Analyzing the Effectiveness of Candlestick Technical Trading Strategies in Foreign Exchange Market

Seyyed Behshad Yassini
Ph.D. Student, Department of Financial Management, Science and Research Branch, Islamic Azad University, Tehran, Iran

Fereydoon Rahnamay Roodposhti
Professor and Faculty Member, Department of Financial Management, Science and Research Branch, Islamic Azad University, Tehran, Iran.
(Corresponding Author)
f-rahnamayroudposhti@srbiau.ac.ir

Mir Feiz Fallahshams
Assistant Professor and Faculty Member, Department of Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.

ABSTRACT

Candlestick charts are a type of financial chart for tracking the movement of securities. Some of the earliest technical trading analysis was used to track prices of rice in the 18th century. Some investors find them more visually appealing than the standard bar charts and the price actions easier to interpret. In technical analysis, a candlestick pattern is a movement in prices shown graphically on a candlestick chart that some believe can predict a particular market movement.

In this paper it is analyzed whether various candlestick patterns can predict trends in Foreign Exchange Market. The first group of minor hypotheses include whether a candle with an inverted color proceed by these patterns. The second group analyze whether the profit of trading after various patterns is significantly profitable.

Three "open" prices of first candles are considered as different possible stop points. These three different points have different results, hence I've categorized them in three various scenarios and discussed about them separately.

At the end on the basis of minor hypotheses, it is concluded that there is not any evidence on predicting power of candlestick patterns in trend recognition. Although the rates of correct prediction of the next candle after a confirmed pattern is almost insignificant in all cases, the trading profit of confirmed patterns are significant

Keywords: Technical Analysis, Major currency-pairs, Forex, Candlestick Charts, Candlestick Patterns.

1. Introduction

The Foreign Exchange Market (FOREX) — most often called the Forex market, or simply the FX market — is the most traded financial market in the world (Rhoads, 2008). This market is the crossroads for international capital, the intersection through which global commercial and investment flows have to move (Rhoads, 2008).

Technical analysis and fundamental analysis are the two main schools of thought in the financial markets. While technical analysis concentrates on the study of market action, fundamental analysis focuses on the economic forces of supply and demand that cause prices to move higher, lower, or stay the same.

In 1750 a wealthy Japanese merchant, Munehisa Homma, began trading at his local rice exchange in Sakata using his own personal candlestick analysis. Homma became a legendary rice trader and amassed a huge fortune. Today's Japanese candlestick methodology is credited to Homma's trading principles as he applied them to the rice markets (Marshal at al., 2007).

There are some ways to classification of candlesticks. From one perspective they can be divided into two types of 'Reversal Patterns', and 'Continuation Patterns' (Nison, 1991) There is another perspective that divides candlesticks to three distinct types: 'Single-Stick Patterns', 'Double-Stick Patterns', and 'Three-Stick Patterns' (Rhoads, 2008).

Traders use technical studies to establish target points for buy and sell financial assets, whether to open or close trading positions. These traders include banks, hedge funds, equity and bond fund managers, multinational corporations, brokers, central banks, government agencies, and individuals. According to the Bank for International Settlements, as of April 2010, average daily turnover in global foreign exchange markets is estimated at $3.98 trillion, a growth of approximately 20% over the $3.21 trillion daily volume as of April 2007.

Technical analysis has become popular over the past several years, as more and more people believe that the historical performance of a stock is a strong indication of future performance. The use of past performance should not come as a big surprise. In contrast, people using fundamental analysis have always looked at the past performance by comparing fiscal data from previous quarters and years to determine future growth.

As I searched, there are very few researches those focus on candlesticks. These researches just discussed about very popular forms of patterns. There are many patterns of candlesticks that are not analyzed. Moreover I didn't find any research that focuses on applying candlesticks in Foreign Exchange Market. There were few researches about applying western instruments such as trend lines, resistance and persistence levels, various indicators, head and shoulder pattern, etc. But I didn't find any research about the profitability of candlesticks in Forex.

The keywords are defined as below:
- Forex:
  The foreign exchange market (forex, FX, or currency market) is a global decentralized market for the trading of currencies.
- Currency pair
  A currency pair is the quotation of the relative value of a currency unit against the unit of another currency in the foreign exchange market. The currency that is used as the reference is called the counter currency or quote currency and the currency that is quoted in relation is called the base currency or transaction currency
- Major currency-pairs
  Currencies are traded in pairs and exchanged one against the other. The majority of currencies are traded against the US dollar (USD). The four currencies traded most frequently after the US dollar are the euro (EUR), Japanese yen (JPY), the British pound sterling (GBP), and the Swiss franc (CHF). Some sources also include the Australian dollar (AUD) and the Canadian dollar (CAD) within the group of major currencies.
- Candlestick Patterns
  In technical analysis, a Candlestick pattern is a movement in prices shown graphically on a candlestick chart that some believe can predict a particular market movement. The patterns analyzed in this paper are hammer, hanging man, dragonfly doji, gravestone doji, long-legged doji, bearish and bullish engulfing, piercing pattern, and dark cloud cover.

2. Literature Review
2.1. Background Research

Marshal (2005) in his paper "Candlesticks Technical Trading Strategies: Can They Create Value for Investors?" examines the profitability of technical analysis, candlestick trading strategies. The literature review is divided into three major sections. In the first the extensive literature that covers the random walk and efficient market hypothesis, two of the most important concepts in modern finance are considered. In section Two, the finance literature in which attempts are made to explain financial phenomena using psychology literature is discussed. This emerging area, known as behavioral finance, suggest that seemingly irrational financial market behavior can be explained by looking at the psychological make-up of market participants. The extensive literature in which the profitability of technical trading strategies is considered is then discussed. In this section the empirical literature is divided into two categories: that which finds that technical trading strategies are not profitable once transaction costs and risk are taken into account, and that which finds that profitability of these strategies is robust to those adjustments. The former findings are consistent with market efficiency while the latter is not.

Varun Juneja (2011) in his essay "Price Behaviour Analysis of Major Forex Pairs" which include EURUSD, GBPUSD, USDCHF and USDJPY, aimed to study the four major factors - Fundamental Factors, Technical Factors, Time Factors and Correlation Factors which affect the movement of the price. The study covered these four factors and how each of them contributed to the movement of the price of the above mentioned four Forex pairs. This study has analyzed the daily and 4H prices of the four major pairs (EURUSD, GBPUSD, USDCHF and USDJPY) over a period of 8years and 6 years respectively, up until 30th April, 2011. It has analyzed two different candlestick patterns and one general technical pattern. Candlestick patterns analyzed include the pin bar and the bearish/bullish engulfing patterns whereas the technical pattern analyzed includes number of successive up moves or down moves. It has analyzed the said patterns on two time frames i.e. on a daily chart and on a 4 hourly chart. This study acknowledged that there is no 100% accurate method of trading the Forex markets. The study was aimed towards understanding the behavioral patterns of price from a trader's perspective. The project extensively used secondary data and inferred certain logical conclusions based on the behavior shown by the data. In end it concluded that the project does accomplish its aim to understand the reasoning behind price moves and lends a credible insightful eye to any trader who wishes to trade successfully in the Foreign Exchange markets.

Ramadhani and Mashaushi (2006) in their paper "An Analysis of Technical Trading Strategies" extends the literature on the efficacy of technical analysis in the direction of the `risk premium view' as an explanation for excess trading rule returns. The empirical analysis is based mainly on a sample of stocks drawn from the London Stock Exchange, (LSE), portfolios constructed from three US markets; the New York Stock Exchange, (NYSE), the American Stock Exchange, (ASE), and the National Association of Securities Dealers Automated Quotation market, (NASDAQ). Data from ten small emerging markets of Africa is also used in empirical analyses. Focusing on documented evidence of differences in risk levels among several markets or market segments, the empirical analyses examined whether these risk differentials can explain excess trading rule profits as compensation for bearing risk.

2.2. Theoretical Framework

The Forex market is the biggest and fastest growing market on the earth. The participants in this market are central and commercial banks, corporations, industrial investors, hedge funds, and private individuals. Average daily turnover in global foreign exchange markets has more than trebled over the past decade, reaching around $4 trillion in 2010, according to the 2010 BIS Triennial Central Bank Survey (O'Connor, 2011).

Technical analysis and fundamental analysis are the two main schools of thought in the financial markets. While technical analysis concentrates on the study of market action, fundamental analysis focuses on the economic forces of supply and demand that cause prices to move higher, lower, or stay the same. The fundamental approach examines all of the relevant factors affecting the price of a market in order to determine the intrinsic value of that market. The intrinsic value is what the fundamentals indicate something is actually worth based on the law of supply

and demand. If this intrinsic value is under the current market price, then the market is overpriced and should be sold. If market price is below the intrinsic value, then the market is undervalued and should be bought (Murphy, 1999). Technical analysis is the study of market action, primarily through the use of charts, for the purpose of forecasting future price trends. The term "market action" includes the three principal sources of information available to the technician- price, volume, and open interest (Murphy, 1999).

With advancements in technology and the growing availability of trading and investing resources available to traders, many options exist for the charting of securities. There are several different types of charts and dozens of variations and features to be configured on each type (Rhoads, 2008).

In 1750 a wealthy Japanese merchant, Munehisa Homma, began trading at his local rice exchange in Sakata using his own personal candlestick analysis. Homma became a legendary rice trader and amassed a huge fortune. Today's Japanese candlestick methodology is credited to Homma's trading principles as he applied them to the rice markets (Marshal at al., 2007).

In this paper 9 different candlestick patters are analyzed. They include hammer, hanging man, doji gravestone, doji dragonfly, doji long-lagged, bearish and bullish engulfing, piercing pattern, and dark cloud cover.

The hammer and hanging man can be recognized by three criteria:

1) The real body is at the upper end of the trading range. The color of the real body is not important.
2) A long lower shadow should be twice the height of the real body
3) It should have no, or a very short, upper shadow.

The longer the lower shadow, the shorter the upper shadow and the smaller the real body the more meaningful the bullish hammer or bearish hanging man. Although the real body of the hammer or hanging man can be white or black, it is slightly more bullish if the real body of the hammer is white, and slightly more bearish if the real body of the hanging man is black. If a hammer has a white real body it means the market sold off sharply during the session and then bounced back to close at, or near, the session's high. This could have bullish ramifications. If a hanging

man has a black real body, it shows that the close could not get back to the opening price level. This could have potentially bearish implications. (Nison, 1991)

The Doji is one of the most important signals in Candlestick analysis. It is formed when the open and the close are the same or nearly the same. The lengths of the shadows can vary. The longer the shadows are, the more significance the Doji becomes. The Dragonfly Doji occurs when trading opens, trades lower, and then closes at the open price that is the high of the day. At the top of the market, it becomes a variation of the Hanging Man. At the bottom of a trend, it becomes a specific Hammer. An extensively long shadow on a Dragonfly Doji at the bottom of a trend is very bullish.

The Long Legged Doji is comprised of long upper and lower shadows. The price opened and closed in the middle of the trading range. Throughout the day, the price moved up and down dramatically before it closed at or near the opening price. This reflects the great indecision that exists between the bulls and the bears. (Bigalow, 2002)

There are three criteria for an engulfing pattern:

1) The market has to be in a clearly definable uptrend or downtrend, even if the trend is short term.
2) Two candlesticks comprise the engulfing pattern. The second real body must engulf the prior real body (it need not engulf the shadows).
3) The second real body of the engulfing pattern should be the opposite color of the first real body. (The exception to this rule is if the first real body of the engulfing pattern is so small it is almost a doji (or is a doji). Thus, after an extended downtrend, a tiny white real body engulfed by a very large white real body could be a bottom reversal. In an uptrend, a minute black real body enveloped by a very large black real body could be a bearish reversal pattern) (Nison, 1991).

The following is a list of some factors that intensify the importance of dark-cloud covers:

1) The greater the degree of penetration of the black real body's close into the prior white real body, the greater the chance for a top.

If the black real body covers the prior day's entire white body, a bearish engulfing pattern would occur. The dark-cloud cover's black real body only gets partially into the white body. Think of the dark-cloud cover as a partial solar eclipse blocking out part of the sun (that is, covers only part of the prior white body). The bearish engulfing pattern can be viewed as a total solar eclipse blocking out the entire sun (that is, covers the entire white body). A bearish engulfing pattern, consequently, is a more meaningful top reversal. If a long, white real body closes above the highs of the dark-cloud cover, or the bearish engulfing pattern, it could presage another rally.

2) During a prolonged uptrend, if there is a strong white day which opens on its low (that is, a shaven bottom) and closes on its high (that is, a shaven head) and the next day reveals a long black real body day, opening on its high and closing on its low, then a shaven head and shaven bottom black day have occurred.

3) If the second body (that is, the black body) of the dark-cloud cover opens above a major resistance level and then fails, it would prove the bulls were unable to take control of the market.

4) If, on the opening of the second day there is very heavy volume, a buying blow off could have occurred. For example, heavy volume at a new opening high could mean that many new buyers have decided to jump aboard ship. Then the market sells offs. It probably won't be too long before this multitude of new longs (and old longs who have ridden the uptrend) realize that the ship they jumped onto is the Titanic. For futures traders, very high opening interest can be another warning (Nison, 1991).

The bullish piercing pattern is akin to the bullish engulfing pattern. In the bullish engulfing pattern the white real body engulfs the previous black real body. With the bullish piercing pattern, the white real body only pierces the prior black body. In the piercing pattern, the greater the degree of penetration into the black real body, the more likely it will be a bottom reversal. An ideal piercing pattern will have a white real body that pushes more than halfway into the prior session's black real body. If the market closes under the lows of the bullish engulfing pattern or the piercing pattern by way of a long black candlestick, then another down leg should resume (Nison, 1991).

To analyzing the prediction power of candlestick patterns we can consider these major and minor hypotheses.

3. Methodology

"MetaTrader 4.0" is used for data downloading. In this paper I selected 1H (hourly), 4H (4-hourly), and 1D (daily) data, because firstly most of traders use these time intervals and secondly they include both short-term and long-term periods. Also three major currency pair are selected: EURUSD, USDJPY, and GBPUSD. The forex market is open 24 hours a day from 5pm EST on Sunday until 4pm EST Friday.

In this dissertation, for more accurate result, a vast range of data in each group of time frame are selected. Ten years of daily, every four hours (4-hourly), and hourly data are downloaded through the software. These data start from December 1st, 2002 till November 30th, 2012. It means there are about 2600 daily set of data, 15600 4-hourly, and 62400 hourly set of data include OHLC prices & volume for each EURUSD, GBPUSD, and USDJPY currency-pairs.

First of all the "color of candle body" is determined with regard to closing price of each candle and its opening price. The "length of body" is calculated by subtracting the closing price from the opening price. The "upper shadow" is equal to difference between high price and the upper side of candle body. And the "lower shadow" is calculated by subtracting the low price and the lower shadow of a candle.

For trend recognition the averages of last four closing prices are calculated. If the averages are in an ascending order, there is a bullish trend, vice versa if the averages are in a descending order, there is a bearish trend, and else there is not any trend.

With regard to previous calculations, nine different patterns are identified. The characteristics of each pattern are very critical to recognize them accurately. These characteristics are studied in different

candlesticks books. Fortunately most of writers introduce patterns in a same way and mention similar criteria for them. One on the best books in this field is written by Thomas N. Bulkowski, "Encyclopedia of Candlestick Charts". The summary of properties of these patterns are listed in the following table (Exhibit 1).

Some criteria used for pattern recognition: length of bodies, length of shadows, comparative lengths of bodies, comparative lengths of shadows, previous trend, and next trend. Percentile indices are used to recognize comparative lengths of bodies and shadows. 10th, 30th, 70th, and 90th percentiles are used to recognize lengths and shadows as "very short", "short", "medium", "long", and "very long".

Exhibit1, Properties of Patterns

	Candles	Color$_{-1}$	Color$_0$	RB$_{-1}$	RB$_0$	LS	US	PT	NT	Other Criteria			Power Indices		
Hammer	1	-	ND	-	Sh	Ln	VS	DT	UT	LS>= 2*RB			Volume		
Hanging Man	1	-	ND	-	Sh	Ln	VS	UT	DT	LS>= 2*RB			Volume		
Doji Long Leged	1	-	ND	-	VS	VL	VL	ND	ND				Volume		
Doji Gravestone	1	-	ND	-	VS	VS	Ln	UT	DT				Volume		
Doji Dragomfly	1	-	ND	-	VS	Ln	VS	DT	UT				Volume		
Bullish Engulfing	2	B	W	-	Ln	ND	ND	DT		$C_{-1}{>}{=}O_0$	$O_{-1}{<}C_0$		Volume	2nd Length	1st is short
Bearish Engulfing	2	W	B	-	Ln	ND	ND	UT		$C_{-1}{>}{=}O_0$	$O_{-1}{<}C_0$		Volume	2nd Length	1st is short
Piercing Pattern	2	B	W	Ln	Ln	ND	ND	DT		$O_0{<}{=}C_{-1}$	$C_0{>}0.5{*}RB_{-1}$	$C_0{<}O_{-1}$	Volume	Length 1st	2nd Length
Dark Cloud Cover	2	W	B	Ln	Ln	ND	ND	UT		$O_0{>}{=}C_{-1}$	$C0{<}0.5{*}RB_{-1}$	$C_0{>}O_{-1}$	Volume	Length 1st	2nd Length

The abbreviations of the previous table are in exhibit2.

Exhibit2, the Abbreviations

Abbr.							
RB	Real Body	VS	Very Short	H	High	B	Black - Down
UT	Up Trend	Sh	Short	L	Low	W	White- Up
LS	Lower Shadow	Md	Medium	C	Close	ND	Not Definition
US	Upper Shadow	Ln	Long	O	Open		
NT	Next Trend	VL	Very Long				
PT	Previous Trend						

Major Hypotheses:

A. Various candlestick patterns predict candles and trends in Foreign Exchange Market effectively.

Minors Hypotheses:

A1. A candle with an inverted color proceed by a pattern of "Hammer".

A2. A candle with an inverted color proceed by a pattern of "Hanging Man".

A3. A candle with an inverted color proceed by a pattern of "Doji Long-Leged".

A4. A candle with an inverted color proceed by a pattern of "Doji Gravestone".

A5. A candle with an inverted color proceed by a pattern of "Doji Dragonfly".

A6. A candle with an inverted color proceed by a pattern of "Bullish Engulfing".

A7. A candle with an inverted color proceed by a pattern of "Bearish Engulfing".

A8. A candle with an inverted color proceed by a pattern of "Piercing Pattern".

A9. A candle with an inverted color proceed by a pattern of "Dark Cloud Cover".

A10. The profit of trading after a pattern of "Hammer" is significantly profitable.

A11. The profit of trading after a pattern of "Hanging Man" is significantly profitable.

A12. The profit of trading after a pattern of "Doji Long-Leged" is significantly profitable.

A13. The profit of trading after a pattern of "Doji Gravestone" is significantly profitable.

A14. The profit of trading after a pattern of "Doji Dragonfly" is significantly profitable.

A15. The profit of trading after a pattern of "Bullish Engulfing" is significantly profitable.

A16. The profit of trading after a pattern of "Bearish Engulfing" is significantly profitable.

A17. The profit of trading after a pattern of "Piercing Pattern" is significantly profitable.

A18. The profit of trading after a pattern of "Dark Cloud Cover" is significantly profitable.

Scenario Analysis

After emerging and forming a specific pattern, the trade can be started. The point that the position is closed is also a key factor in calculations of loss and profit of trades. It can be closed after the first, second, or other next candles. In each case the profit and loss can be different, while to define a profitable strategy we must specify the time point of inverse position taking.

As described in the last paragraph, On the other hand, for diagnosis of trend direction one to four previous candles have been used, so I considered the first, second, and the third candles as different possible points for finishing the trades. These three different points have different results, hence I've categorized them in three various scenarios and discussed about them separately.

The tests are done in each scenario separately. In the first scenario, the trade starts just right after closing the candle of recognized pattern and closes after closing of the first next candle. The position is taken with regard to some factors like color of candle pattern, direction of pattern, and previous trend. In the second and third scenario the position is closed after closing the second and third next candles. All the tests are analyzed in different categories based on these various scenarios.

Abbreviations used in Exhibits

In the exhibits of this part some abbreviations are used. They are listed here (exhibit 3):

Exhibit 3: The abbreviations used in Exhibits

P1	Pattern 1, Hammer
P2	Pattern 2, Hanging Man
P3	Pattern 3, Long-Leged DOJI
P4	Pattern 4, Gravestone DOJI
P5	Pattern 5, Dragonfly DOJI
P6	Pattern 6, Bullish Engulfing
P7	Pattern 7, Bearish Engulfing
P8	Pattern 8, Piercing Pattern
P9	Pattern 9, Dark Cloud Cover

The following exhibits (exhibit 4) shows the volume of downloaded data of three currency-pairs in three different time-zones.

Exhibit 4: Volume of downloaded data

	daily	4-hourly	hourly
Daily	2605	11593	61950
4-Hourly	2602	11582	61918
Hourly	2602	11581	61929

The number of observed patterns are summarized in the following exhibits (exhibit 5 to 7):

Exhibit 5: Number of observed patterns

ALL Sgnls.	P1	P2	P3	P4	P5	P6	P7	P8	P9
EURUSD-D1	4	8	3	2	6	16	20	3	6
GBPUSD-D1	7	4	10	5	3	15	19	8	5
USDJPY-D1	5	3	3	2	4	16	14	8	7
EURUSD-H4	23	18	21	10	12	70	77	35	37
GBPUSD-H4	20	19	21	5	9	77	80	45	42
USDJPY-H4	23	20	27	7	13	88	90	58	27
EURUSD-H1	88	84	91	30	33	363	351	199	170
GBPUSD-H1	70	92	81	31	33	375	354	215	172
USDJPY-H1	78	67	142	32	40	408	353	202	158

Exhibit 6: Number of observed patterns with a buying signal

BUY Sgnls.	P1	P2	P3	P4	P5	P6	P7	P8	P9
EURUSD-D1	4	0	2	0	6	16	0	3	0
GBPUSD-D1	7	0	7	0	3	15	0	8	0
USDJPY-D1	5	0	3	0	4	16	0	8	0
EURUSD-H4	23	0	14	0	12	70	0	35	0
GBPUSD-H4	20	0	12	0	9	77	0	45	0
USDJPY-H4	23	0	21	0	13	88	0	58	0
EURUSD-H1	88	0	67	0	33	363	0	199	0
GBPUSD-H1	70	0	47	0	33	375	0	215	0
USDJPY-H1	78	0	109	0	40	408	0	202	0

Exhibit 7: Number of observed patterns with a selling signal

SELL Sgnls.	P1	P2	P3	P4	P5	P6	P7	P8	P9
EURUSD-D1	0	8	1	2	0	0	20	0	6
GBPUSD-D1	0	4	3	5	0	0	19	0	5
USDJPY-D1	0	3	0	2	0	0	14	0	7
EURUSD-H4	0	18	7	10	0	0	77	0	37
GBPUSD-H4	0	19	9	5	0	0	80	0	42
USDJPY-H4	0	20	6	7	0	0	90	0	27
EURUSD-H1	0	84	24	30	0	0	351	0	170
GBPUSD-H1	0	92	34	31	0	0	354	0	172
USDJPY-H1	0	67	33	32	0	0	353	0	158

4. Results
Scenario 1
a. Rates of correct prediction of the next candle
'Success Rates' of prediction of the next candle in this scenario are calculated and listed below (exhibit 8). As it is shown, in 75% of the cases in daily data of EURUSD, the color of the first next candle is predicted correctly after a 'hammer' pattern.

b. Meaningfulness of 'Success Rates'
The figures in the previous exhibit are tested whether or not they are significant. Those have been tested in three different confidence levels (90%, 95%, and 99%). The figure '0' represent if the result is not meaningful and '1' represent if the result is meaningful (exhibit 9).

As it is shown, the profit is not significant in daily data of EURUSD, after a 'hammer' pattern (pattern 1) in none of the confidence levels. The only significant profit is about daily EURUSD data, after the third

pattern (Long-Leged DOJI) in confidence level of 90%.

c. Meaningfulness of the Profit
The profit after each candlestick patterns have been calculated in all currency-pairs. In this scenario this figure is based on the first next candle. A part of these figures are shown in the following exhibit (exhibit 10).

These figures are for daily EURUSD in all patterns. In the first part the first next candle is the basis of calculations. The second and third parts are related to the calculations of profit/loss to the second and third next candles.

There are three rows in each part. The first row shows the amount of profit and loss. The second row shows 'standard deviation' of profits and losses. In the third row, the statistic is calculated based on amount of profit or loss, standard deviation, and the sample size. This statistic has been compared with three P-Values of 1%, 5%, and 10%. The meaningfulness of profits to the next closing price are tested in three confidence levels (90%, 95%, and 99%). The results are listed in the following exhibit (exhibit 11).

The figure '0' represent if the result is not meaningful and '1' represent if the result is meaningful. For example the profit is meaningful in EURUSD daily data after a candlestick 'hammer' pattern.

Exhibit 8: rates of correct prediction of the next candle

Pattern		1	2	3	4	5	6	7	8	9
Daily	EURUSD	75%	50%	100%	50%	17%	50%	50%	67%	67%
	GBPUSD	57%	50%	50%	60%	67%	60%	58%	50%	60%
	USDJPY	20%	67%	0%	50%	75%	50%	50%	25%	57%
4-Hourly	EURUSD	30%	44%	48%	80%	42%	51%	40%	49%	41%
	GBPUSD	60%	32%	33%	20%	33%	48%	44%	60%	52%
	USDJPY	52%	50%	44%	57%	31%	52%	48%	48%	52%
Hourly	EURUSD	51%	55%	47%	47%	55%	41%	48%	48%	50%
	GBPUSD	57%	55%	53%	58%	67%	50%	50%	50%	51%
	USDJPY	50%	48%	51%	59%	53%	46%	49%	49%	55%

Exhibit 9: Meaningfulness of 'success rates'

Pattern			1	2	3	4	5	6	7	8	9
Daily	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	1	0	0	0	0	0	0
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
4-Hourly	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
Hourly	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0

Exhibit 10: a part of profit

EURUSD-H1		P1	P2	P3	P4	P5	P6	P7	P8	P9
Candle 1	Prft Ave.	-0.01587	0.00652	-0.00535	-0.00249	0.00004	-0.05038	-0.02563	-0.05203	-0.01414
	stdev	0.00137	0.00142	0.00252	0.00158	0.00161	0.00198	0.00195	0.00202	0.00217
	Stat	-108.36	41.9374	-20.2253	-8.60932	0.1429	-483.863	-246.803	-363.177	-84.9735
Candle 2	Prft Ave.	-0.01792	0.03075	0.05456	-0.01149	0.00323	-0.04265	-0.05544	0.02460	-0.00429
	stdev	0.00208	0.00214	0.00461	0.00244	0.00134	0.00305	0.00279	0.00303	0.00320
	Stat	-80.8788	131.389	112.914	-25.7996	13.8356	-266.703	-372.469	114.505	-17.4587
Candle 2	Prft Ave.	-0.04481	-0.02614	0.02460	-0.03320	-0.00559	-0.07184	-0.07921	-0.00354	0.03973
	stdev	0.00231	0.00242	0.00495	0.00247	0.00203	0.00370	0.00347	0.00366	0.00411
	Stat	-181.784	-98.8258	47.3859	-73.5912	-15.8313	-369.576	-427.258	-13.6289	125.969

Exhibit 11: meaningfulness of the profit

Pattern			1	2	3	4	5	6	7	8	9
Daily	EURUSD	1%	1	0	0	0	0	1	1	0	0
		5%	1	0	1	0	0	1	1	0	0
		10%	1	0	1	0	0	1	1	1	1
	GBPUSD	1%	0	0	1	1	0	1	1	0	0
		5%	0	0	1	1	0	1	1	0	1
		10%	0	0	1	1	0	1	1	0	1
	USDJPY	1%	0	0	0	0	1	0	1	0	1
		5%	0	0	0	0	1	1	1	0	1
		10%	0	0	0	0	1	1	1	0	1
4-Hourly	EURUSD	1%	0	0	1	1	0	0	0	1	0
		5%	0	0	1	1	0	0	0	1	0
		10%	0	0	1	1	0	0	0	1	0

Pattern			1	2	3	4	5	6	7	8	9
	GBPUSD	1%	1	0	0	0	0	1	0	1	1
		5%	1	0	0	0	0	1	1	1	1
		10%	1	0	0	0	0	1	1	1	1
	USDJPY	1%	0	0	1	0	0	1	0	0	0
		5%	0	0	1	0	0	1	0	0	0
		10%	0	0	1	0	0	1	0	0	0
Hourly	EURUSD	1%	0	1	0	0	0	0	0	0	0
		5%	0	1	0	0	0	0	0	0	0
		10%	0	1	0	0	0	0	0	0	0
	GBPUSD	1%	0	0	1	1	1	1	0	1	1
		5%	0	0	1	1	1	1	0	1	1
		10%	0	0	1	1	1	1	0	1	1
	USDJPY	1%	1	1	1	1	1	1	0	0	1
		5%	1	1	1	1	1	1	0	0	1
		10%	1	1	1	1	1	1	0	0	1

Scenario 2

a. Rates of correct prediction of the next candle

'Success Rates' of prediction of the next candle in this scenario are calculated and listed below. As it is shown, in 50% of cases in daily data of EURUSD, the color of the second next candle is predicted correctly after a 'hammer' pattern (exhibit 12)

b. Meaningfulness of 'Success Rates'

The figures in the previous exhibit are tested whether or not they are significant. Those have been tested in three different confidence levels (90%, 95%, and 99%). The figure '0' represent if the result is not meaningful and '1' represent if the result is meaningful. (Exhibit13)

For example as it is shown, the success rates is not significant in any of the daily data of EURUSD, GBPUSD, and USDJPY after all nine patterns in none of the confidence levels.

c. Meaningfulness of the Profit

The profit after each candlestick patterns have been calculated in all currency-pairs. In this scenario this figure is based on the second next candle.

The meaningfulness of the profits to the 2nd next closing price are tested in three confidence levels (90%, 95%, and 99%). The results are listed in the following exhibit (exhibit 14).

The figure '0' represent if the result is not meaningful and '1' represent if the result is meaningful. For example the profit is meaningful in EURUSD daily data to the second closing price after a candlestick 'bearish engulfing' pattern (P7).

Exhibit 12: rates of correct prediction of the next candle

%Success		P1	P2	P3	P4	P5	P6	P7	P8	P9
Daily	EURUSD	50%	50%	33%	100%	50%	56%	60%	0%	50%
	GBPUSD	29%	50%	20%	60%	67%	67%	58%	75%	60%
	USDJPY	20%	67%	67%	50%	50%	50%	50%	75%	29%
4-Hourly	EURUSD	48%	67%	24%	40%	58%	43%	42%	43%	59%
	GBPUSD	45%	47%	52%	80%	56%	49%	44%	49%	62%
	USDJPY	65%	45%	48%	43%	62%	47%	37%	69%	52%
Hourly	EURUSD	51%	55%	52%	50%	52%	50%	50%	53%	48%
	GBPUSD	53%	53%	49%	42%	64%	50%	44%	56%	51%
	USDJPY	50%	63%	51%	53%	55%	51%	47%	53%	44%

Exhibit 13: Meaningfulness of 'success rates'

Pattern			1	2	3	4	5	6	7	8	9
Daily	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
4-Hourly	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
Hourly	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0

Exhibit 14: meaningfulness of the profit

Pattern			1	2	3	4	5	6	7	8	9
Daily	EURUSD	1%	0	0	0	1	0	0	1	0	0
		5%	0	0	0	1	0	0	1	0	1
		10%	0	0	0	1	0	0	1	0	1
	GBPUSD	1%	0	0	0	1	1	1	1	1	0
		5%	0	0	0	1	1	1	1	1	0
		10%	0	0	0	1	1	1	1	1	0
	USDJPY	1%	0	1	1	0	1	1	0	1	0
		5%	0	1	1	0	1	1	0	1	0
		10%	0	1	1	0	1	1	0	1	0
4-Hourly	EURUSD	1%	0	1	0	0	0	0	0	0	1
		5%	0	1	0	0	0	0	0	0	1
		10%	0	1	0	0	0	0	0	0	1
	GBPUSD	1%	0	0	1	0	1	0	0	1	1
		5%	0	0	1	0	1	0	0	1	1
		10%	0	0	1	0	1	0	0	1	1
	USDJPY	1%	1	1	0	0	0	0	0	1	1
		5%	1	1	0	0	0	0	0	1	1
		10%	1	1	0	0	0	0	0	1	1
Hourly	EURUSD	1%	0	1	1	0	1	0	0	1	0
		5%	0	1	1	0	1	0	0	1	0
		10%	0	1	1	0	1	0	0	1	0
	GBPUSD	1%	1	1	0	0	1	0	0	1	1
		5%	1	1	0	0	1	0	0	1	1
		10%	1	1	0	0	1	0	0	1	1

Pattern		1	2	3	4	5	6	7	8	9
USDJPY	1%	0	1	1	0	1	1	0	1	0
	5%	0	1	1	0	1	1	0	1	0
	10%	0	1	1	0	1	1	0	1	0

Scenario 3

a. Rates of correct prediction of the next candle

'Success Rates' of prediction of the next candle in this scenario are calculated and listed below. As it is shown, in 25% of cases in daily data of EURUSD, the color of the third next candle is predicted correctly after a 'hammer' pattern (exhibit 15).

b. Meaningfulness of 'Success Rates'

The figures in the previous exhibit are tested whether or not they are significant. Those have been tested in three different confidence levels (90%, 95%, and 99%). The figure '0' represent if the result is not meaningful and '1' represent if the result is meaningful (exhibit 16).

For example as it is shown, the success rates is not significant in any of the daily data of EURUSD,

GBPUSD, and USDJPY after all nine patterns in none of the confidence levels.

c. Meaningfulness of the Profit

The profit after each candlestick patterns have been calculated in all currency-pairs. In this scenario this figure is based on the third next candle.

The meaningfulness of the profits to the 3rd next closing price are tested in three confidence levels (90%, 95%, and 99%). The results are listed in the following exhibit (exhibit 17).

The figure '0' represent if the result is not meaningful and '1' represent if the result is meaningful. For example the profit is meaningful in GBPUSD daily data after the third candlestick 'Piercing' pattern (P8).

Exhibit 15: rates of correct prediction of the third next candle

%Success		Hammer	Hanging Man	Long-Legged Doji	Gravestone Doji	Dragonfly Doji	Bullish Engulfing	Bearish Engulfing	Piercing Pattern	Dark Cloud Cover
Daily	EURUSD	25%	25%	33%	100%	67%	31%	45%	67%	33%
	GBPUSD	43%	50%	60%	60%	0%	20%	47%	50%	60%
	USDJPY	80%	33%	67%	100%	50%	50%	71%	38%	43%
4-Hourly	EURUSD	52%	39%	57%	20%	33%	47%	60%	46%	65%
	GBPUSD	55%	47%	43%	60%	67%	44%	48%	44%	48%
	USDJPY	52%	40%	52%	14%	31%	50%	62%	50%	30%
Hourly	EURUSD	43%	46%	54%	37%	45%	51%	50%	47%	51%
	GBPUSD	53%	51%	54%	45%	58%	57%	51%	55%	52%
	USDJPY	44%	55%	51%	59%	73%	46%	46%	51%	61%

Exhibit 16: Meaningfulness of 'success rates'

Pattern			1	2	3	4	5	6	7	8	9
Daily	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
4-Hourly	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0

Pattern			1	2	3	4	5	6	7	8	9
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
Hourly	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	GBPUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0
	USDJPY	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	0	0	0	0	0	0

Exhibit 17: meaningfulness of the profit

	Pattern			1	2	3	4	5	6	7	8	9
Daily	EURUSD	1%	0	0	0	0	0	0	0	0	0
		5%	0	0	0	0	0	0	0	0	0
		10%	0	0	0	1	0	0	0	1	0
	GBPUSD	1%	0	0	0	1	0	0	0	1	0
		5%	0	0	0	1	0	0	1	1	0
		10%	0	0	0	1	0	0	1	1	0
	USDJPY	1%	1	0	0	0	0	0	1	0	0
		5%	1	0	0	1	1	0	1	0	0
		10%	1	0	0	1	1	0	1	0	0
4-Hourly	EURUSD	1%	0	0	1	0	0	0	1	0	1
		5%	0	0	1	0	0	0	1	0	1
		10%	0	0	1	0	0	0	1	0	1
	GBPUSD	1%	0	0	0	1	0	0	0	1	0
		5%	0	0	0	1	0	0	0	1	0
		10%	0	0	1	1	0	0	0	1	0
	USDJPY	1%	1	0	1	0	0	1	1	1	0
		5%	1	0	1	0	0	1	1	1	0
		10%	1	0	1	0	0	1	1	1	0
Hourly	EURUSD	1%	0	0	1	0	0	0	0	0	1
		5%	0	0	1	0	0	0	0	0	1
		10%	0	0	1	0	0	0	0	0	1
	GBPUSD	1%	1	1	1	1	0	0	0	1	1
		5%	1	1	1	1	0	0	0	1	1
		10%	1	1	1	1	0	0	0	1	1
	USDJPY	1%	0	1	1	1	1	0	0	0	1
		5%	0	1	1	1	1	0	0	0	1
		10%	0	1	1	1	1	0	0	0	1

Identification of Appropriate ARIMA Model

By plotting the 'autocorrelation' (ACF) and 'partial autocorrelation' (PACF) one could determine the appropriate lags p in an AR (p) model or in an extended ARIMA(p,d,q) model.

In all cases autocorrelation have decreased gradually. On the other hand, partial autocorrelation plots of the differenced data with a 95% confidence band shows that only the partial autocorrelation at lag 1 is significant. Based on the partial autocorrelation plot, an AR(1) model is suggested for the differenced data. As a sample, exhibits 18 shows ACF and PACF of the first three cases.

Exhibit 18: ACF & PACF of EURUSD
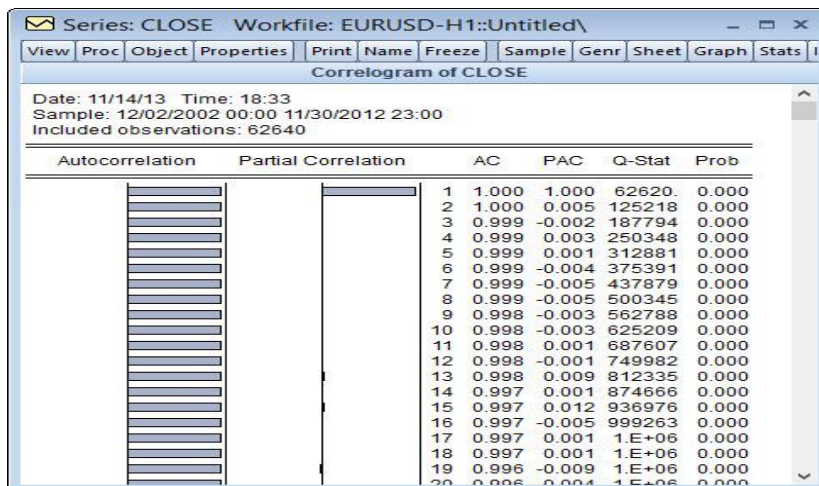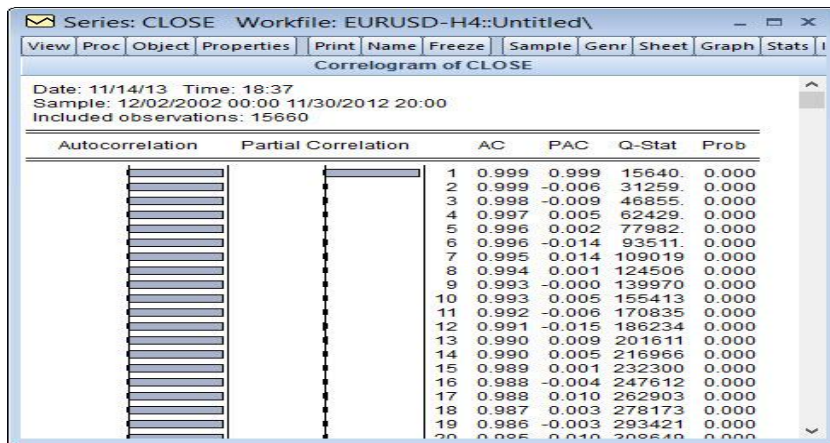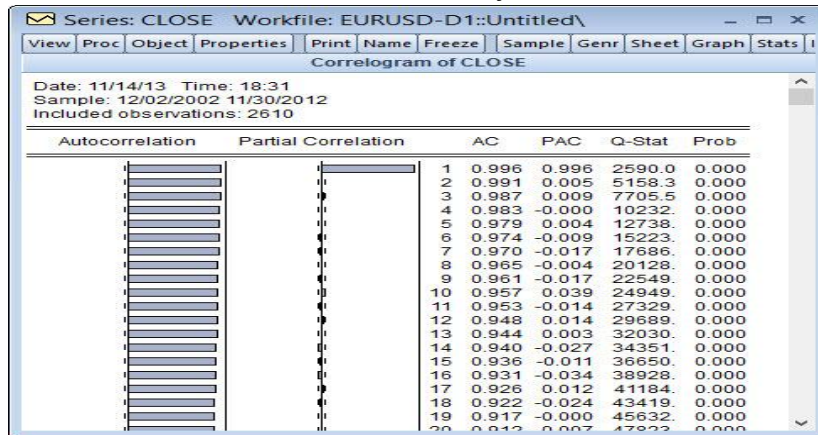
Using AR(1) Model

The results of AutoRegressive testing model are summarized in the following exhibit (exhibit19).

Forecasting by AR(1)

AR(1) model is used to forecast future data as a function of past data. The results are diagramed in three categories and the first one is shown in exhibits 20.

Exhibit 4.19: AR(1) model results

	EURUSD- H1	EURUSD- H4	EURUSD-D1	GBPUSD- H1	GBPUSD- H4	GBPUSD-D1	USDJPY-H1	USDJPY-H4	USDJPY-D1
Intercept	1.3351	1.3366	1.3356	1.7345	1.7360	1.7368	87.915	87.238	87.183
Std. Err.	0.0392	0.0396	0.0396	0.1003	0.1020	0.1043	15.313	16.233	15.789
t-Stat.	34.077	33.744	33.767	17.298	17.028	16.660	5.7412	5.3740	5.5218
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Slope	0.9998	0.9993	0.9959	0.9999	0.9997	0.9981	0.9999	0.9998	0.9989
Std. Err.	0.0000	0.0002	0.0015	0.0000	0.0002	0.0012	0.0000	0.0001	0.0009
t-Stat.	16034	4064.4	661.86	19411	4932.2	839.45	26698	6862.3	1143.5
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.9998	0.9991	0.9941	0.9998	0.9994	0.9963	0.9999	0.9997	0.9980
Adj. R-squ.	0.9998	0.9991	0.9941	0.9998	0.9994	0.9963	0.9999	0.9997	0.9980
S.E. Reg.	0.0018	0.0035	0.0087	0.0022	0.0043	0.0103	0.1383	0.2683	0.6560
Akaike Inf.	-9.8465	-8.4825	-6.6521	-9.4240	-8.0660	-6.3177	-1.1182	0.2065	1.9956
Schwarz cri.	-9.8462	-8.4815	-6.6476	-9.4237	-8.0650	-6.3132	-1.1179	0.2074	2.0001
Hann.-Quin.	-9.8464	-8.4822	-6.6505	-9.4239	-8.0657	-6.3160	-1.1181	0.2068	1.9972
Dur.-Wat.	2.0165	1.9836	2.0204	2.0345	2.0131	1.9488	2.0290	2.0377	2.1158

Exhibit 4.20: forecasting EURUSD-H1 using AR(1) Model
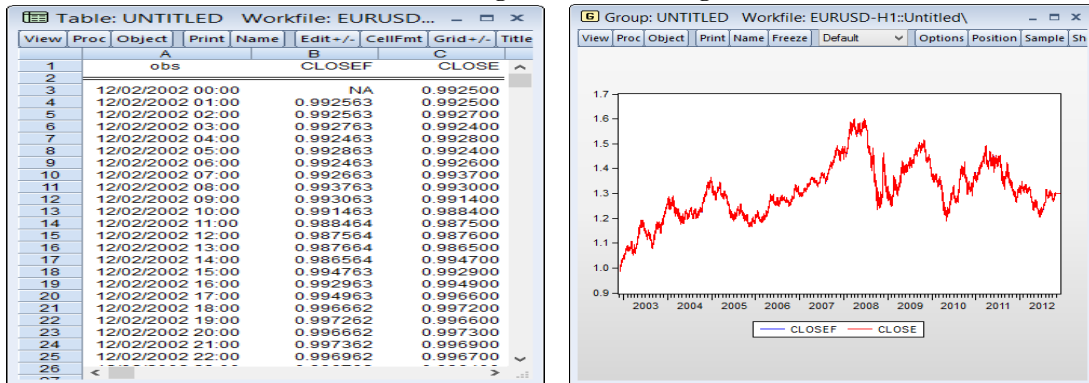
5. Discussion and Conclusions

On the basis of minor hypotheses, there is not any evidence that we can say "various candlestick patterns predict candles and trends in Foreign Exchange Market effectively", so we can reject this main hypothesis.

The success rates of correct prediction of the next candle after a confirmed pattern is almost insignificant in all cases. We can conclude that "a reversal pattern does not proceed by a confirmed candle" in all mentioned patterns, so all these hypotheses are rejected.

The profit is significant in many cases, especially about 4-hourly and hourly data. This meaningful profit include all patterns. It can be said that "the profit of trading after all mentioned confirmed patterns is significantly profitable".

Partial autocorrelation plots of the differenced data with a 95% confidence band shows that only the partial autocorrelation at lag 1 is significant. Based on the partial autocorrelation plot, an AR(1) model is suggested for the differenced data.

The rate of success after the first candle (in the 1st scenario) is not significant almost in all the time zones and about all patterns. This rate is significant in none of the time zones after the second and third candles (in the 2nd and 3rd scenario), thus it is obvious that "a candle with an inverted color does not proceed by any mentioned patterns".

The profit is sometimes significant and sometimes insignificant. The profits of hourly USDJPY (the 1st scenario) are almost significant about all patterns except patterns 7 and 8. On the other hand the profits after patterns 6 and 7 are significant in daily data of all currency-pairs. There is not obvious different in various time zones and patterns, except this point that pattern 7 has a better result in daily data and a worse result in hourly data in all the scenarios.

The next trend is not recognized correctly in any of the cases. This include all patterns, all time zones, all currency-pairs, and all the scenarios. A reversal trend is not proceed by mentioned patterns and these all hypotheses are rejected.

There is not any evidence that we can say "various candlestick patterns predict candles and trends in Foreign Exchange Market effectively".

The success rates of correct prediction of the next candle after a confirmed pattern is almost insignificant in all cases, so "a reversal pattern does not proceed by a confirmed candle" in all mentioned patterns, so all these hypotheses are rejected.

The profit (after a confirmed pattern) is significant in many cases, especially about 4-hourly and hourly data. This meaningful profit include all patterns. It can be said that "the profit of trading after all mentioned confirmed patterns is significantly profitable".

Although the success rates of correct prediction of the next candle after a confirmed pattern is almost insignificant in all cases, but the profit of trading after this confirmation can be significant. We can conclude that a confirmed pattern could be profitable in all mentioned patterns.

The suited ARIMA Model could not predict the reverse trends after patterns.

The suited ARIMA Model can predict the color of the next candle after all mentioned patterns (except patterns 4 and 5) in hourly data. The next candle color has been rarely predicted correctly in 4-hourly and especially daily data.

The suited ARIMA Model cannot predict the next trend after mentioned patterns, but it could help to predict the color of next candle in hourly data.

Marshal (2005) in his paper "Candlesticks Technical Trading Strategies: Can They Create Value for Investors?" founds that technical trading strategies are not profitable once transaction costs and risk are taken into account, and that which finds that profitability of these strategies is robust to those adjustments. By using an innovative extension of the bootstrap methodology, which allows the generation of random open, high, low and close prices, to test the profitability of candlestick technical trading strategies, he showed that candlestick technical analysis does not have value. Although this conclusion is consistent with the first hypothesis of our research, but the findings of this research are based on statistical tests of historical data. Moreover the second hypothesis shows that in the case of first candle confirmation after a specific trend, the profit of trading can be significant.

References
1) Bigalow Stephan W., "Profitable Candlestick Trading", Wiley Publishing, Inc., 2002
2) Varun Juneja, "Price Behaviour Analysis of Major Forex Pairs", MBA dissertation, University of Strathclyde, 2011

3) Marshal Benjamin Richard, "Candlestick Technical Trading Strategies: Can They Create Value for Investors?", PhD. dissertation in finance, Massey University, New Zealand, 2005

4) Marshal Ben R., Young R. Martin, Rose C. Lawrence, "Making Time with Candlestick Technical Analysis", Journal of financial transformation, Sep. 2007

5) Murphy John J., "Technical Analysis of the Financial Markets", New York Institute of Finance, 1999

6) Nison Steve, "Japanese Candlestick Charting Techniques", New York Institute of Finance, 1991

7) O'Connor James et al., "The Use of Foreign Exchange Markets by Non-Banks", Quarterly Bulletin Q2 Bank of England, 2011

8) Ramadhani K., Mashaushi Sh., "An Analysis of Technical Trading Strategies", PhD. dissertation in business, The University of Leeds, 2006

9) Rhoads Rossel, "Candlestick Charting for Dummies", Wiley Publishing, Inc., 2008