



Profitable candlestick trading strategies—The evidence from a new perspective

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ABSTRACT

This paper aims to investigate the profitability of two-day candlestick patterns by buying on bullish (bearish) patterns and holding until bearish (bullish) patterns occur. Our data set includes daily opening, high, low, and closing prices of component stocks in the Taiwan Top 50 Tracker Fund for the period from 29 October 2002 through 31 December 2008. We examine three bullish reversal patterns and three bearish reversal patterns. We find that three bullish reversal patterns are profitable in the Taiwan stock market. For robustness checks, we evaluate the applicability of our results to diverse market conditions, conduct an out-of-sample test and employ a bootstrap methodology.

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1. Introduction

Academicians have been skeptical of technical analysis (Malkiel, 1981). In practice, however, traders generally adopt technical analysis in their daily trading. Billingsley and Chance (1996) find that about 60% of commodity trading advisors heavily or exclusively rely on computer-guided technical trading systems.

Emotion and irrational beliefs have been documented as important factors affecting market prices and technical analysis could purportedly gauge the extent of emotional components in the markets (Nison, 1991). From the growing body of literature on behavioral finance, it seems that investors do not behave completely rationally as they face gain and loss. Technical analysts can transform investors' mental emotion into charts to demonstrate investors' real fear and greed. In this way, technical analysis appears to be consistent with behavioral finance. For example, positive feedback rules (De Long, Shleifer, Summers, & Waldmann, 1990) probably could explain trend-chasing in price movements. The anchoring effect (Tversky & Kahneman, 1974) seems to be in accordance with the support and resistance trading rules in technical analysis.

Candlestick analysis originated from Japan in 1700s and was initially used for rice forward contracts trading (Nison, 1991). It is the oldest technical analysis method and now is used to reveal the shifts in supply and demand forces by tracking daily price movements.

The motivation for this research is to fill in the gap in the literature on candlestick analysis. Prior studies generally focus on the short-term profitability of candlestick analysis, probably because candles have value with the maximum holding period of ten days (Morris, 1995). Our research contributes to the literature by examining the long-term profitability of candlestick trading strategies. Unlike prior technical analysis literature on candlesticks, this study is the first study that rigorously investigates these strategies by buying on bullish (bearish) patterns and holding until bearish (bullish) patterns occur. Moreover, early empirical studies (Alexander, 1964; Fama & Blume, 1966) find that profits made through technical analysis are eroded by transaction costs. We therefore examine and report the average profit after commissions and taxes.

For robustness, we further test the predictive power of six reversal patterns by dividing entire sample into three market conditions. We also conduct an out-of-sample test and employ a bootstrap methodology. Our empirical results reveal that the three bullish reversal patterns, especially the *Piercing* pattern, are significantly profitable in the Taiwan stock market.

The rest of this paper is structured as follows. Section 2 reviews the literature. Section 3 describes the data and the methodology. Section 4 discusses the empirical results. Section 5 extends the additional evidence. The last section concludes the paper.

2. Literature review

There is no general consensus on the effectiveness of candlestick charting in the literature. Marshall, Young, and Rose (2006) propose an empirical framework for predictive power of candlesticks. They employ the bootstrap methodology to retest the results, and find

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that candlestick technical analysis cannot help investors make a profit. Marshall, Young, and Cahan (2008) use a similar approach in analyzing the Japanese stock market by dividing 100 stocks listed on the Tokyo Stock Exchange into three ten-year sub-periods. They find that candlesticks have no value for traders in the Japan stock market. Horton (2009) observes nine candlestick patterns for 349 stocks listed in the S&P 500 index and finds that the use of *Stars*, *Crows*, or *Doji* in trading individual stocks is not recommended.

Fock, Klein, and Zwergel (2005) examine the predictive power of candlesticks by employing intraday rather than daily data. Their data are from the index futures on the German stock index and the futures on German government bonds. They investigate 19 patterns and find negative results. Furthermore, they use four technical analysis methods, including moving average, momentum, relative strength index, and moving average convergence/divergence indicators and find that the forecasting power of candlesticks can be improved by combining these Western technical analysis methods.

The work by Caginalp and Laurent (1998) is the first study that shows in great detail how to define trends and recognize candlestick patterns. In their paper, they claim that the returns could be compounded over 200% for a year after transaction costs. Most of the eight three-day candlestick reversal patterns that were examined appear to generate large profits. Additional evidence in support of candlestick charting is provided by Goo, Chen, and Chang (2007). They compare average returns of various patterns and holding days and find that investors can gain an average return of 9.99% by using the *Bullish Harami* pattern for a ten-day holding period. Meanwhile, the performance of candlesticks seems to be improved by implementing stop-loss strategies. Using a quantile regression, Shiu and Lu (2011) employ daily data on Taiwan 69 electronic securities to test the predictive power of the two-day candlestick patterns. They find that the *Bearish Harami* pattern possesses genuine predictive power.

Little research, if any, has been published on candlesticks from a long-term perspective. By a long-term perspective, we mean that investors buy on bullish patterns and hold until bearish patterns occur. We attempt to ascertain the profitability of candlesticks in a new manner. Our research differs from previous studies in that we examine long-term strategies for candlesticks.

Caginalp and Laurent (1998) argue that candlestick analysis has several advantages such as precise definitions of patterns and fixed time intervals of analysis. Moreover, candlestick analysis is more robust to the criticism of data snooping than other technical trading rules, because it was first developed for an entirely different market, i.e., the Japanese rice market (Marshall et al., 2006).

Using the fixed holding period method, prior studies reveal that the performance of candlesticks can be improved in conjunction with other methods such as technical indicators (e.g., momentum) (Fock et al., 2005) or stop-loss strategies (Goo et al., 2007). In this paper, we use a variable holding period method and find that candlestick reversal patterns are themselves useful without recourse to these methods.

3. Data collection and methodology

3.1. Data

Our data consist of daily prices, including opening, high, low, and closing prices, for the individual stocks that comprise the Taiwan 50 for the period 29 October 2002 (the date when Taiwan 50 launched) to 31 December 2008. Fig. 1 shows the Taiwan Capitalization Weighted Stock Index during the period from 29 October 2002 to 31 October 2011. As shown in this figure, the diverse market conditions provide an interesting setting for conducting our analysis to examine the profitability of candlestick patterns. Additionally, we use the data from 5 January 2009 to 31 October 2011 for an out-of-sample test.

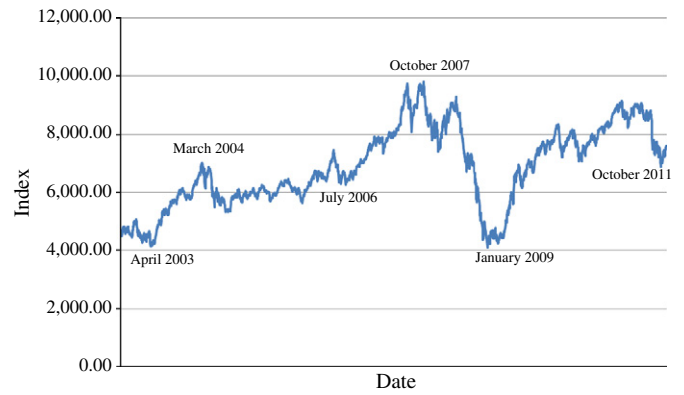


Fig. 1. Taiwan Capitalization Weighted Stock Index for the period October 2002 through October 2011.

3.2. Pattern definitions

Candlesticks are more frequently used with daily data than intraday data (Nison, 1991). Presumably investors' reaction takes some time to be incubated. Popular daily candlestick patterns include single lines, two-day patterns, and three-day patterns. Several consecutive single lines can combine to form a pattern. Patterns can be then divided into continuation and reversal patterns. In general, investors pay more attention to reversal patterns. In this paper, we consider three two-day bullish patterns and three two-day bearish patterns. The precise definitions are shown below, while their statements and shapes are presented in Fig. 2.

1. The *Piercing*: in a downtrend, $O_1 > C_1$, $O_2 < C_2$, $O_2 \leq C_1$, $C_2 < O_1$, and $C_2 > C_1 + 0.5(O_1 - C_1)$.
2. The *Bullish Engulfing*: in a downtrend, $O_1 > C_1$, $O_2 < C_2$, $O_2 \leq C_1$, and $C_2 \geq O_1$.
3. The *Bullish Harami*: in a downtrend, $O_1 > C_1$, $O_2 < C_2$, $O_2 > C_1$, and $C_2 < O_1$.
4. The *Dark-cloud Cover*: in an uptrend, $O_1 < C_1$, $O_2 > C_2$, $O_2 \geq C_1$, and $C_2 < C_1 - 0.5(C_1 - O_1)$.
5. The *Bearish Engulfing*: in an uptrend, $O_1 < C_1$, $O_2 > C_2$, $O_2 \geq C_1$, and $C_2 \leq O_1$.
6. The *Bearish Harami*: in an uptrend, $O_1 < C_1$, $O_2 > C_2$, $O_2 < C_1$, and $C_2 > O_1$.

where O_1 and C_1 indicate the opening and closing prices of the first day of the pattern, and O_2 and C_2 refer to the opening and closing prices of the second day of the pattern.

3.3. Identifying trends

The first issue about defining reversal patterns is to identify uptrends/downtrends. Following Caginalp and Laurent (1998) and Shiu and Lu (2011), we employ the five-day moving average over six days. The moving average on day t is defined by:¹

$$MA_5(t) = \frac{C(t-4) + C(t-3) + C(t-2) + C(t-1) + C(t)}{5}$$

where $C(t)$ refers to the closing price on day t .

¹ The number of signals will change when we employ other than the five-day MA. For instance, using the three-day (ten-day) MA will decrease (increase) the number of signals. Since the average of shorter duration is more volatile than the average of longer duration, it is therefore more difficult for the shorter-duration MA to satisfy the trend criteria. Take the *Piercing* for example. Its frequencies are 13 for the five-day MA, six for the three-day MA, and 25 for the ten-day MA.

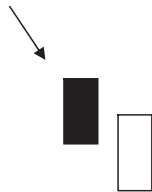
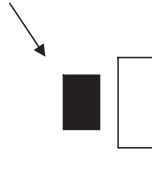
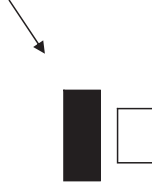
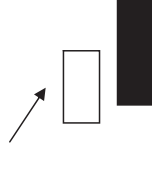
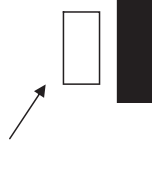
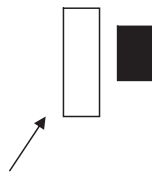
Name	Statement	Chart
<i>Piercing</i>	In a downtrend, following a black line the market opens lower, but closes above the mid-point of the prior candlestick's real body.	
<i>Bullish Engulfing</i>	In a downtrend, following a black line the market opens lower, but closes above the open of the prior candlestick's real body.	
<i>Bullish Harami</i>	In a downtrend, following a long black line the market opens higher than the prior close, and closes below the prior open. The second day's small real body holds within the prior long real body.	
<i>Dark-Cloud Cover</i>	In an uptrend, following a white line the market opens higher, but closes below the mid-point of the prior candlestick's real body.	
<i>Bearish Engulfing</i>	In an uptrend, following a white line the market opens higher, but closes below the open of the prior candlestick's real body.	
<i>Bearish Harami</i>	In an uptrend, following a long white line the market opens lower than the prior close, and closes above the prior open. The second day's small real body holds within the prior long real body.	

Fig. 2. Two-day reversal patterns.

An uptrend on day t is defined by:

$$MA_5(t-6) < MA_5(t-5) < \dots < MA_5(t-1) < MA_5(t)$$

Conversely, a downtrend on day t is defined by:

$$MA_5(t-6) > MA_5(t-5) > \dots > MA_5(t-1) > MA_5(t)$$

3.4. Calculating profit

Following Brock, Lakonishok, and LeBaron (1992) and Marshall et al. (2006), we measure profits of candlestick reversal patterns by raw returns rather than abnormal returns. First, the buying price is the

opening price on the day following a reversal pattern. Second, the selling price is the opening price on the day after the opposite pattern has occurred. Third, the returns are multiplied by 1 if the signals are bullish, and multiplied by -1 if the signals are bearish. The formula for bullish returns is as follows:

$$\frac{\text{Opening Price}_{R+1} - \text{Opening Price}_{L+1}}{\text{Opening Price}_{L+1}} \times 100\%$$

where the $\text{Opening Price}_{R+1}$ represents the opening price after a bearish pattern and the $\text{Opening Price}_{L+1}$ denotes the opening price after a bullish pattern.

In order to remove the ex-right and ex-dividend effects of stocks on our results, we delete the observations with two-day patterns

Table 1
Individual pattern results after transaction costs.

Patterns	No.	Returns (%)				Skewness	Skewness adjusted <i>t</i> -test <i>p</i> -value	Winning rate (%)	Binomial test <i>p</i> -value
		Max	Min	Median	Average				
<i>Panel A. Bullish patterns</i>									
Piercing	11	24.80	−6.72	15.05	13.25	−0.90	<0.01 [*]	90.91	0.01 [*]
Bullish Engulfing	139	159.93	−52.35	2.45	4.41	3.24	0.01 [*]	61.15	0.01 [*]
Bullish Harami	147	90.89	−42.96	3.17	3.60	1.13	<0.01 [*]	63.27	<0.01 [*]
<i>Panel B. Bearish patterns</i>									
Dark-cloud Cover	25	29.31	−38.83	4.61	1.31	−1.03	0.73	72.00	0.04 [*]
Bearish Engulfing	149	70.10	−58.31	2.01	1.66	−0.08	0.20	59.73	0.03 [*]
Bearish Harami	87	28.10	−41.40	−0.78	−0.97	−0.73	0.49	48.30	0.83

* Indicates statistical significance at the 5% level.

occurring on the ex-right and/or ex-dividend dates or those with a holding period covering the ex-right and/or ex-dividend dates² because the opening prices after the ex-right and ex-dividend dates will be adjusted for a downward gap. We manually collected ex-right dates for the component stocks from their annual reports.

3.5. Transaction costs and risk

Treatment of market microstructure issues needs to be addressed. There are three items of transaction costs that must be considered when investors invest in stocks in Taiwan. These costs include 0.3% of trading taxes, 0.285% of round-trip brokerage commissions and fees, and financing interest. Since most people use electronic trading, brokerage commissions and fees have fallen by at least 50%. Other risk costs, such as execution costs, liquidity costs, and slippage costs, must also be taken into account when doing trading in real-world markets. In this paper, the total transaction costs and risk are arbitrarily assumed to be 1% per round turn.

4. Empirical results

As shown in Table 1, the return series exhibits skewness. To determine whether candlestick reversal patterns generate reliable profits when the skewness exists, we use the skewness adjusted *t*-statistic developed by Johnson (1978) to test the null hypothesis $H_0: \mu = 0$ for the average returns, and employ the binomial test to test the null hypothesis $H_0: p = 0.5$ for the winning rates. As stated by Conover (1999), the binomial test has an amazing versatility, and is powerful enough to reject the null hypothesis when it should be rejected. When we attempt to ascertain the existence of superior pattern returns, it is necessary to test the dependence between the results of the patterns. Employing the binomial test to examine the randomization of each reversal pattern seems to be an appropriate method.

Table 1 also shows that the bullish reversal patterns are more profitable than the bearish reversal patterns. The frequencies of patterns range from 11 (minimum) for the *Piercing* to 149 (maximum) for the *Bearish Engulfing*. We also find that the *Bullish Engulfing* has the largest difference between maximum and minimum returns. This finding reveals that investors who follow the *Bullish Engulfing* to buy stocks may carry relatively high risk. Additionally, the *Piercing* shows marvelous results in average returns and winning rates after transaction costs. On the contrary, the *Bearish Harami* does not perform well. On average it has a negative return after transaction costs.

In Panel A of Table 1, the average returns after transaction costs are 13.25% for the *Piercing*, 4.41% for the *Bullish Engulfing*, and 3.60% for the *Bullish Harami*, respectively. Then the winning rates are

90.91% for the *Piercing*, 61.15% for the *Bullish Engulfing*, and 63.27% for the *Bullish Harami*. The binomial test results are all significant, indicating the usefulness of these patterns. In Panel B of Table 1, the average returns after transaction costs are all insignificant for the three bearish patterns. It is worth mentioning that the *Bearish Harami* is the only pattern with a negative return. However, its binomial test is insignificant, suggesting that this pattern has a stochastic character in the Taiwan stock market. This result, therefore, should be treated with caution.

On the whole, the results for bullish and bearish patterns are remarkably different. All bullish reversal patterns tested in this paper present statistical significance both in the skewness adjusted *t*-test and the binomial test, but bearish reversal patterns show insignificant results. Moreover, the average returns yielded by bullish patterns exceed those by bearish patterns. These findings are consistent with prior studies, such as Brock et al. (1992) and Lai, Chen, and Huang (2010), showing that buying signals generally produce higher average returns than selling signals.

To check our results for different market conditions, we further test the predictive power of the six reversal patterns by dividing the entire sample into three subsamples, including the bull, bear, and oscillating markets. As shown in Fig. 1, the bull markets include two periods, from May 2003 to March 2004 and from August 2006 to October 2007. The bear markets include two periods, from October 2002 to April 2003 and from November 2007 to December 2008. The oscillating market refers to the period from April 2004 to July 2006. The subsample results are reported in Table 2. We find that the *Piercing* and *Bullish Engulfing* in the bull markets and the *Bullish Harami* and *Bearish Engulfing* in the oscillating market show significant results both in the average return and winning rate after transaction costs.

Taken together, we document evidence that using the three bullish patterns is profitable. To be more specific, they are more profitable in some subsamples than in the entire sample. For the *Piercing*, the average returns and the winning rates increase from 13.25% to 13.67% and 90.91% to 100%, respectively. For the *Bullish Engulfing*, the average returns and the winning rates increase from 4.41% to 6.24% and 61.15% to 67.92%, respectively. For the *Bullish Harami*, the average returns and the winning rates increase from 3.60% to 5.05% and 63.27% to 67.21%, respectively.

5. Additional evidence

To check the robustness of our results, we conduct an out-of-sample test and employ a bootstrap methodology. Our out-of-sample period covers from January 2009 to October 2011. As shown in Table 3, the out-of-sample results are consistent with the in-sample results in that three bullish patterns have significant predictive power for the Taiwan 50 component stocks.

Inspired by Heiden et al. (in press), we adopt the AR (1) process for actual stock closing prices to simulate new closing prices, and

² Take Taiwan Semiconductor Manufacturing Company for example. In 2007, its ex-right date is on 8 June 2007. The date of the short-sell signal emitted by the *Bearish Harami* is on 23 August 2006 and this trade is finished by the *Bullish Engulfing* on 30 July 2007. We will then delete this observation from our sample.

Table 2
Results for three market conditions.

Patterns	Bull markets		Bear markets		Oscillating market	
	Returns	Winning rate	Returns	Winning rate	Returns	Winning rate
	(%)	(%)	(%)	(%)	(%)	(%)
<i>Panel A. Bullish patterns</i>						
Piercing	13.67 (0.01)*	100.00 [0.05]*	10.25 (0.45)	66.67 [1.00]	15.54 (0.16)	100.00 [0.25]
Bullish Engulfing	6.24 (<0.01)*	67.92 [0.01]*	−0.37 (0.88)	41.38 [0.46]	5.13 (0.12)	64.91 [0.03]*
Bullish Harami	3.38 (0.14)	65.00 [0.03]*	0.69 (0.78)	50.00 [1.00]	5.05 (<0.01)*	67.21 [0.01]*
<i>Panel B. Bearish patterns</i>						
Dark-cloud Cover	−5.21 (0.45)	63.64 [0.55]	12.46 (0.07)	100.00 [0.25]	4.79 (0.15)	72.73 [0.23]
Bearish Engulfing	−2.74 (0.21)	45.76 [0.60]	5.16 (0.09)	67.57 [0.05]*	4.11 (0.01)*	69.81 [0.01]*
Bearish Harami	−3.17 (0.27)	40.74 [0.44]	−1.88 (0.54)	47.62 [1.00]	1.04 (0.61)	53.85 [0.75]

Note: 1. The bull markets include two periods, May 2003 to March 2004 and August 2006 to October 2007, the bear markets include two periods, October 2002 to April 2003 and November 2007 to December 2008, and the oscillating market refers to April 2004 to July 2006.

2. The “Returns” columns represent the average returns after transaction costs.

3. The numbers in parentheses and brackets represent *p*-values of skewness adjusted *t*-test and binomial test.

* Indicates statistical significance at the 5% level.

Table 3
Out-of-sample test results.

Patterns	No.	Returns (%)				Skewness	Skewness adjusted <i>t</i> -test <i>p</i> -value	Winning rate (%)	Binomial test <i>p</i> -value
		Max	Min	Median	Average				
<i>Panel A. Bullish patterns</i>									
Piercing	12	38.32	−22.16	6.40	10.66	0.01	0.04 [*]	91.67	<0.01 [*]
Bullish Engulfing	49	26.33	−23.34	5.07	5.31	−0.22	<0.01 [*]	73.47	<0.01 [*]
Bullish Harami	90	63.54	−37.95	5.56	6.42	0.31	<0.01 [*]	74.44	<0.01 [*]
<i>Panel B. Bearish patterns</i>									
Dark-cloud Cover	21	17.34	−32.27	2.12	−1.90	−0.65	0.55	52.38	1.00
Bearish Engulfing	72	22.96	−49.04	−0.76	−5.97	−0.67	<0.01 [*]	47.22	0.72
Bearish Harami	42	34.44	−39.01	−2.75	−4.75	−0.21	0.10	45.24	0.64

* Indicates statistical significance at the 5% level.

employ a bootstrap methodology to further test our results. We create vectors of original price percentage changes, (high−close)/close and (close−low)/close, and then randomize these percentage change vectors on the simulated closing prices to form the simulated high, low, and opening prices. If the opening price is higher than the high or lower than the low, we resample the (close−open)/close percentage changes. In total, we simulate 500 sets of these series.

We then compare the actual returns of candlestick patterns to the simulated returns. As shown in Table 4, the random bootstrap series are not significantly more profitable than the actual series. As regards the winning rate, the actual bullish patterns are significantly greater than the bootstrap ones, except for *Bullish Harami*. Our results reveal

that the three bullish patterns possess genuine forecasting power indeed.

6. Conclusion and suggestion

In this paper, we investigate six two-day reversal patterns in candlestick charting by using the Taiwan 50 component stocks. Out of six reversal patterns, we find that the bullish reversal patterns generally are more profitable than the bearish reversal patterns and that the three bullish patterns tested in this paper have significantly predictive power in the Taiwan stock market. To our best knowledge, this research is one of the first studies that test the predictive power of

Table 4
Bootstrap results.

Pattern	No.		Average returns (%)		Winning rate (%)	
	BS	Orig.	BS	Orig.	BS	Orig.
<i>Panel A. Bullish patterns</i>						
Piercing	13	11	9.00 (0.09)	13.25 (<0.01)*	69.23 [0.27]	90.91 [0.01]*
Bullish Engulfing	124	139	−2.13 (0.26)	4.41 (0.01)*	48.39 [0.79]	61.15 [0.01]*
Bullish Harami	108	147	2.10 (0.17)	3.60 (<0.01)*	66.67 [<0.01]*	63.27 [<0.01]*
<i>Panel B. Bearish patterns</i>						
Dark-cloud Cover	26	25	−4.97 (0.27)	1.31 (0.73)	53.85 [0.85]	72.00 [0.04]*
Bearish Engulfing	101	149	−1.72 (0.21)	1.66 (0.20)	68.32 [<0.01]*	59.73 [0.03]*
Bearish Harami	71	87	−1.61 (0.43)	−0.97 (0.49)	36.62 [0.03]*	48.30 [0.83]

Note: 1. The “BS” columns refer to bootstrap results, and the “Orig.” columns represent empirical results originally.

2. The results of this table are after transaction costs.

3. The numbers in parentheses and brackets represent *p*-values of skewness adjusted *t*-test and binomial test.

* Indicates statistical significance at the 5% level.

candlestick reversal patterns using the skewness adjusted *t*-test and the binomial test. We enter a trade based on a reversal pattern and stay with that trade until another opposite pattern indicates otherwise. In fact, it is the key to the spirit of technical analysis.

Previous studies have attempted to improve the performance of candles by using technical indicators such as momentum as a filter (Fock et al., 2005) or stop-loss strategies (Goo et al., 2007). Without using technical indicators or stop-loss strategies, in this study we document evidence of candlestick profitability by buying on bullish (bearish) patterns and holding until bearish (bullish) patterns occur. Unlike these previous studies, our holding period is variable.

In a next step further studies should also consider the following factors. One of the factors is the support or resistance level, because technical analysts believe that investors are willing to sell at the peak and to buy at the bottom (Brock et al., 1992). Besides, it has been argued, by Nison (1991) and Pring (2002), that candlestick reversal patterns are notable when they occur in high-price or low-price areas. Another factor is the volume effect since it is a measure of demand and supply forces. It is also a confirmation of price trends. The changes of volume patterns serve as the omen of the reversal of a trend.

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