Efficient Utilization Condition of MACD on Stock Market and Nontrend Status Detecting Indicator

Jung-Youn Lee and Sun-Myung Hwang*

Department of Computer Engineering, Daejeon University, Korea; bijou1224@hanmail.net, sunhwang@dju.kr

Abstract

Background/Objectives: In the trend stock market, when low frequency components determine wave form of stock price, MACD can be useful for predicting stock price. The MA and MACD occurs time delay and whipsaw problem. In order to use the MACD efficiently, we propose indicators are derived from the power measurement of the price waveform. Methods/Statistical Analysis: The proposed method differentiates trend market against nontrend market. In this method, given stock signal is converted into the sum of many frequency components by using the fourier transform and the power of low frequency components is measured. Findings: When power values increase rapidly it is highly likely that market is in trend market and when the values linearly decrease then the inflection point in stock price waveform can be occurred. Therefore, once appropriate reference line is set up, one can determine that trend market is in progress if values increase passing the reference line, that opposite trend market after inflection point is in progress if values decrease passing the reference line using power calculation. Improvements/Applications: The market is determined as 'trend market' if the power value is larger enough, and it is remarkably helpful and particularly useful at automatic trading systems.

Keywords: Novel Index, Nontrend Market, Power Calculation, Power Value, Trend Market

1. Introduction

Economic conditions are changing all the time and consequently stock markets respond to these changes. Even without changes in macroeconomic conditions investors in stock markets create changes in stock prices in order to obtain the differentials or profits. The changes in stock prices can be expressed dynamically, which can be explained as the wave forms created by two forces working against each other: one driving away from equilibrium, the other leading to convergence into equilibrium. One of the typical theories explaining stock price change is the Elliott wave principle. In order to make profits in the stock and futures markets it is important to identify center price of the changing stock prices. Typical way of obtaining the center price is to use moving averages, which can be defined as the average of stock price time series as follows:

\[ v_n = \frac{1}{N} \sum_{i=0}^{N-1} P_{n-i} \]  

One can trade stocks based on the assumption that if stock price increases beyond the moving average then the stock price has high probability of further increase, and that if the price goes below the moving average then the price will further decrease. And also one can determine the stock price is over-evaluated if the price is sufficiently greater than the moving average, and that the stock price is under-evaluated in the opposite case of stock price being smaller than the moving average. Therefore, one can set proper trading positions based on these determinations.

MACD (Moving Average Convergency Divergency) index was proposed by Gerald Appel in late 1970's to obtain the information on trend commandment and
moment by using convergence and divergence phenomena which occur between the average values in short term and in long term.

\[
C_{d,n} = \text{short term moving average} - \text{long term moving average}
\]  

(2)

In this study, we propose a method to differentiate trend market against nontrend market. In this method, given stock signal is converted into the sum of many frequency components by using the Fourier transform and the power of low frequency components is measured, and the market is determined as 'trend market' if the power value is larger enough\(^{4–6}\).

When applied for successful trading, MACD can be used only during the trend market and not during the nontrend market. The method is especially useful for MACD automatic trading systems

2. Waveform for MACD [Characteristics of MACD]

To understand the time delay and whipsaw problems of MA and MACD, it is necessary to investigate the issues in case of stock signal in simpler form and then further expand the investigation into the case of real stock signal.

For example, by using the Fourier transform, any signal can be expressed as the sum of the equivalent sinusoidal components. Therefore, we first look into the characteristics of time delays and whipsaw problems connected to moving average and MACD obtained from sinusoidal stock signal with single frequency. Then we can expand the results of these investigations for the case to understand the MACD characteristics of a stock signal which is composed of the sum of sinusoidal terms with different frequency values.

2.1 Moving Average of a Single Sinusoidal Stock Signal\(^7,8\)

For a single sinusoidal stock signal, \(N_1\) moving average can be expressed as follows. If we set a sinusoidal stock signal \(P_n = \cos W_T n\) where \(W_T\) is angular frequency, amplitude is 1, and initial phase is zero, and we put this equation for stock signal equation (1), then we obtain the moving average as:

\[
A_{n} = \frac{1}{N_1} \sum_{i=0}^{N_1-1} P_{n-i}
\]

\[
= \frac{1}{N_1} \sum_{i=0}^{N_1-1} \cos W_T (n-i)
\]

\[
= \frac{1}{N_1} \Re \left[ \sum_{i=0}^{N_1-1} e^{j W_T (n-i)} \right]
\]

\[
= \frac{1}{N_1} \Re \left[ e^{j W_T n} \sum_{i=0}^{N_1-1} e^{-j W_T i} \right]
\]

\[
= \frac{1}{N_1} \Re \left[ e^{j W_T n} \frac{1 - e^{-j W_T N_1}}{1 - e^{-j W_T}} \right]
\]

\[
= \frac{1}{N_1} \left[ \frac{\sin \left( \frac{W_T N_1}{2} \right)}{\sin \left( \frac{W_T}{2} \right)} \right] \Re \left( e^{j W_T n} e^{-j \frac{W_T N_1}{2}} e^{j \frac{W_T n}{2}} \right)
\]

\[
= \frac{1}{N_1} \frac{\sin \left( \frac{W_T N_1}{2} \right)}{\sin \left( \frac{W_T}{2} \right)} \cos \left( W_T n - \frac{W_T (N_1 - 1)}{2} \right)
\]

(3)

Figure 1. Amplitude of moving average for \(1 - \frac{\sin \left( \frac{W_T N_1}{2} \right)}{\sin \left( \frac{W_T}{2} \right)}\).

Figure 1 shows the effect of \(N_1\) on the amplitude of moving average for two cases of stock signals with different angular frequency \(W_T\) values. It is clear that smoother stock signal can be obtained by increasing \(N_1\) and consequently this will work strongly against whipsaw. However, if \(W_T N_1 \ll 1\) is not satisfied then phase delay can increase as \(W_T\) increases, and consequently information which is not useful in real stock trading can be obtained. Therefore, it is important to note that moving average can be more useful if \(W_T N_1 \ll 1\) is better satisfied

2.2 MACD of Single Sinusoidal Stock Signal\(^8\)

We can rewrite equation (2) for short term \(N_1\) and long term \(N_2\) as:
If we assume \( R = \frac{N_2}{N_1} > 1 \) and also assume that time series stock signal \( \{p_{n}\} \) change sufficiently slow for a given interval \( R \) so that interpolation can be used without the distortion due to decimation, that is the stock signal can approximately satisfy the Nyquist condition, the following relationship can be established:

\[
\sum_{i=0}^{N_2-1} p_{n-i} = R \sum_{i=0}^{N_1-1} p_{n-Ri}
\]

Therefore, we can rewrite equation (4) as:

\[
Cd_n = \frac{1}{N_1} \sum_{i=0}^{N_1-1} p_{n-i} - \frac{1}{N_2} \cdot R \sum_{i=0}^{N_1-1} p_{n-Ri}
\]  

\[
= \frac{1}{N_1} \sum_{i=0}^{N_1-1} \left[ p_{n-i} - p_{n-Ri} \right]
\]

If we compare equation (6) with equation (1) then moving average is the average of time series stock signal \( \{p_{n-(N-1)}, p_{n-(N-2)}, \ldots, p_{n-1}, p_n\} \) and MACD is the average of time series stock signal

\[
\{ \cos (w_1(n-i)) - \cos (w_1(n-Ri)) \}
\]

We can use Fourier transform on stock signal, where the signal is expressed as the sum of many sinusoidal signal components with different frequency values:

\[
p_n = \sum_{i=0}^{\infty} A_i \cos (w_i n + \theta_i)
\]

Here, \( A_i \) is magnitude of the amplitude for a sinusoidal wave corresponding to angular frequency \( w_i, \theta_i \), and \( \theta_i \) is phase, and each of these values can be obtained from the Fourier transformation of the time series stock signal.

As we are interested in the relative magnitude of amplitude and relative value of phase between the stock signal and MACD, we put the following sinusoidal stock signal into equation (6)

\[
p_n = \cos (w_1 n)
\]

where, \( w_1 \) is angular frequency, magnitude of amplitude is 1, initial phase is zero.

Then, we follow the procedure as we obtained equation (3) to get:

\[
Cd_n = \frac{1}{N_1} \sum_{i=0}^{N_1-1} \left[ \cos (w_1(n-i)) - \cos (w_1(n-Ri)) \right]
\]

\[
= \frac{1}{N_1} \left[ \frac{\sin (\frac{w_1 N_1}{2})}{\sin (\frac{w_1}{2})} \right] \cos \left( w_1 n - \frac{w_1 N_1 - 1}{2} \right)
\]

\[
= \frac{1}{N_1} \left[ \frac{\sin (\frac{w_1 N_1 R}{2})}{\sin (\frac{w_1 R}{2})} \right] \cos \left( w_1 n - \frac{w_1 N_1 - 1}{2} \right)
\]

If \( w_1 N_1^2 R \ll 1 \) is satisfied, then we have .

Therefore, we can rewrite equation (9) by approximation as:

\[
Cd_n \approx \cos \left( w_1 n - \frac{w_1 N_1}{2} \right) - \cos \left( w_1 n - \frac{w_1 N_1 R}{2} \right)
\]

\[
= -2 \sin \left( \frac{w_1 N_1 (R - 1)}{4} \right) \sin \left( \frac{w_1 n - w_1 N_1 (R + 1)}{4} \right)
\]

Figure 2 shows the results showing MACD as an example, where equation (9) is used for the case that \( w_1 N_1^2 \ll 1 \) is satisfied and \( w_1 = 0.002 \times 2\pi, N_1 = 20, R = 2 \).

**Figure 2.** Stock price signal (red line) and MACD(blue line) if \( w_1 N_1^2 \ll 1 \).

**Figure 3.** Stock price signal and MACD unless \( w_1 N_1^2 \ll 1 \).
Figure 3 shows the results showing MACD as another example, where equation (9) is used for the case that \(w_I N_x \ll 1\) is not satisfied and \(w_I = 0.002 \times 2\pi, N_x = 200, R = 2\).

3. A Proposal for a Method to Analyze Frequency Components

Stock price signal spectrum is the result of expressing stock price as the sum of sinusoidal components where each component is a function of frequency. Stock price signal spectrum can be obtained by using DFT because stock price signal is discrete time signal based on the samples. On the other hand, for the purpose of drawing a spectrum one may use DFT which displays as discrete time signal even on the frequency axis. DFT is defined as follows:

\[
P(\mathbf{k}) = \sum_{k=0}^{M-1} p_n W_M^{nk} \\
p_n = \left(\frac{1}{M}\right) \sum_{k=0}^{M-1} P(k) W_M^{-nk}
\]

(11)

where, \(P(\mathbf{k})\) is kth frequency component, \(p_n\) is sample values in time series, \(W_M = e^{-\frac{2\pi i}{M}}\), is total number of samples in the time series.

In this study we propose step by step method to identify the market as trend market or nontrend market by using power calculation based on spectral analysis.

Step 1. Obtain the spectrum for moving average on sample series of stock prices, and calculate the total sum of power values for components in a given low frequency range. If only a few of low frequency components are used it is not necessary to obtain all the spectrum by using the Fast Fourier Transform (FFT). This is because using FFT requires more time, and therefore direct calculation of spectrum component by using the DFT definition is more efficient.

Step 2. If the calculated power value of low frequency components exceeds the pre-determined threshold values, one can judge that trend is in progress. When these conditions are not satisfied and the values stay low then one can determine the market as nontrend market.

As shown in Figure 4 when power values increase rapidly it is highly likely that market is in trend market and when the values linearly decrease then the inflection point in stock price waveform can be occurred. Therefore, once appropriate reference line is set up, one can determine that trend market is in progress if values increase passing the reference line, that opposite trend market after inflection point is in progress if values decrease passing the reference line, and that nontrend market is in progress if the values stay well below the guideline. The information obtained as described above, combined with MACD index can be used to achieve successful trading.

Setting the reference for differentiating high versus low frequency values, and for threshold power values for low frequency components can be determined by attitude of the traders, target profits, and other variables, which will not be considered in this study. Also in this study power charts for 10 or 30 low frequency components which include DC components are shown, but if other conditions are used then more useful outcome can be obtained.

4. Conclusions

In this study, characteristics of moving average and MACD for a given stock signal are investigated based on the analysis of spectrums. In the trend market when low frequency components determine waveform of stock price, MACD can be very useful for predicting stock prices. In the nontrend market, however, when low frequency components are weak, it is likely that MACD loss can occur. Therefore, a power chart method using the power of low frequency values is proposed to determine whether a given market is in trend market or nontrend market.

Results of our study are presented as power chart for a simple case of differentiating low versus high frequency.
components, where we used a certain frequency value as a reference. On the other hand, we can have alternative method of giving more weight on low frequency components and less weight on high frequency components, so that all frequency range can be considered for formulating power charts.

Another approach is to obtain power chart from tick data instead of using time series stock signal based on close value of 1 min candle, which would be more efficient because tick data contains information on real trading.

The power chart method proposed in this study can be used not only in stock, futures, and option markets, but also in all other financial markets where profits can be made by analyzing time series wave forms.

5. Acknowledgement

This work was supported by Business for Cooperative R&D between Industry, Academy, and Research Institute funded Korea Small and Medium Business Administration in 2016.

6. References

1. Nahin PJ. Dr. Euler’s Fabulous Formula, Princeton University Press, Ch. 4, Sect. 4; 2006
2. Chen CT. Linear system theory and design, Oxford; 2012.
3. Orfanidis SJ. Introduction to signal processing, Prentice Hall Inc.; 2010.
4. Redzepagic S, Andjelic G, Eric D. Application of MACD and RVI indicators as functions of investment strategy optimization on the financial market, Journal of Economics and Business. 2009; 27(1):171–96.
5. Chong T T-L, Ng W-K, Liew V K-S. Revisiting performance of MACD and RSI oscillators. Journal of Risk and Financial Management. 2014; 7(1):1–12
6. Lee JY, Hwang SM. Efficient utilization condition of MACD and nontrend status detecting index. KISS Spring Proceeding; 2015. p. 630–32.
7. Kim CY. An empirical study on the usefulness of technical analysis: focusing on MACD and PBGT, Master Dissertation of KAIST; 2003
8. Sung K. Study on the trading feasibility using Gibbs effect. Collection of Journal, Daejeon University, Industrial Technical Laboratory. 2007; 18(1):10–17.
9. Hwang SM, Lee JH. Design and implementation of JAVA dynamic testing tool using instrumentation. Indian Journal of Science and Technology. 2014; 8(S1):475–80. DOI: 10.17485/ijst/2015/v8iS1/59426.