) < Signal(i) Then
```

```
  If (MACD(i + 1) > Signal(i + 1)) Or ((MACD(i + 1) = Signal(i + 1)) And (MACD(i + 2) > Signal(i +
2))) Then Trading(i) = 1
  End If
Next i

AllTrade = 0
CurrentPos = 0
CurrentTrade = 0

For i = AllSigl - 1 - DayDelay To NearDay + 1 Step -1 'skip the final day (i=1 or NearDay) and deal with it
later

 'the 1st possible MACD trading signal will start from Trading(AllSigl-1)
 'first possible trading will be 3(=DayDelay) days after seeing that signal
 'therefore the starting point is AllSigl-4
 'since we will close out position on the last day, we will process the last day separately

 TradeNow = False 'should we do trade today?

 If Trading(i + DayDelay) <> 0 Then 'There's MACD trading signal 3(=DayDelay) days ago
  If -Trading(i + DayDelay) * (MACD(i) - Signal(i)) / Price(i) >= Trigger Then TradeNow = True
  '3 days later the gap between MACD and Signal is large enough
 End If

 If TradeNow = True Then
  If Not (CurrentTrade = Trading(i + DayDelay)) Then 'do nothing if the signal is identical to the existing
position

    If CurrentTrade <> 0 Then 'new trade certainly has different signal versus existing position
     'close out existing position
     ClosingTrade = -CurrentTrade
     TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
     AllTrade = AllTrade + 1
     TradeRecord(AllTrade) = TradePos(i)
    End If
    'no need to worry any pending position now

    'open new position here
    TradePos(i) = TradePos(i) + Price(i) * Trading(i + DayDelay) * (1 - Cost(Trading(i + DayDelay) + 2) *
Trading(i + DayDelay))
    'in case we have a close out deal and a new trade in same day, TradePos( ) will record total amount

    AllTrade = AllTrade + 1
    TradeRecord(AllTrade) = Price(i) * Trading(i + DayDelay) * (1 - Cost(Trading(i + DayDelay) + 2) *
Trading(i + DayDelay))
    'record new trade amount (while TradePos(i) might accumulate 2 same way trades in same day)

    CurrentPos = TradeRecord(AllTrade)
    CurrentTrade = Trading(i + DayDelay)
  End If 'Not (CurrentTrade = trade(i + DayDelay))

 Else 'no new trade for this day

  If CurrentTrade <> 0 Then 'is it time for profit-taking?
    ClosingTrade = -CurrentTrade
    Profit = CurrentPos + ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
```

```
    Profit = Profit / Abs(CurrentPos) 'convert into %
    TargetReached = False
    If Profit > 0 And Target > 0 And Profit >= Target Then TargetReached = True 'confirm to take profit
    If Profit < 0 And Target < 0 And Profit <= Target Then TargetReached = True 'confirm to stop loss
    If TargetReached Or Trading(i) = ClosingTrade Then 'close out because of (1) TakeProfit or StopLoss,
(2) MACD signal said so
      TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
      AllTrade = AllTrade + 1
      TradeRecord(AllTrade) = TradePos(i)
      CurrentPos = 0
      CurrentTrade = 0
    End If
   End If

 End If 'TradeNow=True

Next i

i = NearDay  'to deal with the last working day
If CurrentTrade <> 0 Then 'after running through the for-next loop, we still have position
 ClosingTrade = -CurrentTrade
 TradePos(i) = ClosingTrade * Price(i) * (1 - Cost(ClosingTrade + 2) * ClosingTrade)
 AllTrade = AllTrade + 1
 TradeRecord(AllTrade) = TradePos(i)
 CurrentPos = 0 'in fact it won't do any harm if we don't reset them
 CurrentTrade = 0
End If

RoundTrip = AllTrade / 2

CompoundedReturn = 1
For i = 1 To RoundTrip   'Count Profit/Loss for each round trip
 TradePL(i, 1) = TradeRecord(i * 2) + TradeRecord(i * 2 - 1)
 TradePL(i, 2) = TradePL(i, 1) / Abs(TradeRecord(i * 2 - 1))
 CompoundedReturn = CompoundedReturn * (1 + TradePL(i, 2))
Next i
CompoundedReturn = CompoundedReturn - 1

AvgPL = 0

For i = 1 To RoundTrip
 AvgPL = AvgPL + TradePL(i, 2)
Next i

If RoundTrip > 0 Then AvgPL = AvgPL / RoundTrip

'Transferring results back to sub Learning()
Performance(1) = RoundTrip
Performance(2) = AvgPL
Performance(3) = CompoundedReturn
Performance(4) = FarDay 'with this info user is able to verify results manually

End Sub
```

ClearPublicMatrix

```
Sub ClearPublicMatrix()

Erase Price
Erase MACD
Erase EMA
Erase Signal
Erase Trading

End Sub
```

Sheet1 Code

```
Private Sub CommandButton1_Click() 'RUN

 Call CopyPrice
 Call MACDinitiate
 Call MACDtradingsignal
 Call MACDtrading1
 Call MACDtrading2
 Call MACDR2trading
 Call MACDtrading4

End Sub

Private Sub CommandButton2_Click()

 Call MACDoutput 'it is quite slow

End Sub

Private Sub CommandButton3_Click() 'Clear All

 ClearPublicMatrix

 Sheets("Sheet1").Select
 Range("A10:AC65536").Select
 Selection.ClearContents

 Range("H2:J5").Select
 Selection.ClearContents

 Range("I6").Select
 Selection.ClearContents

 Range("L2:N5").Select
 Selection.ClearContents

 Range("M6").Select
 Selection.ClearContents

 Range("P2:R5").Select
 Selection.ClearContents

 Range("Q6").Select
 Selection.ClearContents
```

```
 Range("T2:V5").Select
 Selection.ClearContents

 Range("U6").Select
 Selection.ClearContents

 Range("W9:AC9").Select
 Selection.ClearContents

 Range("A1").Select

End Sub

Private Sub CommandButton4_Click() ' Clear output but keep index data

 ClearPublicMatrix

 Sheets("Sheet1").Select
 Range("D10:AC65536").Select
 Selection.ClearContents

 Range("H2:J5").Select
 Selection.ClearContents

 Range("I6").Select
 Selection.ClearContents

 Range("L2:N5").Select
 Selection.ClearContents

 Range("M6").Select
 Selection.ClearContents

 Range("P2:R5").Select
 Selection.ClearContents

 Range("Q6").Select
 Selection.ClearContents

 Range("T2:V5").Select
 Selection.ClearContents

 Range("U6").Select
 Selection.ClearContents

 Range("W9:AC9").Select
 Selection.ClearContents

 Range("A1").Select

End Sub

Private Sub CommandButton5_Click() 'Optimizer1
  Call Optimizer1
End Sub
```

```
Private Sub CommandButton6_Click() 'Optimizer2
  Call Optimizer2
End Sub

Private Sub CommandButton7_Click()
  Call Optimizer3
End Sub

Private Sub CommandButton8_Click()
  Call Optimizer4
End Sub

Private Sub ToggleButton1_Click() 'Strategy1 long only


If ToggleButton1.Value = True Then
  ToggleButton1.Caption = "ON"

  Columns("G:J").Select
  Selection.EntireColumn.Hidden = False
  Range("A1").Select

Else
  ToggleButton1.Caption = "OFF"

  Columns("G:J").Select
  Selection.EntireColumn.Hidden = True
  Range("A1").Select

End If

End Sub

Private Sub ToggleButton2_Click() 'Strategy2 long or short

If ToggleButton2.Value = True Then
  ToggleButton2.Caption = "ON"

  Columns("K:N").Select
  Selection.EntireColumn.Hidden = False
  Range("A1").Select

Else
  ToggleButton2.Caption = "OFF"

  Columns("K:N").Select
  Selection.EntireColumn.Hidden = True
  Range("A1").Select

End If

End Sub

Private Sub ToggleButton3_Click() 'Strategy3 MACDR2

If ToggleButton3.Value = True Then
```

```
  ToggleButton3.Caption = "ON"

  Columns("O:R").Select
  Selection.EntireColumn.Hidden = False
  Range("A1").Select

Else
  ToggleButton3.Caption = "OFF"

  Columns("O:R").Select
  Selection.EntireColumn.Hidden = True
  Range("A1").Select

End If

End Sub

Private Sub ToggleButton4_Click() 'Strategy4 short only

If ToggleButton4.Value = True Then
  ToggleButton4.Caption = "ON"

  Columns("S:V").Select
  Selection.EntireColumn.Hidden = False
  Range("A1").Select

Else
  ToggleButton4.Caption = "OFF"

  Columns("S:V").Select
  Selection.EntireColumn.Hidden = True
  Range("A1").Select

End If

End Sub

Private Sub ToggleButton5_Click() 'Optimizer1 output detail

If ToggleButton5.Value = True Then
  ToggleButton5.Caption = "ON"
Else
  ToggleButton5.Caption = "OFF"
End If

End Sub

Private Sub ToggleButton6_Click() 'Trade detail

If ToggleButton6.Value = True Then
  ToggleButton6.Caption = "ON"
Else
  ToggleButton6.Caption = "OFF"
End If

End Sub
```

Sheet2 Code

```
Private Sub CommandButton1_Click() 'Learn and Apply Strategy1

  Sheets("Sheet2").Select
  Range("B10:U65536").Select
  Selection.ClearContents
  Range("A1").Select

  Call Learning(1)

End Sub

Private Sub CommandButton2_Click() 'Learn and Apply Strategy2

  Sheets("Sheet2").Select
  Range("B10:U65536").Select
  Selection.ClearContents
  Range("A1").Select

  Call Learning(2)

End Sub

Private Sub CommandButton3_Click() 'Learn and Apply Strategy3 - MACDR2

  Sheets("Sheet2").Select
  Range("B10:U65536").Select
  Selection.ClearContents
  Range("A1").Select

  Call Learning(3)

End Sub
```

REFERENCE LIST

Appel, G. "The Moving Average Convergence Divergence Method", Great Neck, NY: Signalert, 1979

Brorsen, B. W., and S. H. Irwin. "Future Funds and Price Volatility." *The Review of Futures Markets*, 6(1987)

Brown, D. P., and R. H. Jennings. "On Technical Analysis." *Review of Financial Studies*, 2(1989)

Chang, P. H. K., and C. L. Osler. "Methodical Madness: Technical Analysis and Irrationality of Exchange-Rate Forecasts." *Economic Journal*, 109(1999)

Cheng, W. Y., Cheung, Y. L., and Yung, H. M. "Profitability of the CRISMA System: From World Indices to the Hong Kong Stock Market", *Asia-Pacific Financial Markets* 10: 45-57, 2003.

Cheung, Y. W., and C. Y. P. Wong. "A Survey of Market Practitioners' View on Exchange Rate Dynamics." *Journal of International Economics*, 51(2000)

Fama, E. F., and M. E. Blume. "Filter Rules and Stock Market Trading." *Journal of Business*, 39(1966)

Fama, E. F. "Efficient Capital Markets: A Review of Theory and Empirical Work." *Journal of Finance*, 25(1970)

Fyfe, C., J. P. Marney, and H. F. E. Tarbert. "Technical Analysis versus Market Efficiency – A Genetic Programming Approach." *Applied Financial Economics*, 9(1999)

Goodacre, A., Bosher J. and Dove A. "Testing the CRISMA trading system: evidence from the UK market", Applied Financial Economics, 1999, 9, 455-468

Gunter, M., Albin A. and Kai N. "A Refined MACD Indicator – Evidence against the Random Walk Hypothesis?" *ABAC Journal*, (August 2001)

Jensen, M. C., and G. A. Bennington. "Random Walks and Technical Theories: Some Additional Evidence." *Journal of Finance*, 25(1970)

Lukac, L. P., B. W. Brorsen, and S. H. Irwin. *A Comparison of Twelve Technical Trading Systems.* Greenville, SC: Traders Press, Inc, 1990

Murphy, A. "Futures Fund Performance: A Test of the Effectiveness of Technical Analysis." *Journal of Futures Markets*, 6(1986)

Park, C. H., and S. H. Irwin. "The Profitability of Technical Analysis" *AgMAS Project Research Report*, (2004-04)

Pring, M. J. *Technical Analysis Explained.* New York, NY: McGraw-Hill, 2002.

Pruitt, S. W., and R. E. White. "The CRISMA Trading System: Who Says Technical Analysis Can't Beat the Market?" *Journal of Portfolio Management*, (Spring 1988)

Pruitt, S. W., and R. E. White. "Exchange-Traded Options and CRISMA Trading" *Journal of Portfolio Management*, (Summer 1989)

Pruitt, S. W., K. S. Maurice Tse, and R. E. White. "The CRISMA Trading System: The next Five Years" *Journal of Portfolio Management*, (Spring 1992)

Soros, G. *The Theory of Reflexivity.* Soros Fund Management, New York, NY. 1994.

Stevenson, R. A., and R. M. Bear. "Commodity Futures: Trends or Random Walks?" *Journal of Finance*, 25(1970)

Sweeney, R. J. "Beating the Foreign Exchange Market" *Journal of Finance*, 41(1986)

Wong, W. K., M. Manzur, and B. K. Chew. "How Rewarding Is Technical Analysis? Evidence from Singapore Stock Market." *Applied Financial Economics*, 13(2003)

Zitzlsperger, David. "Empirically Testing the Assumption of the Technical Analysis" *Simon Fraser University*, (September 2002)