

# Backtesting Exponential Moving Average Crossover Simple Trading Strategy using R

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**Abstract**—Recently advanced mathematics and computer science is commonly applied at stocks trading to help make decision. Actually, even without using complex knowledge like machine learning and various data mining techniques, computer itself already provides a great help in supporting decision making. Computer computational power can be used to backtest a trading strategy to evaluate whether that strategy is profitable according to historical data. One tools which provide such capabilities is R programming language which is supported with various packages.

**Keywords**—exponential moving average, backtesting, R, BBICA, moving average crossover, bear, bull, signal

## I. BACKGROUND

In this modern ages, trading, especially securities, is often supported with advanced mathematics and statistics [3]. Such approach is used to make a data-backed decision rather than random gambling and speculative play. Various formulas and statistical model is derived by using mathematical knowledge.

More recently, with the growing popularity of machine learning and various mining technique, a new possibility for computer and computer science to assist securities trading is opened. But before such things is popular, computer is widely used for simulating, calculating, and testing strategies. Such strategies usually employ some kind of signal to determine buy and sell timing. In this paper, a simple trading strategy with a signal will be tested using R programming language.

## II. INTRODUCTION

One of the most common indicator used to determine a signal in trading is moving average. Basically moving average will average past n-days data for every time step. There are some varieties of moving average. The most basic are SMA (simple moving average) and EMA (exponential moving average). The main difference between SMA and EMA is that EMA gives more weight to recent data [1]. By doing this, EMA can react faster to price change compared to SMA. Of course there's pros and cons for respective MA. One of them is EMA being unstable for short-term period.

The simplest strategy to obtain signal is by using 2 MA with different range of time. The MA with smaller n-days is called fast moving average while the one with bigger n-days is called slow moving average [3]. Buy signal is generated when the fast MA crosses above the slow MA while a sell signal is generated when the fast MA crosses below the slow MA (assuming a long

position) [2]. One reasoning of such signal is a slow MA indicates trend in longer time while fast MA indicates trend in shorter term. When the crossover happens, it might indicate that momentum is shifting [2]. The period when fast MA is above the slow MA will then be referred as uptrend or bullish and the period when the fast MA is below the slow MA will be referred as downtrend or bearish. In this paper EMA-20 (past 20 days) and EMA-50 (past 50 days) will be used to make a strategy which will be backtested. Backtesting itself is using historical data to determine profitability of a strategy.

## III. TOOLS

The main tools used for the test is a programming language called R. There's various packages which are available for R. The packages which will be used in this testing includes TTR, quanstrat, devtools, IKTrading, quantmod, and their dependencies.

R has 5 basic classes of object [5]. Those classes are character, numeric, integer, complex, and logical. An object belongs to certain class. Those classes have attributes such as dimensions names, dimensions, class, and length which explain something about the object. Attributes of an object can be accessed by using the *attributes()* function [5].

R has various data types. Some of them are vector, list, matrices, and data frame [5]. A vector contains objects of same class. Vector can be created with *c()* or *vector()* function. A list is similar to a vector, but a list may contains objects with different class. A list can be created with *list()* function. Matrices is simply two dimensional vector (vector with column and row). A matrix can be created with *matrix()* function. Data frame is most commonly used in R and can be interpreted list of vector. It is used to store tabular data. A data frame can be created using *data.frame()* function.

Variables can be considered into two types. The first one is continuous variables while the second one is categorical variables. In R categorical variables are represented by factor [5]. Think a factor as some kind of label or classification. A number is not necessarily a continuous variable as number can also be used as category.

R also has control structures such as if, else, for, while, etc. Just like other programming languages, these control structures are used to control the execution flow of a program [5].

#### IV. IMPLEMENTATION

The strategy constructed in this paper is simple. Like previously stated, EMA-20 and EMA-50 are used, and when EMA-20 crosses above EMA-50, stocks will be bought and when it crosses below, the previously bought stocks will be sold. For this example Bank Central Asia Tbk. stocks with ticker BBCA will be used. The historical price data source is Yahoo Finance. BBCA data can be found as BBCA.JK there.

The backtesting will cover BBCA movements from first day of 2012 until April 1, 2017. The EMA used will use smoothing ratio of  $2/(n+1)$ .

The portfolios will initially have 100 million rupiah. The maximum buy amount will be 10% of the portfolios equity while the sell will always all of the owned stocks. The portfolios will only invest in single stock, which is BBCA. Also it is assumed that buy and sell does not need to be lot-based, (not a multiply of 100 stocks) and trading fee is not calculated. It must be noted that a real portfolios will likely invest in multiple stocks and must takes account the previously assumed factors

#### V. RESULT

From the initial processing, it is found that there are 916 bullish days and 397 bearish days. Weekends are not counted but public holidays are counted. Within those days there are 9 buy signals and 8 sell signals. The following figure is daily chart of BBCA price complete with volume and previously mentioned signals. The blue indicator at the bottom is the signal. If its value is 1, it's a buy signal and if it is -1, then it is a sell signal.

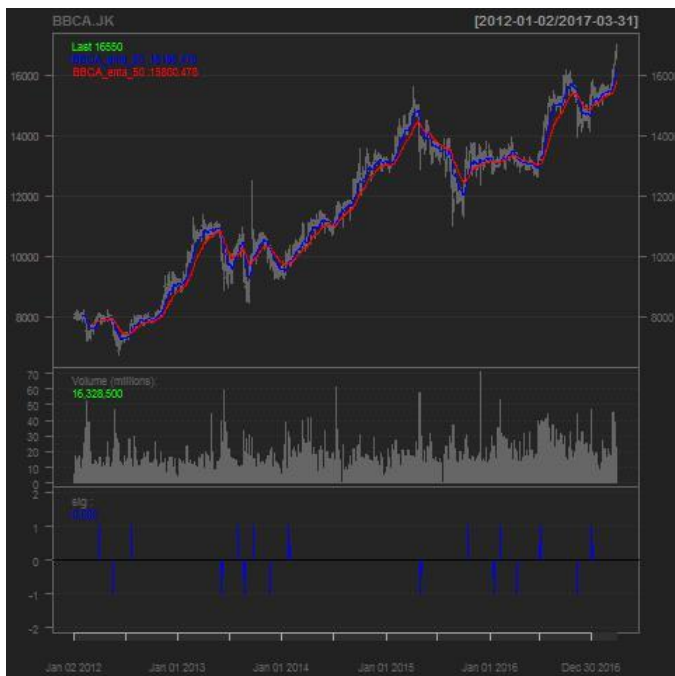


Fig. 1. Charting with signals (blue at the bottom)

Below is an example of more detailed view of the candlestick chart.

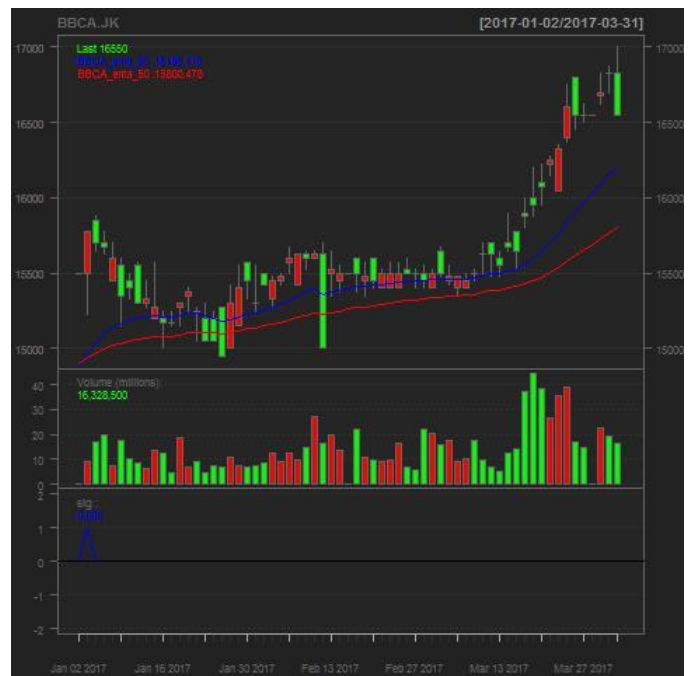


Fig. 2. Zoomed chart for 2017 with signals (blue at the bottom)

Up to April 1, 2017, there are 17 transactions (there is still floating profit by April 1, 2017). The gross profits over those time are Rp. 7,762,750.00 while the gross losses are Rp. 2,533,925.00. The end equity is Rp.105,228,825.00. The following figures illustrate equity movement in those time.

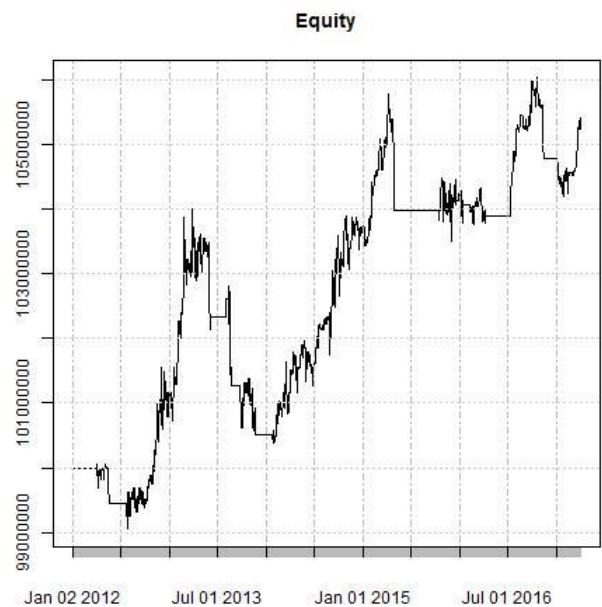


Fig. 3. Equity growth chart

In a glance this result does not seems bad as our portfolios value grow by around 5% with only 10% of our portfolios invested. This means over those 6 years, it grows by 50%. If it's compare to IDX Composite, the IDX Composite grows by

around 45% over those time. This means our strategy is more profitable compared to the average.

But, if we take a look at BBCA growth, it is more profitable to just buy it once in early 2012 and keep it. By using this simple strategy at April 1, 2017, our portfolios values grow by around 95%.

## VI. CONCLUSION

R programming language provide suitable capabilities to process data and visualize it. R also supported by various packages which provide various capabilities. One of them is the capability to evaluate proposed trading strategy on historical data known as backtesting.

By backtesting using R, it is concluded that the proposed simple Exponential Moving Average 20-50 crossover on BBCA, while still generate profit, is not a good strategy. The strategy is compared simple buy once sell once. The second simple strategy beats the profit of the first by more than 40%. This suggests that the proposed strategy is not good enough. It is of course better to avoid complex strategies which is outperformed by simpler one [4].

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## DECLARATION

With this, I hereby declare that this paper which I wrote is my own writing, not an adaptation, or translataion of other paper and is not a plagiatiion.

Bandung, 5 May 2017



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