In practice, some investors rely heavily and exclusively on technical analysis, and this is true for both professional and amateur traders (Smidt 1965; Billingsley and Chance 1996). However, if an investing scheme is valid, it will soon be adopted by many investors, and the profit will thus decline or disappear, which eventually leads to the self-destruction of this particular approach (Caginalp and Laurent 1998). But although candlestick charting has been used for more than 300 years, it still appears to be effective (Marshall et al. 2006). In that regard, the main aim of this paper is to examine the performance of candlestick trading strategies within the context of European stock markets.

The findings of earlier studies examining the effectiveness of candlestick analysis have been mixed. They include Caginalp and Laurent (1998), Goo et al. (2007), Shiu and Lu (2011), Lu and Shiu (2012) and Lu et al. (2012), which all conclude that candlestick charting has value for investors. In contrast, Fock et al. (2005), Marshall et al. (2006), Marshall et al. (2008) and Horton (2009) find that the approach is ineffective.

The results of the current study provide some positive support for candlestick charting. More specifically, the findings reveal that one reversal pattern is profitable for stocks in the FTSE 100 (UK), one continuation pattern is profitable for the DAX 30 (Germany), and another is profitable for the CAC 40 (France). The main contribution of this study, in addition to its examination of candlestick patterns in European stock markets, is its development of a vector approach (building on the four-digit approach inspired by Levy (1971) and used by Lu and Shiu (2012)) to categorise a wider variety of two-day patterns in an objective manner. The study also examines the robustness of the results by comparing pre- and post-financial crisis data.

Candlestick charting and classification procedures

Candlestick charting was first developed in Japan in the 18th century by Munehisa Honma (Nison 1991; Caginalp and Laurent 1998). A few centuries later, Steve Nison introduced it to the West, where it has been increasingly popular (Nison 1991). This approach is based on the shape of candlesticks, as shown in Figure 1, which is made up of the opening, high, low and closing prices. The area between the opening and closing prices is drawn as a box, which is called the real body. The vertical lines drawn above and below the real body are the upper and lower shadows, respectively. If the closing price is higher than the opening one, the real body is white or hollow, which defines the session as bullish, while if the closing price is lower than its opening price, the real body is black or filled, and the session is regarded as bearish.

FIGURE 1: Single candlestick pattern
In practice, candlestick patterns are generally divided into bullish and bearish patterns. This makes the potential force behind the direction of trends more apparent. A bullish pattern after a downtrend can be regarded as a contrarian pattern, while after an uptrend it turns into a momentum one. This rationale can also be applied to a bearish pattern.

Candlestick charting has been in practical use for more than three hundred years, as it is believed to reveal excess supply or demand pressures in a market (Nison 1991; 1994). Weir (2006) also notes that candlestick analysis provides tools that can be used to measure how emotions affect the market. Proponents of candlestick charting thus suggest entering the market following certain candlestick signals or patterns, and then exiting after holding for about 10 days (Nison 1991; Marshall et al. 2006; 2008). The trends that form before candlestick patterns are very important with regard to the profitability of this approach (Nison 1991). There are thus three key issues with regard to candlestick patterns, i.e. categorising patterns, identifying trends, and calculating profits, and these are discussed in more detail below.

**Categorising patterns**

While candlestick charting is one of the oldest methods of technical analysis, there are few scientific and systematic investigations of the related patterns. This paper adopts a systematic method by coding all two-day patterns using a 1×4 vector, as below (and also shown in the grids in Figure 2).

\[
\begin{bmatrix}
  k_1 \\
  k_2 \\
  k_3 \\
  k_4
\end{bmatrix}
\]

where \(k_1\) and \(k_2\) represent the ranking of the opening and closing prices of the first day of the two-day pattern; whereas \(k_3\) and \(k_4\) refer to the ranking of the opening and closing prices of the second day of the two-day pattern, respectively.

**Identifying trends**

To identify any uptrends or downtrends before the patterns of interest, we adopt a general definition of trends based on Shiu and Lu (2011), Lu and Shiu (2012) and Lu et al. (2012), using a five-day moving average. This is because Nison (1991) and Morris (1995) suggested that candlestick charting is most useful for short-term trading, and five trading days (a week) seems to be an appropriate length of time. A five-day moving average at time \(t\) is defined by:

\[
MA_5(t) = \frac{1}{5} \left[ P(t-4) + P(t-3) + P(t-2) + P(t-1) + P(t) \right]
\]

where \(P(t)\) denotes the closing price on day \(t\).

An uptrend on day \(t\) is defined by:

\[
MA_5(t-6) < MA_5(t-5) < \ldots < MA_5(t-1) < MA_5(t)
\]

Analogously, a downtrend on day \(t\) is defined by:

\[
MA_5(t-6) > MA_5(t-5) > \ldots > MA_5(t-1) > MA_5(t)
\]

**Calculating profits**

For practical reasons, we simulate a trade at the opening price on the day following a two-day pattern, and the end of the measurement is at the closing price on the tenth holding day. Nison (1991) and Morris (1995) propose that the maximum holding
period for candlesticks is 10 days. Following Brock et al. (1992), the current study tests the profits by examining raw returns rather than abnormal returns, as this is deemed more appropriate for short-term trading strategies (Sweeney 1986). The return rates are calculated from a buy-and-hold perspective, in which positive return rates for buying patterns and negative ones for selling patterns indicate that the trade has been profitable.

To sum up, the trading rule examined in this study is that if at the end of day \( t \) the five-day moving average of closing prices has increased consistently for the past seven days, from day \( t \) to day \( t-6 \), an uptrend is identified as existing at the end of day \( t \). Next, the two-day candlestick patterns are observed for days \( t+1 \) and \( t+2 \). Then, a trading position is opened at the start of day \( t+3 \) and held until the end of day \( t+13 \) (a 10-day holding period). Finally, the returns from the trading positions opened following each pattern are then measured and analysed.

**Empirical results**

**Data and transaction costs**

Most prior technical analysis studies utilise index data, which can be biased due to non-synchronous trading (Day and Wang 2002), and so this paper adopts individual stock data. The data consist of the daily opening, high, low, and closing prices of component stocks in the FTSE 100, DAX 40 and CAC 30. The data are gathered for the period from 2 January 2003 to 31 October 2012. Moreover, since the research period includes the global financial crisis, we take the accepted start of this, 14 September 2008, as the cut-off point to examine the robustness of the results.

There is still little evidence to prove that technical trading rules can generate abnormal returns after transaction costs, so it is of considerable interest to take both transaction costs and risk into consideration in this study. None of the three stock markets examined in this work has trading taxes, but investors face a 0.5 per cent stamp tax in Britain. Brokerage commissions and fees are about 0.3 per cent for a round-trip in each market. The execution costs, such as the bid-ask spread, are generally in the range of 0.1 per cent to 0.3 per cent (Caginalp and Laurent 1998), and are thus set at 0.3 per cent in this paper. More precisely, total costs are 1.1 per cent for the FTSE 100, and 0.6 per cent for both the DAX 30 and CAC 40.

**Results for uptrends**

We apply the skewness-adjusted \( t \)-test proposed by Johnson (1978) to test the null-hypothesis, \( H_0: \mu = 0 \) for the average returns, and the binomial-test to test the null-hypothesis \( H_0: p = 0.5 \) for the winning rates. We assume that winning trades should be as frequent as losing trades without candlestick signals, and therefore the binomial-test is used to examine the randomisation of two-day patterns. We also use a more stringent significance level to examine the robustness of the results, namely the Bonferroni-adjusted significance level (adjusted for the number of different patterns). If the results for one pattern satisfy the requirements of both two tests, then it can be regarded as a profitable trading rule which has genuine predictive power.

The trends that form before candlestick patterns are crucial with regard to the profitability of this approach (Nison 1991). Therefore, this study investigates all 24 patterns (shown in Figure 2) after uptrends and downtrends. Panel A in Table 1 shows the results for the three different stock markets when the trend is an upward one. (For reasons of space, only significant results in average returns, which occurred for 11 out of 24 patterns, are shown.) Note that a positive value for the bullish (buying) signals and a negative one for the bearish (short-selling) signals reveal that the pattern correctly predicted the direction of the market. A positive (negative) value after an uptrend indicates this pattern might be used to implement a momentum (contrarian) strategy.

The best performance is produced by pattern \( 1324 \) in the DAX 30 and pattern \( 2314 \) in the CAC 40, with the average returns for these being significantly positive over transaction costs, at 1.09 per cent and 1.33 per cent for the 10 holding days, respectively, and the proportion of positive profits in both markets is significantly greater than 50 per cent. To be more specific, holding the 10-day pattern \( 1324 \) for the DAX 30 has an average return of 0.49 per cent, while pattern \( 2314 \) has an average return of 0.73 per cent for the CAC 40 after considering transaction costs. These patterns, which produce buying signals after uptrends, are called ‘bullish continuation’ patterns, and have significant practical implications. For example, the opening price of the first day of pattern \( 1324 \) is above the prior day’s high following an uptrend, and thus market sentiment is positives. Next, the low of the second day falls to a new low during the pattern. In this case, the bulls have more control over the market and their aim is accumulation of stock. Finally, uncertain and fearful investors may easily be overwhelmed by bulls who utilise trading psychology, and this is often called a ‘flag consolidation’ pattern in the practical literature. Pattern \( 2314 \) has similar characteristics, in that the second day falls to a new low price, and this is known as an ‘engulfing’ pattern in several references.

**Results for downtrends**

As shown in Panel B in Table 1, only one significant result, pattern \( 2134 \), was found for the FTSE 100, and there are no convincing results in the other two
markets. Comparing the current study with Lu and Shiu (2012), bullish pattern 1324 after an uptrend tends to be profitable not only in Germany but also in Taiwan, with similar average returns of 1.09 per cent and 1.20 per cent, respectively, while bullish pattern 2314 after an uptrend in this study is similar to the ‘bearish engulfing’ pattern in Nison (1991), although the related trading strategies are opposites. The fact that different patterns are profitable in different markets is probably due to the characteristics of the related investors, as well as the varied institutional contexts, such as different price limits and auction systems.

### TABLE 1: Results for the patterns

<table>
<thead>
<tr>
<th>Patterns</th>
<th>FTSE 100</th>
<th>DAX 30</th>
<th>CAC 40</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Return</td>
<td>Winning</td>
</tr>
<tr>
<td><strong>Panel A. Uptrends</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1324</td>
<td>1062</td>
<td>0.23 (&lt;0.21)</td>
<td>53.58* (&lt;0.02)</td>
</tr>
<tr>
<td>1423</td>
<td>309</td>
<td>-0.22 (&lt;0.44)</td>
<td>51.13 (&lt;0.73)</td>
</tr>
<tr>
<td>2134</td>
<td>691</td>
<td>-0.63* (&lt;0.02)</td>
<td>47.90 (&lt;0.29)</td>
</tr>
<tr>
<td>2314</td>
<td>486</td>
<td>0.45 (&lt;0.07)</td>
<td>55.35* (&lt;0.02)</td>
</tr>
<tr>
<td>2341</td>
<td>624</td>
<td>-0.52* (&lt;0.01)</td>
<td>49.04 (&lt;0.66)</td>
</tr>
<tr>
<td>2431</td>
<td>615</td>
<td>-0.61* (&lt;0.02)</td>
<td>49.92 (&lt;1.00)</td>
</tr>
<tr>
<td>3124</td>
<td>720</td>
<td>0.09 (&lt;0.74)</td>
<td>54.03* (&lt;0.03)</td>
</tr>
<tr>
<td>3214</td>
<td>1030</td>
<td>0.05 (&lt;0.80)</td>
<td>52.04 (&lt;0.20)</td>
</tr>
<tr>
<td>3241</td>
<td>427</td>
<td>-0.10 (&lt;0.74)</td>
<td>55.04* (&lt;0.04)</td>
</tr>
<tr>
<td>4213</td>
<td>1305</td>
<td>-0.44* (&lt;0.01)</td>
<td>52.80* (&lt;0.05)</td>
</tr>
<tr>
<td>4321</td>
<td>2404</td>
<td>-0.42* (&lt;0.01)</td>
<td>49.96* (&lt;0.98)</td>
</tr>
<tr>
<td><strong>Panel B. Downtrends</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1234</td>
<td>1879</td>
<td>0.75* (&lt;0.01)</td>
<td>59.34* (&lt;0.01)</td>
</tr>
<tr>
<td>1243</td>
<td>645</td>
<td>0.66* (&lt;0.04)</td>
<td>53.80* (&lt;0.06)</td>
</tr>
<tr>
<td>1324</td>
<td>1315</td>
<td>0.78* (&lt;0.01)</td>
<td>57.95* (&lt;0.01)</td>
</tr>
<tr>
<td>1342</td>
<td>869</td>
<td>0.71* (&lt;0.01)</td>
<td>56.27* (&lt;0.01)</td>
</tr>
<tr>
<td>2134</td>
<td>368</td>
<td>1.31** (&lt;0.01)</td>
<td>61.41* (&lt;0.01)</td>
</tr>
<tr>
<td>2341</td>
<td>710</td>
<td>0.41 (&lt;0.10)</td>
<td>53.80* (&lt;0.05)</td>
</tr>
<tr>
<td>2431</td>
<td>989</td>
<td>0.75* (&lt;0.01)</td>
<td>57.74* (&lt;0.01)</td>
</tr>
<tr>
<td>3124</td>
<td>350</td>
<td>0.88* (&lt;0.02)</td>
<td>58.00* (&lt;0.01)</td>
</tr>
<tr>
<td>3142</td>
<td>142</td>
<td>0.89* (&lt;0.01)</td>
<td>63.38* (&lt;0.01)</td>
</tr>
<tr>
<td>3214</td>
<td>628</td>
<td>0.83* (&lt;0.01)</td>
<td>58.28* (&lt;0.01)</td>
</tr>
<tr>
<td>3421</td>
<td>752</td>
<td>-0.13 (&lt;0.66)</td>
<td>56.38* (&lt;0.01)</td>
</tr>
</tbody>
</table>

Note: Winning rate represents the proportion of positions with positive returns. The numbers in parentheses and brackets represent p-values of skewness-adjusted t-test and binomial test. * indicates statistical significance at the 5% level. † indicates Bonferroni-adjusted significance at the level of 5% divided by the number of patterns. Returns following other patterns are insignificant in the three markets. For reasons of space, only significant results in average returns, which occurred for 11 out of 24 patterns, are shown here.
To check the sensitivity to profitability of the three patterns, the results of holding for five days compared with holding for 10 days are shown in Table 3. It can be seen that there are statistically significant results for the two holding periods, but the returns from a five-day holding period are smaller than those for a 10-day period, except for pattern 2134. This agrees with the prior literature (Nison 1991; Morris 1995) which found that candlestick charting is most useful for short-term trading with a holding period of less than 10 days, and its power gradually increases from five to 10 days.

To check the influence of the global financial crisis, we use 14 September 2008 as the cut-off point to divide the sample period into two groups.

### Robustness check

To deal with the issue of data snooping, we not only consider the Bonferroni-adjusted significance levels, but also employ the bootstrap methodology to check the robustness of the empirical results. In prior candlestick literature, Marshall et al. (2006), Marshall et al. (2008), Lu and Shiu (2012), and Lu et al. (2012) also adopt this method to test their results. The approach proposed by Marshall et al. (2006) uses the GARCH-M process to produce new closing prices and then randomises the original price percentage changes on them (i.e. it produces new closing prices). The results in Table 2 show that the average returns on the original series are all better than those on the bootstrapping series, and the winning rates are also better with the former than the latter.

To check the sensitivity to profitability of the three patterns, the results of holding for five days compared with holding for 10 days are shown in Table 3. It can be seen that there are statistically significant results for the two holding periods, but the returns from a five-day holding period are smaller than those for a 10-day period, except for pattern 2134. This agrees with the prior literature (Nison 1991; Morris 1995) which found that candlestick charting is most useful for short-term trading with a holding period of less than 10 days, and its power gradually increases from five to 10 days.

To check the influence of the global financial crisis, we use 14 September 2008 as the cut-off point to divide the sample period into two groups.
Table 4 presents the results for the two periods before and after the financial crisis, which seems to reduce both the profitability and statistical significance of the patterns. More specifically, the average returns of the three profitable patterns before the crisis are significantly greater than those after it, and the winning rates also decline after the crisis, except for pattern 2134. In addition, the statistical significance after the crisis decreases from satisfying both the basic and Bonferroni levels to only satisfying the former (5 per cent). It thus seems highly plausible that the global financial crisis weakened the predictive power of the candlestick method in the three stock markets examined in this work.

**Conclusion**

Three findings are worth summarising. First, the candlestick method has predictive power and can generate value for investors in the three main European stock markets. Second, the direct comparisons between the three markets carried out in this study reveal that candlestick charting would need to be used differently in each of these markets. Third, the global financial crisis reduced the efficacy of candlestick patterns in these markets.

From a behavioural finance perspective, candlestick charting might be used to implement a contrarian (FTSE 100) or momentum (DAX 30 and CAC 40) strategy, and based on the historical data examined here, they may be expected to deliver above-average returns.

The conclusion of the current study seems to go against the efficient markets hypothesis, which implies that any technical approach to market price prediction is invalid. The results of the present study suggest two dimensions that might profitably be addressed by further researchers. One is extending the approach proposed in this paper to a matrix form; the other is investigating whether different institutional backgrounds influence the efficacy of candlestick charting in different markets.

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**Note**

1. See Marshall et al. (2006, p. 2310) for the details about how to produce bootstrapping results of candlesticks.

**References**


