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Bullish and Bearish Engulfing Japanese Candlestick Patterns: A Statistical Analysis on the SandP 500 Index

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Bullish and Bearish Engulfing Japanese Candlestick Patterns: A Statistical Analysis on the S&P 500 Index

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Short Title: Bullish/Bearish Engulfing Japanese Candlesticks

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Highlights

- **Bullish Engulfing is effective to forecast bottoms using open and low prices**
- **Bearish Engulfing is effective to forecast tops using open and high prices**
 - The size of the first candle is not a statistically significant factor
 - Pattern's failures were not as drastic as in a buy and hold strategy
 - Frequency of occurrence did not fit several well-known distributions
- A past trend did not statistically improve the engulfing patterns' effectiveness
- The longer the time frame, the lower the effectiveness of the engulfing patterns
 - Bullish Engulfing can be used to initiate a short put strategy
- Bearish Engulfing can be used to initiate a short call in a covered call strategy

Abstract

Technical analysts believe that by studying past price action, it is possible to forecast future prices of specific securities. Technical analysts rely on the use of charts, which graphically show the past fluctuations of prices. This study focuses on the chart style known as Japanese candlesticks, which relies on four pieces of information for every session: Open, High, Low and Close prices. It is believed that some candle patterns possess predictive capabilities that can alert investors of imminent price tops, bottoms, or price trend continuations. For this study, we performed a statistical analysis, using historical prices of the S&P 500 index, of the effectiveness of Bullish

Engulfing and Bearish Engulfing patterns, which are believed to forecast bottoms and tops respectively. Results indicate that the Bearish Engulfing provide strong short-term forecasting power when using the Open and High criteria but not the Close criterion. Likewise, the Bullish Engulfing offered strong short-term forecasting power when using the Open and Low criteria but not the Close criterion.

Key Words: Japanese Candlesticks, Bullish Engulfing, Bearish Engulfing, Stock market forecasting, S&P 500

Key messages:

- Bullish Engulfing pattern outperformed the success rate of the studied population on OPEN and LOW criteria
- Bearish Engulfing pattern outperformed the success rate of the studied population on OPEN and HIGH criteria
- Engulfing candle size and prior trend are not significant for candle success
- The patterns' failures were less severe than those of the studied population

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Section 1. Introduction

Technical analysis is a popular methodology used in the financial industry to predict future price movements of financial securities. It is the study of market action, primarily through the use of charts, for the purpose of forecasting future price trends [1]. Charts are drawn using historical prices and may contain additional information such as volume and open interest. Historically, the technical approach has suffered its fair share of criticism. Arguably the most well-known argument against technical analysis is the Efficient-market hypothesis (EMH), which states that it is not possible to consistently achieve returns superior to those of the market on a risk-adjusted basis by using public information [2].

Although the effectiveness of technical analysis remains unproven, it is immensely popular in the investment community. Popular financial websites such as Yahoo! Finance [3], Google Finance [4], MSN Money [5], and CNN Money [6] provide charts with a wide variety of technical indicators. One of the most popular technical tools [7] is *Japanese Candlesticks*, which are symbols that visually provide open, high, low and closing prices of a specific period, such as a day, a week, or a month. When these candlesticks are presented on a chart, they display patterns believed to forecast temporary price tops, bottoms, continuations, and trend reversals [8]. Once again, even though there is no conclusive evidence of the effectiveness of Japanese Candlestick patterns, they are widely used by financial commentators, investment professionals and novices alike [9] [10] [11].

While there have been several studies to determine the usefulness of Japanese Candlesticks Patterns, they focus on detection, modeling or analyzing numerous patterns over multiple stocks, indexes and/or timeframes (refer to Section 2). On the other hand, few studies thoroughly analyze a specific pattern. One such study [12] examines the performance of Shooting Star and Hammer patterns in the S&P 500 index over several decades. Although this study is robust, it does not provide analysis of failures, frequency of occurrences, comparison of recent decades versus previous decades, discussion of usefulness in trading systems, etc. To this respect, our work is more extensive and also comprehensive. We concentrate on 2 well-known patterns, the Bullish and Bearish Engulfing, which are believed to forecast uptrends and downtrends respectively. We perform an in-depth statistical analysis on historical daily prices of the S&P 500 index over the years 1950-2018, 1950-1998, 1999-2010 and 2010-2020. In addition, our paper discusses how to use Japanese Candlestick signals using derivatives such as options to take advantage not only of market direction but also of time decay.

We begin with Section 2, which discusses known results on Japanese Candlesticks models, detection algorithms, statistical analysis, and others. Section 3 provides a brief introduction to Japanese Candlesticks patterns, detection, interpretation and a real-life example concentrating on Bullish and Bearish Engulfing patterns, which are the focus of our study. Section 4, provides an overview of our work by explaining our methodology as well as the terminology used. Section 5, presents an in-depth analysis by offering descriptive as well as inferential statistics, analysis of variance (ANOVA), inferential analysis for percent errors of failures, exploratory distributional analysis of inter-arrival times for Bullish and Bearish Engulfing patterns, and comparing success rates of 1999-2010 and 2010-2020 vs 1950-1998. Section 6, discusses how to incorporate the Bullish and Bearish Engulfing patterns into a profitable trading strategy by using the results described in Section 5. Finally, Section 7 presents a summary and describes future work.

Section 2. Literature review

The Japanese candlestick approach is an empirical model of investment decision. This model assumes that the candlestick patterns reflect the psychology of the market, and that investors can make their investment decision based on the identified candlestick patterns. Examination of the literature does not lead to a consensus concerning whether or not Japanese candlesticks are effective market

predictors. Some studies claim that technical approaches are not useful. With markets becoming efficient such techniques do not work any longer.

For instance, Sullivan, Timmerman, and White [13] utilize White's Reality Check bootstrap methodology [14] to evaluate simple technical trading rules without getting much evidence in favor of technical analysis. For the first time, their paper presents a comprehensive test of performance across all technical trading rules examined. The study expands the universe of Brock's 26 trading rules [15], and applies the rules to 100 years of daily data on Dow Jones Industrial Average (DJIA) and determines the effects of data snooping.

Similarly, Bagrowicz and Scaillet [16] apply technical trading rules on daily prices of DJIA from 1897 to 2011 using false discovery rate (FDR) as a new approach to data snooping. FDR selects more outperforming rules, which allows diversifying against model uncertainty. Persistence tests show that, even with the more powerful FDR technique, an investor would never have been able to select ex-ante, the future best-performing rules. Generally, their results seriously call into question the economic value of technical trading rules.

In a seminal case study, Horton [17] examines eight different candlestick patterns using statistical analysis for 349 randomly selected stocks from Commodity Systems Inc., concluding that these patterns had no value for trading individual stocks. Prado et al [18] replicate a study performed on the U.S. Market, and apply these to the Brazilian market. Not only is no statistical evidence found to confirm predictive power, but at least one pattern's analysis shows its trend is contrary to the original interpretation of the pattern. A few patterns show predictive power in the markets of their intended use, but not in the Brazilian market.

Fock et al [19] develop a mathematical model to examine intra-day market performance. In most cases, their results are not significantly better than results for a benchmark with randomized transactions. This is confirmed by Duvinage et al [20], who examine the predictive power of candlesticks at the 5-minute interval for the 30 constituents of the DJIA index. They find no evidence that candlesticks outperform the buy-and-hold method, after transaction costs are considered.

Despite the disappointing outcomes for technical analysis from the above studies, the results of our paper suggest that candlestick patterns can be a useful technique. Even if it is difficult to predict a very accurate value and equally difficult to model, candlesticks can be an important and valuable technique. In fact, support for our notion is found in several other studies. For example, conclusions from Fiess and MacDonald [21], Lee, Liu, and Chen [22], Arroyo [23], Marszalek and Burczynski [24], Cervello, Martinez, and Michniuk [25], and Naranjo, Arroyo, and Santos [26] are mostly supportive of inefficiencies in securities markets.

Fiess and MacDonald [21] assign a special importance to the Open, High, Low and Close prices in forecasting the mean and volatility of exchange rates to investigate the time series properties and the informational content of these different prices, using range and cointegration methods. The application of these methods to a high frequency data set indicates the existence of stable structural relationships and asymmetric information flows, which is supportive of certain predictions of market microstructure models of the foreign exchange market. They conclude that a technical analysis of High, Low and Close prices is a useful way of learning about latent Granger causality in high frequency exchange rates.

Lee, Liu, and Chen [22] model the imprecise and vague candlestick patterns and transfer the financial time series data to fuzzy candlestick patterns for pattern recognition leading to increased efficiency of investment strategies. Arroyo [23] forecasts candlestick time series using locally weighted learning methods, such as the k-Nearest Neighbors algorithm. Such methods have been successfully applied to forecast other kind of financial time series as shown by Aparicio et al. [27] and Fernández-Rodríguez et al. [28]. Arroyo illustrates successful forecasting ability of the proposed methods with a high frequency candlestick time series of the S&P500 index.

Marszalek and Burczynski [24] present an experimental evaluation of fuzzy time series models which are based on ordered fuzzy numbers to predict financial time series. In an empirical study ordered fuzzy autoregressive (OFAR) models are applied to modeling and predict price movement of futures contracts on Warsaw Stock Exchange Top 20 Index. Their results suggest that there is a potential to make profit using technical analysis based on OFAR predictors. They conclude that the representation of financial data using their concept of ordered fuzzy candlestick can be very useful to investors.

Cervelló Royo, Martínez, and Michniuk [25] present empirical evidence, which confronts the classical Efficient Market Hypothesis. They propose a risk-adjusted profitable trading rule based on technical analysis and the use of a new definition of the flag pattern. This rule defines when to buy or sell, the profit pursued in each operation, and the maximum bearable loss. In order to untie the results from randomness, they use a database comprised of 91,307 intraday observations from the DJIA index. They further parameterize the trading rule by generating 96 different configurations and report the results of the whole sample over three subperiods. They also replicate the analysis on two leading European indexes: the German DAX and the British FTSE. The returns provided by the proposed trading rule are higher for the European than for the US index, which highlights the greater inefficiency of the European markets.

The fuzzy approach in Naranjo, Arroyo, and Santos [26] makes possible to account for the vagueness and uncertainty of the patterns. The authors make three well-known candlestick patterns to generate a fuzzy trading system. This system is tested in two portfolios of different stock markets, Nasdaq and Eurostoxx to demonstrate that it obtains more profits in a less risky way than the other trading systems considered in their study, namely the classical buy-and-hold strategy. Their fuzzy candlestick-based system not only improves the pattern recognition, but it also exhibits a more stable behavior in the markets analyzed and obtains more profits in a less risky way than other trading systems.

Several other studies also had positive results for limited markets or for certain patterns. For example, Lu, et al. [29] found that three bullish reversal patterns, i.e. the Bullish Engulfing, the Bullish Harami, and the Piercing, “have significant predictive power in the Taiwan stock market.” Examination of bearish patterns did not yield the predictive power of the bullish patterns.

In another study, Zhu et al. [30] conclude that Bullish Harami, Engulfing and Piercing patterns are seen to work well when applied to highly liquid, small company stocks in the Chinese exchanges. Xie et al. [31] claim to have demonstrated that candlesticks do provide predictive power based on past performance using S&P 500 index data.

In a comprehensive study, Jamaloodeen et al. [12] statistically analyze the predictive power of Shooting Star and Hammer candlesticks. Results show that historically, these patterns offer little forecasting reliability when using closing prices but are highly reliable when using the high price for the Shooting Star and the low price for the Hammer.

Mixed results are obtained in a study by Chmielewski et al. [32] applied to the Warsaw, Poland market. The study found no evidence to suggest candlesticks can be used to make a profit. However, the preliminary results obtained in a subsequent study [33] show that “there are types of candlesticks which frequently tend to appear close to trend-reversal regions and others which cannot be found in such regions”.

Section 3. Japanese candlesticks

Japanese candlesticks is a charting technique conceived in Japan over two centuries ago. They were primarily used to study the price variations of rice. Each candle depicts the open, high, low and close prices for a particular period. As shown in **Error! Reference source not found.**, the box part of the

candle is referred to as the “body” and it represents the open and close prices. The thin vertical line above the body is referred to as the “upper shadow”, and the thin vertical line below the body is referred to as “lower shadow”. A green or empty body indicates that the open price was lower than the close price. A red or solid body indicates that the open was higher than the close. The top and low shadows indicate the high and low prices respectively. In the event that the open and close prices are equal, the candlestick is referred to as Doji.

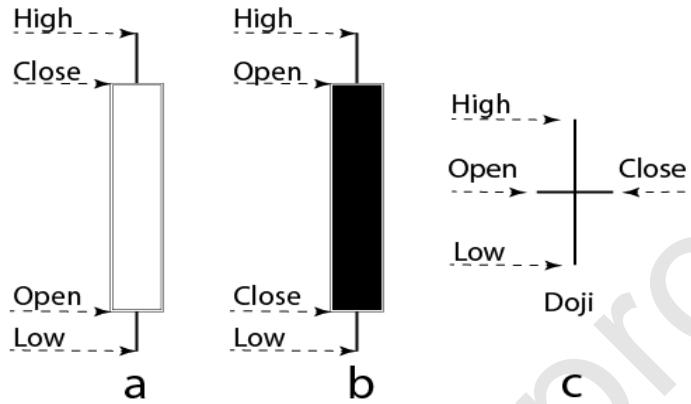


Figure 1. Japanese Candlesticks

Although the most common period is daily, the period can also be 5-minute, 1-hour, 1-week, 1-month, as well as other periods. As candles are drawn on a chart, they create patterns that are believed to forecast price action. Patterns are categorized by the number of candles: either a sequence of 1, 2 or 3 candles to establish the pattern, as well as their expectation: bullish, bearish or continuation. A bullish expectation indicates that the pattern forecasts a price bottom and thus, prices are expected to rise. A bearish expectation indicates that the pattern forecasts a price top and thus, prices are expected to fall.

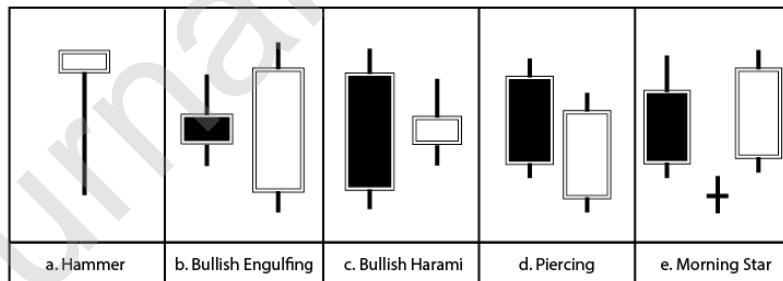


Figure 2. Bullish Patterns

A continuation indicates that future prices are expected to continue to move in the direction of the current trend. **Error! Reference source not found.** shows some common bullish patterns such as Hammer (2a), Bullish Engulfing (2b), Bullish Harami (2c), Piercing (2d) and Morning Star (2e). According to the literature [34], these patterns must be preceded by a downtrend to be valid. For instance, a Bullish Engulfing appearing after an uptrend or sideways movement should be ignored, as it is not valid. Quite often, the literature provides a vague definition of an uptrend [34, pp. 44-46], [35, p. 61] as a period of rising prices but offers no specifics as the length of time, number of higher prices or even what price (open, high, low, close).

The opposite of bullish patterns is bearish patterns. Error! Reference source not found. represents common bearish patterns such as Shooting Star (3a), Bearish Engulfing (3b), Bearish Harami (3c), Dark Cloud Cover (3d) and Evening Star (3e). Similarly, the literature states that these patterns must be preceded by an uptrend to be valid. For instance, a Bearish Engulfing appearing after a downtrend or sideways movement should be ignored. Once again, the definition of a downtrend is usually quite vague [34], [35] since it is stated as a period of decreasing prices but without specifics.

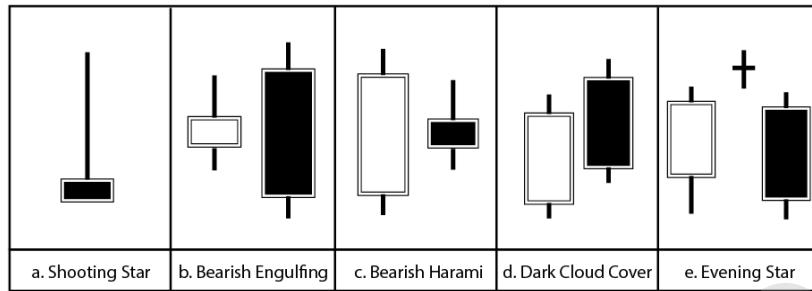


Figure 3. Bearish Patterns

Notice that multiple patterns may appear on a chart for a specific period. It is generally straightforward to identify the patterns in a chart. However, due to the subjective nature of the candlesticks, there are instances where this task is not as simple since there is no clear definition of small or large body, or of uptrend or downtrend. Error! Reference source not found. depicts a 3-month chart of QQQ from Yahoo! Finance. The Bearish Harami pattern (4.A) emerges near the end of January after an uptrend. The Bullish Harami (4.B) appears on the second week of February after a downtrend. The Piercing (4.C) materializes in the first week of March after a short drop in prices. Finally, the Bearish Engulfing (4.D) can be seen in the second week of March after an uptrend.



Figure 4. Bearish Harami (A), Bullish Harami (B), Piercing (C), and Bearish Engulfing (D) Patterns

3.1. Bullish and Bearish Engulfing patterns

The Bullish Engulfing pattern is a two-candle pattern believed to forecast a price bottom and consequently, prices are expected to rise (Error! Reference source not found.). According to the literature [36, p. 34], this pattern is composed of a small dark body (or red) candle followed by a large white body (or green) candle. The second candle's body should completely cover (engulf) the first

candle's body while shadows should not be considered. Notice that there is no specific value for small or large body. Moreover, this pattern is believed to be valid only after a definable downtrend, although, as mentioned earlier, there is no clear definition as to what constitutes a definable downtrend.

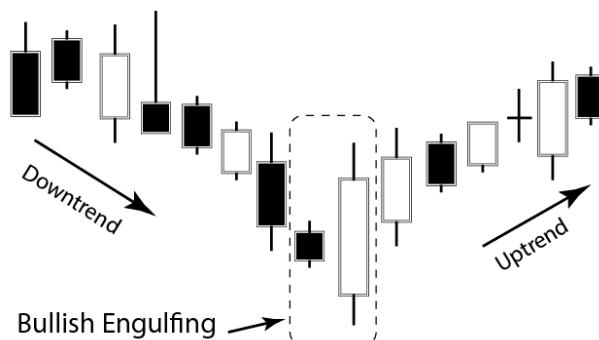


Figure 5. Bullish Engulfing Trends

The pattern psychology is as follows. After a downtrend has occurred over a period of time, the price opens below the previous day's close. During the trading session, the price starts to rise and closes above the previous day's open indicating that buyers have regained control and the trend has reversed.

The Bearish Engulfing Pattern is a two-candle pattern believed to forecast a price top and consequently, prices are expected to fall [36, p. 36]. It is composed of a small white body (or green) candle followed by a large dark body (or red) candle whose body completely covers (engulfs) the previous day's body. Once again, the shadows should not be considered. Figure 6 depicts an occurrence of the Bearish Engulfing pattern. Notice that for the signal to be valid, it must be preceded by an uptrend, so that after the pattern occurs, prices are expected to decline.

The pattern psychology develops after an uptrend has been in effect for a while and the price opens above the previous day's close. During the trading session, prices decline and finish below the previous day's open indicating that sellers have taken over and the trend has changed.

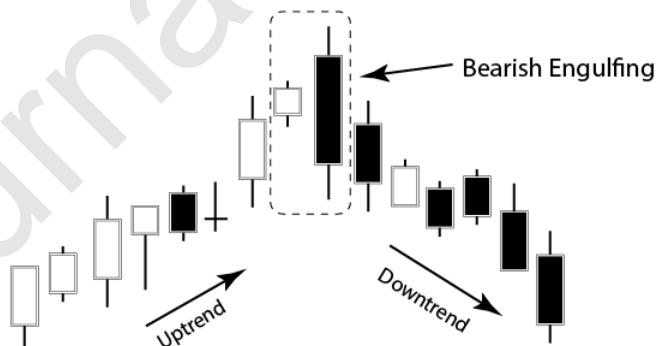


Figure 6. Bearish Engulfing Trends

The aim of our study is to analyze the reliability of the Bullish and Bearish Engulfing candlestick patterns.

Section 4. Overview of the study

We analyze statistically the performance of the Bullish and Bearish Engulfing patterns using historical daily price data of the S&P 500 index from 1950 to 2020. This data was obtained from the Yahoo! Finance website. To perform our study, we created a C# program to detect the bullish and bearish candlestick patterns and calculate statistics for these through MS Excel. Due to the subjective nature of Japanese Candlesticks and Technical Analysis in general, we provide precise terminology for our study, which is detailed in section 4.1. First, we point out that the literature [34] states that in the Bullish and Bearish Engulfing patterns, the body of the first candle should be small, but it does not define how small. We classify the pattern occurrences by the size of the first candle relative to the second candle by 3 categories. In this way, we separately analyzed the instances on which the first candle's body is at most 75%, then 50% and finally 25% of the size of the second candle's body to discover if the size of the first candle's body is relevant to the pattern's forecasting power. Second, the literature states that the Bullish Engulfing should be preceded by a downtrend to be valid and likewise the Bearish Engulfing should be preceded by an uptrend to be valid. For the sake of completeness, then, we studied the occurrences of the engulfing candlestick patterns when preceded by the appropriate trend (uptrend for the Bearish Engulfing, and downtrend for the Bullish Engulfing patterns respectively) as well as when the engulfing patterns occur regardless of a prior trend to determine if the presence of a prior trend makes a difference in the patterns' effectiveness or not. Finally, we compared the Bullish and Bearish Engulfing patterns' success rates for predicting price bottoms and price tops, respectively, against the success rate for all days, regardless of patterns, in predicting bottoms and tops.

4.1. Definitions for our study

4.1.1. General

Session. For the S&P 500, the trading session opens at 9:30 am EST and closes at 4:00 pm EST. For our study, a session consists of a trading day and thus, we use daily candlesticks.

Open (O). The first traded price of the session.

High (H). The highest traded price for the session.

Low (L). The lowest traded price for the session.

Close (C). The last traded price of the session.

Candle Body (CB). The absolute value of the difference between High and Low. Formally: $CB = |H-L|$

Upper Shadow (US). The difference between the High and the maximum price of Open and Close. Formally: $US = H - \text{Max}(O, C)$.

Lower Shadow (LS). The difference between the minimum price of Open and Close minus the Low. Formally, $LS = \text{Min}(O, C) - L$.

White/Green Candle. A Japanese candlestick for which the Open price is lower than the Close price.

Black/Red Candle. A Japanese candlestick for which the Open price is higher than the Close price.

N-day Moving Average (n-MA). The average Close price over a period of n days.

Uptrend. It occurs when the n-day moving average has been increasing for at least 70% of the days.

Downtrend. It occurs when the n-day moving average has been decreasing for at least 70% of the days.

Sideway. It happens when neither an uptrend nor a downtrend occurs.

With Trend (WT, T). It implies that the trend is considered in the study.

Regardless of Trend (RT). It implies that the trend is not considered in the study.

4.1.2. Bullish Engulfing

Bullish Engulfing. A two-candle pattern comprised of a black candle followed by a white candle whose body completely covers (engulfs) the previous day body. Shadows are not a consideration.

Bullish Engulfing (25% of body). A Bullish Engulfing pattern for which the first day's body is at most 25% of the size of the second day's body.

Bullish Engulfing (50% of body). A Bullish Engulfing pattern for which the first day's body is at most 50% of the size of the second day's body.

Bullish Engulfing (75% of body). A Bullish Engulfing pattern for which the first day's body is at most 75% of the size of the second day's body.

Success. For a given Bullish Engulfing appearing on day t , the success over the next n days is evaluated based on the following criteria.

Price

- **Open.** No Close price is lower than the Open of the Bullish Engulfing's second candle.
Formally, $O \leq \min(C_{t+1}, C_{t+2}, \dots, C_{t+n})$
- **Close.** No Close price is lower than the Close of the Bullish Engulfing's second candle.
Formally, $C \leq \min(C_{t+1}, C_{t+2}, \dots, C_{t+n})$
- **Low.** No Close price is lower than the Low of the Bullish Engulfing's second candle.
Formally, $L \leq \min(C_{t+1}, C_{t+2}, \dots, C_{t+n})$
- Trend
 - **After downtrend.** The pattern occurred after a downtrend and a Price criterion is met.
 - **Regardless of trend/no trend.** A Price criterion is met, the pattern occurred, and the previous trend is not considered.

Failure. For a period of n days following the appearance of the Bullish Engulfing, if the pattern was not successful, then it is considered a failure.

4.1.3. Bearish Engulfing

Bearish Engulfing. A two-candle pattern comprised of a white candle followed by a black candle whose body completely engulfs the previous day candle. Shadows are not a consideration.

Bearish Engulfing (25% of body). A Bearish Engulfing pattern for which the first day's body is at most 25% of the size of the second day's body.

Bearish Engulfing (50% of body). A Bearish Engulfing pattern for which the first day's body is at most 50% of the size of the second day's body.

Bearish Engulfing (75% of body). A Bearish Engulfing pattern for which the first day's body is at most 75% of the size of the second day's body.

Success. For a given Bearish Engulfing appearing on day t , the success over the next n days is evaluated based on the following criteria.

- Price
 - **Open.** No Close price is higher than the Open of the Bullish Engulfing's second candle.
Formally, $O \geq \max(C_{t+1}, C_{t+2}, \dots, C_{t+n})$
 - **Close.** No Close price is higher than the Close of the Bullish Engulfing's second candle.
Formally, $C \geq \max(C_{t+1}, C_{t+2}, \dots, C_{t+n})$
 - **High.** No Close price is higher than the High of the Bullish Engulfing's second candle.
Formally, $H \geq \max(C_{t+1}, C_{t+2}, \dots, C_{t+n})$
- Trend
 - **After uptrend.** The pattern occurred after an uptrend and a Price criterion is met.
 - **Regardless of trend/no trend.** A Price criterion is met, the pattern occurred, and the previous trend is not considered.

Failure. For a period of n days following the appearance of the Bearish Engulfing, if the pattern was not successful, then it is considered a failure.

Section 5. Statistical analysis

We provide several statistical analyses for the effectiveness of the Bullish and Bearish Engulfing patterns analyzing S&P 500 data from 1950-2018, 1950-1998, 1999-2010, 2010-2020. We begin with a

descriptive study of their effectiveness in predicting price bottoms and tops as appropriate in Section 5.1. We continue that analysis in Section 5.2, with a more quantitative and inferential study for the effectiveness of the Bullish and Bearish Engulfing candlestick patterns. Next, in Section 5.3 we perform ANOVA analysis for factors corresponding to the engulfing patterns including factor Trend vs No Trend, factor percentage of body (25%, 50%, and 75%), and finally factor success criterion (CLOSE, HIGH, OPEN in the case of the Bearish Engulfing pattern and CLOSE, LOW, OPEN in the Bullish Engulfing pattern case). In section 5.4 we study the failures of the engulfing patterns in more detail; in particular, how severe those failures were on a percentage basis. In section 5.5 we study the inter-arrival times of the Bearish and Bullish Engulfing patterns and present some results on goodness of fit tests for the distributions of these inter arrival times. Finally, in section 5.6 we compare the pattern's success rates of 1999-2010 and 2010-2020 vs 1950-1998.

Recall that the Bearish Engulfing pattern is a bearish signal, which in an uptrend is believed to forecast a top or resistance area, since prices have been consistently moving up but finished near the bottom of the day failing to establish a new high. A Bullish Engulfing pattern is a bullish signal, which in a downtrend is believed to forecast a bottom.

We analyze the Bearish and Bullish Engulfing patterns in scenarios in which there were uptrends and downtrends respectively, as well as when they appeared without any trend. We present analysis for the Bearish Engulfing pattern forecasting a top, and the Bullish Engulfing pattern forecasting a bottom based on 3-, 5-, 7- and 10-day moving averages (MA) under the success criteria of OPEN, CLOSE, and HIGH for the Bearish Engulfing pattern and the criteria of OPEN, CLOSE, and LOW for the Bullish Engulfing pattern. Each such scenario is studied under three measures of engulfing, 25% of body, 50% of body and 75% of body.

5.1. Descriptive analysis of success proportions for engulfing patterns versus all candles

The important data used in the statistical analysis is included in O - Appendix. Table 1 summarizes the proportion of successful predictions of a market top for the Bearish Engulfing pattern compared to the proportion of all market tops (all candles). Likewise, Table 2 summarizes the proportion of successful predictions of a market bottom for the Bullish Engulfing compared to the proportion of all market bottoms (all candles).

Chart 1 presents a graphical summary of these success proportions for the Bearish Engulfing versus the success proportions for all candles, and Chart 2 presents the summary of the proportions of successes for the Bullish Engulfing pattern versus all candles. Notice that the proportion of success for the Bearish Engulfing pattern is much higher than the proportion of successes for all candles except when the CLOSE criterion is used in which case the success proportions for the Bearish Engulfing pattern are similar, if not slightly higher than the success proportion of all candles. The exact same situation is true when comparing the success proportions of the Bullish Engulfing pattern compared to the proportion of successes for all candles—namely the Bullish Engulfing pattern success proportions are much higher except, again, when the CLOSE criterion is used. These are all regardless of trend (whether the pattern was preceded by a trend or not), regardless of the number of moving average days (3-, 5-, 7-, or 10 day) and also regardless of the percentage of body engulfing (25%, 50% or 75%).

Success rate expectations based on price criteria

As detailed in sections 4.1.2., and 4.1.3, the success rate of the pattern is determined by the closing prices of the subsequent candlesticks compared to the Open, High, Low and Close prices of the pattern's most recent candle. These price-based criteria lead to different probabilities of success based on the price used, which it is clearly reflected in the results obtained. For instance, consider the Bullish Engulfing Pattern. There are three success criteria based on Low (L), Open (O) and Close (C) as shown in

Figure 7. Let us call Close_{\min} at the lowest close for the next n candles. The pattern is successful for the Low criterion if $\text{Close}_{\min} > L$, let us call this probability of success $P(L)$; for the Open criterion, it is successful if $\text{Close}_{\min} > O$, let us call this probability $P(O)$ and for the Close criterion success is determined by $\text{Close}_{\min} > C$, let us call this probability $P(C)$. As $L \leq O \leq C$, it follows that $P(C) \leq P(O) \leq P(L)$.

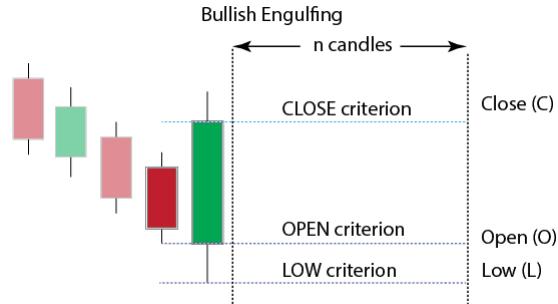


Figure 7. Bullish Engulfing Success Rate Expectations

Conversely, consider the Bearish Engulfing pattern shown in Figure 8. There are three success criteria based on High (H), Open (O) and Close (C). Let us call Close_{\max} at the highest close for the next n candles. The pattern is successful for the High criterion if $\text{Close}_{\max} < H$, let us call this probability of success $P(H)$; for the Open criterion, it is successful if $\text{Close}_{\max} < O$, let us call this probability $P(O)$ and for the Close criterion success is determined by $\text{Close}_{\max} < C$, let us call this probability $P(C)$. As $C \leq O \leq H$, it follows that $P(C) \leq P(O) \leq P(H)$.

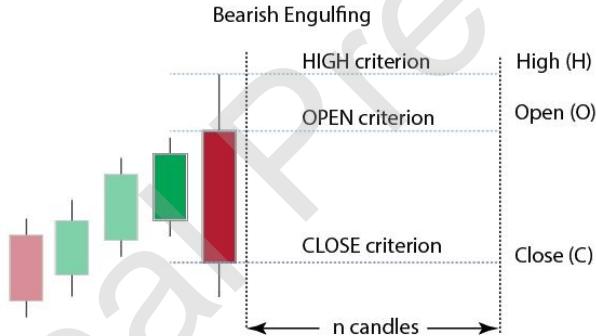


Figure 8. Bearish Engulfing Success Rate Expectations

5.2. Inferential analysis of success proportions for engulfing pattern versus all candles Tests for independence between pattern's signals

We conducted nonparametric chi-squared tests for both the Bearish Engulfing and the Bullish Engulfing patterns. We tested whether the appearance of a top or a bottom was dependent on the Bearish or Bullish Engulfing pattern respectively.

In the case of tops and the Bearish Engulfing pattern the hypotheses are:

- H_0 : tops are independent of the Bearish Engulfing pattern
- H_a : tops are dependent on the Bearish Engulfing pattern

In the case of bottoms and the Bullish Engulfing pattern the hypotheses are:

H_0 : bottoms are independent of the Bullish Engulfing pattern
 H_a : bottoms are dependent on the Bullish Engulfing pattern

The chi-squared tests and p-values are summarized in Table 1 for the Bearish Engulfing and in Table 2 for the Bullish Engulfing.

For example, consider the Bearish Engulfing pattern 3-day moving average and 25% body, after an uptrend (and HIGH criterion). We see that there are 80 successful Bearish Engulfing patterns giving a proportion of successes $0.559441 = 80/143$ of which successfully signaled a top. Using a chi-squared test, we test whether this is independent of the Bearish Engulfing signal, using all days of which there were 6,506 to which there corresponded 3,006 tops or a proportion of $0.462035 = 3,006/6,506$. The nonparametric chi-squared test for independence comparing 80 successful Bearish Engulfing signals out of a total of 143 Bearish Engulfing signals against 3,006 days that are tops out of a total of 6,506 days yields a p-value of 0.02604 suggesting that tops are dependent of the Bearish Engulfing pattern.

With reference to Table 1 and Table 2, notice that in every scenario, except when the CLOSE criteria is used, the small p-values indicate that there is strong evidence to suggest that tops are dependent on the Bearish Engulfing, and that bottoms are dependent on the Bullish Engulfing. In most instances the p-values are much less than 0.01 and, in all cases, less than 0.03 (again except when the CLOSE criteria is used) in which case we conclude that tops are dependent of the Bearish Engulfing pattern and bottoms are dependent of the Bullish Engulfing pattern. This is consistent with the expectation described in Section 5.1 Success rate expectations based on price criteria.

Tests for comparing success proportions between pattern's signals and no signals

We also conducted tests of proportions both parametric and nonparametric. We tested whether the proportion of successes with the candle pattern is greater than the proportion of tops, in the Bearish Engulfing candle case and whether the proportion of success with the candle pattern is greater than the proportion of bottoms, in the Bullish Engulfing candle case. The hypotheses for both patterns are:

H_0 : success proportion for engulfing pattern = success proportion without pattern
 H_a : success proportion for engulfing pattern > success proportion without pattern

For example, with reference to Table 1 again, consider the Bearish Engulfing pattern, 3-day moving average 25% body, after an uptrend (and HIGH criterion). We see that there are 80 successful Bearish Engulfing patterns giving a proportion of successes $r_1 = 0.559441 = 80/143$ of which successfully signaled a top. Using a t-test, we test whether this is greater than the proportion for Bearish Engulfing signal, using all days of which there were 6,506 to which there corresponded 3,006 tops or a proportion of $r_2 = 0.462035 = 3,006/6,506$. The nonparametric t-test for proportions comparing 80 successful Bearish Engulfing signals out of a total of 143 Bearish Engulfing signals against 3,006 days that are tops out of a total of 6,506 days yields a p-value of 0.009737 suggesting that the proportion of successes with the Bearish Engulfing pattern is statistically larger than the corresponding proportion of all tops.

The nonparametric t-tests are summarized in Table 1 for the Bearish Engulfing and Table 2 for the Bullish Engulfing. In every scenario, except when the CLOSE criteria is used, the small p-values indicate that there is strong evidence to suggest that the proportion of successful tops for the Bearish Engulfing is statistically larger than the corresponding proportion of all tops, and that the proportion of successful bottoms for the Bullish Engulfing pattern is statistically larger than the corresponding proportions of all bottoms. In every instance (except when the CLOSE criteria is used) the p-values are less than 1E-6 and in all cases (again except when the CLOSE criteria is used) in which case we conclude that the proportions of successful tops for the Bearish Engulfing pattern and the proportion of successful bottoms for the Bullish Engulfing pattern are statistically larger than the corresponding

proportions of all tops and corresponding proportions of all bottoms. This is consistent with the expectation described in Section 5.1 Success rate expectations based on price criteria.

5.3. ANOVA Inferential analysis of factors

In this section we present basic factor analysis to determine the significant factors for the success proportions. Letting μ denote population success proportion. We test:

$$H_0: \mu_{OPEN} =: \mu_{CLOSE} =: \mu_{HIGH}$$

H_a : at least two population success proportions are different

In the instance of the Bearish Engulfing case, and

$$H_0: \mu_{OPEN} =: \mu_{CLOSE} =: \mu_{HIGH}$$

H_a : at least two population success proportions are different

In the instance of the Bullish Engulfing case, and

$$H_0: \mu_{OPEN} =: \mu_{CLOSE} =: \mu_{LOW}$$

H_a : at least two population success proportions are different

We also test both of the following factors for both the Bearish Engulfing case and the Bullish Engulfing case

$$H_0: \mu_{25\% \text{ of body}} =: \mu_{50\% \text{ of body}} =: \mu_{75\% \text{ of body}}$$

H_a : at least two population success proportions are different

Finally, we test

$$H_0: \mu_{uptrend} =: \mu_{no trend}$$

H_a : at least two population success proportions are different

In the instance of the Bearish Engulfing case. For the Bullish Engulfing case,

$$H_0: \mu_{downtrend} =: \mu_{no trend}$$

H_a : at least two population success proportions are different

The ANOVA results for the Bearish Engulfing and Bullish Engulfing are summarized in Table 3**Error! Reference source not found.** and Table 4 respectivelyTable 4. From the ANOVA analysis we see that large p-values suggest that trend (uptrend/bearish and downtrend/bullish) is not a statistically significant factor for proportions of success for the engulfing patterns. Likewise, large p-values suggest that percent of body engulfing (25%, 50% and 75%) is also not a statistically significant factor for proportions of success for the engulfing patterns. However, the criterion on which to determine if an engulfing pattern is detected (OPEN/CLOSE/HIGH in the case of the Bearish Engulfing) and (OPEN/CLOSE/LOW in the case of the Bullish Engulfing) are statistically significant factors. This last result is to be expected. In the case of the trend, it is clear that if we restrict the pattern occurrences to only those preceded by a downtrend (for Bullish Engulfing) or uptrend (for Bearish Engulfing), there will be less instances that if we do not restrict by trend. Similarly, for the percent of body engulfing, the more we restrict the size of the first candle's body, the lower the number of occurrences we are expected to find.

5.4. Inferential analysis for percent errors of failures

Just as important as identifying the patterns' success ratios, it is also beneficial to study the failures. In particular, how severe those failures were on a percentage basis. This is due to the fact that even a pattern with a high success ratio may have a negative profit expectancy if the failures are too severe and the frequent gains are not large enough to cover the occasional but considerable losses due to the pattern's failure.

We show, statistically, that the average percent of failure for the engulfing pattern is less than the average percent of failure for all candles. Specifically, our hypotheses are:

$$H_0: \mu_{\text{percent of failure of engulfing pattern}} = \mu_{\text{percent of failure for all candles}}$$

$$H_a: \mu_{\text{percent of failure of engulfing pattern}} < \mu_{\text{percent of failure for all candles}}$$

The data and t-statistics for these tests are shown in Table 5 for the Bearish Engulfing, and in Table 6 for the Bullish Engulfing. Consider for example, the Bearish Engulfing in the case of the 3-day MA, with criterion CLOSE, and 25% of body engulfing, we see that there were 341 Bearish Engulfing failures, and that the average percent by which these 341 failed is 0.01079 (1.079%) and the standard deviation for the percent of failure for these 341 instances is 0.00958 (0.958%). By contrast, on the same table, there are 12,368 failures of all candles/patterns and that the average percent of failures for these 12,368 instances is 0.0112 (1.12%) and the standard deviation for the percent of failure of these 12,368 cases is 0.0106 (1.06%). The data shows that statistically (at the 5% level) the average percent by which the engulfing pattern fails is significantly lower than the average percent by which all candles fail except in the case when the CLOSE criterion is used for both the Bearish and Bullish Engulfing patterns.

5.5. Exploratory distributional analysis of inter-arrival times for Bullish and Bearish Engulfing patterns

Another important measure of the patterns' usefulness is the frequency of appearance. A pattern that rarely appears in real life is of little use to the investor. We studied the frequency of occurrence of Bullish and Bearish Engulfing patterns by calculating the number of days (inter-arrival time between pattern occurrences) between each appearance over the entire time period evaluated. The inter-arrival times were analyzed for the following frequencies of patterns observed:

- a) Bearish Engulfing 25% body N=587
- b) Bearish Engulfing 50 % body N=916
- c) Bearish Engulfing 75 % body N=1181
- d) Bullish Engulfing 25% body N=554
- e) Bullish Engulfing 50 % body N=922
- f) Bullish Engulfing 75 % body N=1181

From the distributions of each of these inter-arrival times, (for example 587 inter-arrival times for the Bearish Engulfing pattern with 25% of body) we noticed a skewed exponential/Poisson type distribution. We fitted Weibull, Exponential and Poisson distributions for each of these, for both the Bullish and Bearish Engulfing inter-arrival time distributions. The summaries and parameters of the distributions for each scenario are presented in Table 7 for the Bearish Engulfing inter-arrival time distributions, and in Table 8 for the Bullish Engulfing inter-arrival time distributions. We were not able to fit a statistically significant distribution that matched any of the inter-arrival time distributions.

In particular we tested:

H_0 = the inter-arrival times for (Bullish/Bearish) Engulfing come from a two-parameter Weibull distribution

H_a = the inter-arrival times for (Bullish/Bearish) Engulfing do NOT come from a two-parameter Weibull distribution

For this situation the Cramer-von Mises goodness of fit test was used.

We also tested,

H_0 = the inter-arrival times for (Bullish/Bearish) Engulfing come from a Poisson distribution

H_a = the inter-arrival times for (Bullish/Bearish) engulfing do NOT come from a Poisson distribution

For this situation a Pearson chi-squared goodness of fit test was used.

Finally, we tested

H_0 = the inter-arrival times for (Bullish/Bearish) Engulfing come from an exponential distribution

H_a = the inter-arrival times for (Bullish/Bearish) Engulfing do NOT come from an exponential distribution

For this situation a Kolmogorov D-statistic goodness of fit test was used.

In every case, the p-values were less than 0.01 meaning that the null hypotheses had to be rejected to conclude that the inter-arrival times fit none of the hypothesized distributions above. We plan to pursue a more in-depth modeling analysis of the inter-arrival times for both Bearish and Bullish Engulfing patterns in future work.

While a study of the distribution of the inter-arrival times is still a work in progress, there is one comment we can make here regarding the prevalence of the Bullish and Bearish Engulfing signals. We observe that these patterns are very prevalent compared to other candle pattern studies we have seen in the literature. We compare our study of the Bearish and Bullish Engulfing, to the study of [12] in which the Hammer and Shooting Star patterns were analyzed from 1950 to 2017. A Shooting Star candle pattern in an uptrend is hypothesized to forecast a temporary top price and thus, price is expected to move downward afterwards, which is the same expectation of the Bearish Engulfing pattern. Likewise, a Hammer pattern in a downtrend is hypothesized to forecast a temporary bottom price and thus, price is expected to move upward afterwards similarly to the Bullish Engulfing.

With reference to the Bearish Engulfing, we see that from 1950 to 2018, it appeared $N=587$, $N=916$ and $N=1181$ with 25%, 50% and 75% respectively and the Bullish Engulfing appeared correspondingly, $N=554$, $N=922$ and $N=1181$ times. By contrast from 1950 to 2017 [12] the Shooting Star appeared a maximum of 161 times (regardless of a preceding uptrend or not) and the Hammer appeared a maximum of 289 times (regardless of a preceding downtrend or not). Also, our analysis show that the success proportions of Bearish and Bullish Engulfing patterns are higher than those of the Shooting Star and Hammer, which suggests that the Bearish and Bullish Engulfing patterns provide stronger predictive power.

5.6. Comparing success rates of 1999-2010 and 2010-2020 vs 1950-1998

In this section we look at the engulfing patterns successes based on a study of their effectiveness during the last two decades, 1999-2010 and 2010-2020. We compare the success rates of both the Bullish and Bearish Engulfing patterns for the decade 1999-2010 against the comparable success rates for the five decades 1950-1998, and likewise for the decade 2010-2020 against the same success rates for the five decades 1950—1998. By comparing recent decades with past decades, we address claims that technical approaches are not useful anymore [13] [16].

Chart 3 compares the Bearish Engulfing success rates for the decades 1999-2010 and 2010-2020 against the previous five decades 1998-2020. Likewise, Chart 4 compares the Bullish Engulfing success rates for the decades 1999-2010 and 2010-2020 against the previous five decades 1998-2020.

From Chart 3 and Chart 4, it is clear that the Bullish and Bearish Engulfing pattern success rates, for each of the last two decades 1999-2010 and 2010-2020 are comparable to the corresponding Bullish and Bearish Engulfing pattern success rates for the period 1950-1998. Before we provide a formal statistical inferential analysis of these rates, we make some important remarks. First, most of the years,

in the decade 1999-2010 are considered ex post facto years of a bearish market, and likewise, the decade 2010-2020 is considered a bull market. Second, while Chart 3 and Chart 4 can be used to descriptively compare engulfing pattern success rates for the decades 1999-2010 and 2010-2020 against the comparable engulfing pattern success rates for the prior five decades 1950-1998, in some instances an inferential statistical comparison cannot be made because there have been insufficient Bullish or Bearish Engulfing patterns occurrences in the decades 1999-2010 or the decades 2010-2020 to compare against the prior 5 decades 1950-1998 to permit a robust inferential analysis.

Based on Chart 3 and Chart 4, we see that Bullish and Bearish Engulfing success rates for the years 1950-1998 are consistently higher than the corresponding success rates for the decades 1999-2010 and 2010-2020 only when the CLOSE criterion is used. However, this is consistent with our prior analysis, in which we concluded that the CLOSE criterion is not to be used as a means to establish the effectiveness of Bullish and Bearish Engulfing patterns. In fact, our prior analysis that Bearish Engulfing pattern appears to be effective when the OPEN criterion is used and even more so when the HIGH criterion is used and when the LOW criterion is used in the case of the Bullish Engulfing pattern. In these scenarios, the success rates for the engulfing patterns during the decades 1999-2010 and 2010-2020 appear to be comparable to those of the five prior decades 1950-1998. In a few instances, however, we observed mixed results mainly due to the factors previously mentioned such as the decade (1999-2010 or 2010-2020) was primarily a bull or bear market and if there were insufficient engulfing pattern occurrences in the respective decades to compare against the years 1950-1998. We point these out in the next section, where we formally compare the success rates in the decades against the years 1950-1998 using inferential z-tests to compare two proportions.

5.6.1. Inferential analysis comparing success rates of Bullish and Bearish Engulfing patterns for decades 1999-2010, and 2010-2020 against the prior 5 decades 1950-1998

We present tests to compare two proportion for successes with bearish and bullish patterns with the following hypotheses with $p_{decade}^{pattern}$, being the success proportion for the given decade (1950-1998 against decades 1999-2010 or 2010-2020) and the given pattern (Bearish Engulfing or Bullish Engulfing). For example, considering the decade 1999-2010 with the bullish pattern, the hypotheses would be:

$$H_0: p_{1950-1998}^{bullish} = p_{1999-2010}^{bullish}$$

$$H_a: p_{1950-1998}^{bullish} \neq p_{1999-2010}^{bullish}$$

To show that the Bullish and Bearish Engulfing patterns are as effective for the decades 1999-2010 and 2010-2020 with the prior 5 decades 1950-1998, we need to analyze those cases in which the null hypotheses is rejected with the sample success proportions for the decade under consideration less than the sample proportion for the decade 1950-1998 with $\alpha=0.05$.

We first consider the Bearish and Bullish Engulfing patterns success proportions for the decade 1999-2010 versus those for 1950-1998. The two-proportion tests for success proportions of the Bearish Engulfing comparing success proportions for 1999-2010 against those for 1950-1998 are summarized in Table 9 and for the Bullish Engulfing in Table 10. The comparable tests for Bearish and Bullish Engulfing for the decade 2010-2020 versus those for 1950-1998 are found Table 11 and Table 12 respectively.

5.6.1.1. Comparing the success rates for the decades 1999-2010 against the decades 1950-1998

The two tests for success proportions of the Bearish Engulfing comparing success proportions for 1999-2010 against those for 1950-1998 are summarized in Table 9. The comparison of the respective success rates for the Bullish Engulfing pattern are summarized in Table 10.

The cases where the null hypothesis is rejected and where the sample proportion for the years 1950-1998 are highlighted in orange. For the p-values in the tables ($\alpha=0.05$).

In the case of the Bearish Engulfing pattern, the success rate for the years 1950-1998 appears to be larger than that for the decade 1999-2010 in only 5 instances Table 9, namely the cases of

3-day MA: 50% of body using the CLOSE Criterion regardless of trend; 75% of body with CLOSE criterion regardless of trend. (2 cases)

5-day MA: with 50% of body with CLOSE criterion regardless of trend; 75% of body with CLOSE criterion regardless of trend. (2 cases)

7-day MA with 50% body with CLOSE criterion with trend. (1 case)

Not only are these only a few cases, but they all occur with the CLOSE criterion, which we have already established should not be used in the case of engulfing patterns.

In the case of the Bullish Engulfing pattern, the success rate for the years 1950-1998 appears to be larger than that for the decade 1999-2010 in only 22 out of 72 instances Table 10, namely the cases of

3-day MA: 75% of body using the CLOSE Criterion regardless of trend. (1 case)

5-day MA: with 25% of body with CLOSE criterion regardless of trend; 50% of body with CLOSE criterion regardless of trend; 75% body with CLOSE criterion regardless of trend, and also with trend. (4 cases)

7-day MA: with 25% body with CLOSE criterion with trend; and without trend; 50% of body with CLOSE criterion with trend; and without trend; 50% of body with LOW criterion with trend; 75% of body with CLOSE criterion with trend; and without trend, 75% of body with LOW criterion with trend and without trend. (9 cases)

10-day MA: with 25% body with CLOSE criterion with trend; and without trend; 50% of body with CLOSE criterion with trend; and without trend; 75% of body with CLOSE criterion with trend; and without trend, 75% of body with LOW criterion with trend and without trend. (8 cases)

Of these 22 cases all but 5 (as underlined above) use the CLOSE criterion. Again, this is not evidence against the effectiveness of the Bullish Engulfing for the decade 1999-2010, which we consider quite noteworthy considering that this decade includes the bear markets of 2000-2003 (dot-com bubble) and 2008-2010 (subprime mortgage crisis).

5.6.2. Comparing the success rates for the decades 2010-2020 against the decades 1950-1998

The two proportion tests for success proportions of the Bearish Engulfing comparing success proportions for 2010-2020 against those for 1950-1998 are summarized in Table 11 and comparing the respective success rates for the Bullish Engulfing pattern are summarized in Table 12.

In the case of the Bearish Engulfing pattern, the success rate for the years 1950-1998 appears to be larger than that for the decade 2010-2020 in 24 out of 72 instances (Table 11), namely the cases of

- 5-day MA: with 25% of body with CLOSE criterion regardless of trend; 50% of body with CLOSE criterion regardless of trend; and 75% of body with CLOSE criterion regardless of trend. (3 cases)

- 7-day MA: with 25% body with CLOSE criterion regardless of trend, HIGH criterion regardless of trend; 50% of body with CLOSE criterion with trend, HIGH criterion regardless of trend; 75% body with CLOSE criterion with trend and regardless of trend, OPEN criterion regardless of trend and HIGH criterion regardless of trend. (8 cases)
- 10-day MA: with 25% body with CLOSE criterion regardless of trend, OPEN criterion regardless of trend, HIGH criterion regardless of trend; 50% of body with CLOSE criterion regardless of trend and with trend, OPEN criterion regardless of trend, HIGH criterion regardless of trend and with trend; 75% of body with CLOSE criterion regardless of trend and with trend, OPEN criterion regardless of trend, HIGH criterion regardless of trend, with trend. (13 cases)

Notice that the longer the time frame, the lower the Bearish Engulfing pattern's reliability. There are no cases with 3-day MA, and 21 of 24 cases correspond to the 7 and 10-day MA respectively. Hence, the 3-day MA Bearish Engulfing is just as effective over the decade 2010-2020 as it has been over the 5 decades 1950-1998. Also, the 3 cases for the 5-day MA all correspond to the CLOSE criterion, which means that the 5-day MA Bearish Engulfing pattern using the OPEN or HIGH criterion is just as effective over the years 2010-2020 compared to the years 1950-1998. For the 7-day MA, there are 8 cases and only 4 do not involve the CLOSE criterion. However, all 4 correspond to the scenario regardless of trend. This means that the 7-day MA Bearish Engulfing for the years 2010-2020 was just as effective as it was during 1950-1998 provided that either the OPEN or HIGH criterion is used after an uptrend. The data does suggest however that the 10-day MA Bearish Engulfing over the decade 2010-2020 was not as effective as the corresponding success rates for the Bearish Engulfing during 1950-1998.

In the case of the Bullish Engulfing pattern, the success rate for the years 1950-1998 appears to be larger than that for the decade 1999-2010 in only 19 out of 72 instances (Table 12), namely the cases of

- 5-day MA: with 25% of body with CLOSE criterion regardless of trend; 50% of body with CLOSE criterion regardless of trend; 75% body with CLOSE criterion regardless of trend. (3 cases)
- 7-day MA: with 25% body with CLOSE criterion regardless of trend, OPEN criterion regardless of trend; 50% of body with CLOSE criterion regardless of trend ; OPEN criterion regardless of trend ; 75% of body with CLOSE criterion regardless of trend, OPEN criterion regardless of trend, LOW criterion with regardless of trend. (7 cases)
- 10-day MA: with 25% body with CLOSE criterion regardless of trend, OPEN criterion regardless of trend, LOW criterion regardless of trend; 50% of body with CLOSE criterion regardless of trend, OPEN criterion regardless of trend, LOW criterion regardless of trend; 75% of body with CLOSE criterion regardless of trend, OPEN criterion regardless of trend, LOW criterion regardless of trend. (9 cases)

Of these 20 cases, all but 10 (as underlined above) use the CLOSE criterion. Moreover the 10 that use the OPEN or LOW criterion all occur regardless of trend. This means that the Bullish Engulfing for the years 2010-2020 was just as effective as the Bullish Engulfing for the prior 5 decades 1950-1998 when the signal occurred after a downtrend, which is when it is recommended for use anyways.

Section 6. Incorporating Bullish and Bearish Engulfing into a profitable strategy

Based on the relative higher success rate and lower percentage failure observed when using the Bullish and Bearish Engulfing patterns when compared to all instances, it is natural to ask whether these patterns can be used to create a profitable trading strategy. Although the creation of such a strategy is beyond the scope of our work, we do provide an overview of some assumptions, general characteristics, comparison benchmarks, pros and cons.

6.1. Assumptions

For the purpose of simplicity, we assume that there are no transaction fees and no tax consequences for short-term vs long term profit and losses. That could be the case of a tax-sheltered retirement account such as IRA or Roth IRA. We also assume that the investment vehicle will SPDR S&P 500 ETF Trust (SPY) since it closely tracks the S&P500 index and it offers highly liquid daily, weekly, monthly and even Long-term Equity Anticipation (LEAP) options. At the time of writing, SPY is the largest ETF in the world.

6.2. Characteristics

As the Bullish Engulfing indicates a high probability of a bottom and conversely, the Bearish Engulfing indicates a high probability of a top, these signals could be used in systems investing directly on the underlying security or in derivatives such as options.

6.2.1. Investing in the underlying security

As the patterns' occurrences indicate bullish or bearish signals, they can be used to time entries and exits. For instance, the Bullish Engulfing could be used to indicate a buy opportunity. The holding period could be 3, 5, 7, 10 days or until a Bearish Engulfing pattern emerges. As our studies have shown (see Section 5), the longer the holding period, the lower the pattern's reliability. The Bearish Engulfing may be used to initiate a short position with a holding period of 3, 5, 7, 10 days or until a Bullish Engulfing pattern appears. Once again, the longer the holding period, the lower the pattern's reliability. It is important to note that for long positions, the maximum loss is limited to the capital invested while for short positions, it is unlimited. Therefore, the short selling strategy may suffer significant losses during strong uptrends. Trading systems using candlesticks as well as other technical indicators have been the focus of numerous studies [29] [20] [37] [38].

6.2.2. Investing using options

An interesting approach is to incorporate the candles' signals into a strategy using financial derivatives such as options. Please refer to [39] for an overview of option strategies. In this scenario, the Bullish Engulfing serves as indicator for any option strategy with positive delta. Those strategies include long call, long call spread, short put, short put spread, etc. The Bearish Engulfing serves as a signal for any option strategy with negative delta such as long put, long put spread, short call, short call spread. In the case of strategies with negative theta such as long call, long call spread, long put and long put spread, the investor needs a quick move on the expected position to counteract the negative effect of time decay. For that reason, those strategies would be better suited for LEAPS, since their long-term expiration prevents time decay to erode the option's extrinsic value at a rapid pace. The opposite is true for positive theta positions such as short call, short call spread, short put, and short put spread. Since time decay favors the investor, short-term expirations such as a week or a month are preferred. It is important to note that implied volatility (vega) also plays an important role. Positive vega positions benefit from an increase in implied volatility while negative vega positions are adversely affected. Due to their long-term expiration nature, vega has much higher impact on LEAP options than shorter-term

expirations. Therefore, the choice of strategy should not be based solely on the candlestick pattern but also on the current context (current implied volatility vs historical).

6.2.3. Investing in the underlying security and options

The candles' signals can also be incorporated into a mix strategy using options as well as the underlying in order to enhance the returns of the simple buy and hold strategy. We demonstrate this using the covered call and short put strategy.

When the Bearish Engulfing pattern appears, an investor holding 100 shares of the underlying would sell 1 Out of The Money (OTM) call contract and thus, collect a premium. The strike price would be the pattern's highest price. As the call contract is OTM, the option's strike price is higher than the underlying price and therefore, an assignment would provide a per share gain from appreciation equals to the strike price minus the underlying price. Afterwards, the investor waits for the call contract to expire worthless (contract expires OTM) or be assigned if it does not and therefore sell the shares at the strike price.

When a Bullish Engulfing pattern appears, the investor sells an OTM put contract with a strike below the pattern's lowest price and collects a premium. As the option is OTM, the strike price is lower than the underlying price, and thus an assignment would allow the investor to purchase the underlying at a lower price and thus, decrease cost basis. Afterwards, the investor waits for the put contract to expire worthless or be assigned.

6.3. Comparison benchmarks

To measure the performance of the trading system, it is natural to compare it to the buying and holding of the underlying for the same time period and with the same amount of initial capital invested.

Arguably, the most important statistics to compare are the overall profit and loss amount (PnL\$) and Return on Investment percentage (ROI%). On the other hand, it is also useful to compare not only overall performance but also short-term performance as well as volatility over short periods. For instance, calculating max, min, mean and standard deviation of PnL\$ and ROI% over a month, quarter and year to compare performance against volatility. A system with higher returns is expected to exhibit higher volatility due to higher risks than a system providing lower returns.

In the case of options, the comparison becomes more difficult since many strategies do not require full investment of capital but only a certain margin requirement that varies among brokerage houses. The ROI% previously used represents the ratio between the return and the total invested. As there may not be a total amount invested, that ratio cannot be calculated. This is clear in the short put strategy, where the investor is allowed to sell multiple put contracts even though she may not have enough capital to cover a potential assignment. This will be allowed as long as there is enough capital to cover the brokerage margin requirements.

6.4. Pros and cons

As shown in our studies, the Bullish and Bearish Engulfing patterns provided higher success rate and lower percent errors of failures over short periods (3, 5, 7 and 10 days) as shown in sections 5.2 and 5.4. This may result in better entry and exits prices and thus, avoid large losses, decrease volatility or even decrease cost basis than a buy and hold strategy with random entry points.

Although this may work for short term strategies, it may underperform over longer periods. This is partially due to the fact that the buying and holding approach is always invested and thus, it benefits from the market's natural tendency to go up over time. On the other hand, the pattern's approach may require the investor to wait for long periods of time until the entry signal appears and thus, it may miss several strong uptrends. In other words, the opportunity cost for not being invested during uptrends

may be quite high. In section 5.5 we found that the frequency of occurrence did not fit any of the well-known distributions and thus, it is unclear how often they occur.

Section 7. Summary

In this statistical analysis, we have studied the performance of the Bearish and Bullish Engulfing patterns from periods 1950-2018, 1950-1998, 1999-2010, 2010-2020 using historical daily prices from S&P 500 index. We studied 3, 5, 7 and 10 days after the signal appearance, first candle's body size of 25%, 50% and 75% of the second candle's body size as well as "with trend" and "regardless of trend". We also studied the severity of the failures as well as the distribution of the frequency of appearance. Table 13 displays a summary of the data, parameters, statistical analysis, and some results. In addition, we discussed the characteristics of potential trading systems based on our findings about Bearish and Bullish Engulfing patterns. Those trading systems can either directly invest in the underlying (such as an ETF that tracks the S&P 500 index), options or a combination of the two.

Our results indicated that the Bearish Engulfing provided strong short-term forecasting power when using the Open and High criteria but not the Close criterion. Likewise, the Bullish Engulfing offered strong short-term forecasting power when using the Open and Low criteria but not the Close criterion. Some of these conclusions can be seen in past works such as Cervelló Royo et al [25], which used intraday data from the DJIA index. Fiess and MacDonald [21] also obtained comparable results as well as Jamaloodeen [12], which studied the past performance of Shooting Star and Hammer patterns in the S&P500 index.

In addition, the size of the first candle's body compared to the second was not a statistically significant factor. Likewise, requiring a previous uptrend for the Bearish Engulfing and a downtrend for the Bullish Engulfing provided no statistically significant difference to all instances regardless of trend. Furthermore, percentage of body engulfing were not statistically significant factors for the success of the bearish or bullish engulfing pattern. However, the criteria used to detect the pattern (OPEN, CLOSE, or HIGH price in the case of the bearish engulfing pattern, and OPEN, CLOSE, or LOW price in the case of the bullish engulfing pattern) is a statistically significant factor.

Another result of the study showed that failures observed after the patterns appearance were not as severe as those observed in all instances. Specifically, we show that the average percent by which the engulfing pattern fails is statistically significantly lower than the average percent by which all candles fail. The importance of this lies on the fact that even a pattern with a high success ratio may have a negative profit expectancy if the failures are too severe and the frequent gains are not large enough to cover the occasional substantial losses due to the pattern's failure.

The final observation of our study is that the frequency of occurrence of both Bearish and Bullish Engulfing patterns did not fit any of the distributions tested.

Future work may include an analysis of the performance of Bearish and Bullish Engulfing in other well-known indexes such as NASDAQ, Russell 2000, Dow Jones Industrial Average, or even for specific industries such as Healthcare, Financial Services, Utilities, etc. We also plan on continuing our exploratory analysis of Section 5.5 to study the pattern's inter-arrival time distributions and frequencies.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Appendix

SUCCESS /STATS	p-value						p-value						p-value					
	# Candle Pattern success	% Candle Pattern success	# All Candles success	% All Candles success	t-test	chi-square test	# Candle Pattern success	% Candle Pattern success	# All Candles	% All Candles	t-test	chi-square test	# Candle Pattern Success	% Candle Pattern Success	# All Candles Success	% All Candles Success	t-test	chi-square test
	3 Day Moving Average 25% of Body						3 Day Moving Average 50% of Body						3 Day Moving Average 75% of Body					
[CLOSE] Successes regardless of trend	158	0.316633	4911	0.284218	0.054202	0.125792	284	0.342995	4911	0.284218	8.85E-05	0.000302	366	0.334858	4911	0.284218	0.000103	0.00038
[CLOSE] Successes after uptrend	36	0.251748	1793	0.275592	0.738307	0.591306	69	0.289916	1793	0.275592	0.310449	0.680569	100	0.280899	1793	0.275592	0.411336	0.875041
[OPEN] Successes regardless of trend	283	0.567134	5268	0.304879	0	2.19E-35	506	0.611111	5268	0.304879	0	7.24E-76	659	0.602928	5268	0.304879	0	1.41E-92
[OPEN] Successes after uptrend	60	0.41958	1631	0.250692	1.58E-06	7.11E-06	115	0.483193	1631	0.250692	0	1.62E-15	175	0.491573	1631	0.250692	0	1.72E-23
[HIGH] Successes regardless of trend	329	0.659319	8245	0.477169	0	1.43E-15	574	0.693237	8245	0.477169	0	8.74E-34	759	0.694419	8245	0.477169	0	6.12E-44
[HIGH] Successes after uptrend	80	0.559441	3006	0.462035	0.009737	0.02604	142	0.596639	3006	0.462035	1.56E-05	5.77E-05	221	0.620787	3006	0.462035	9.39E-10	7.08E-09
	5 Day Moving Average 25% of Body						5 Day Moving Average 50% of Body						5 Day Moving Average 75% of Body					
[CLOSE] Successes regardless of trend	128	0.256513	3722	0.215456	0.012849	0.032367	223	0.269324	3722	0.215456	8.16E-05	0.000289	106	0.212425	3058	0.17706	0.019246	0.048099
[CLOSE] Successes after uptrend	43	0.186147	1652	0.211876	0.830706	0.388409	91	0.235142	1652	0.211876	0.131348	0.304152	46	0.17037	1505	0.174473	0.570485	0.92551
[OPEN] Successes regardless of trend	234	0.468938	4112	0.238032	0	5.03E-32	417	0.503623	4112	0.238032	0	2.86E-66	193	0.386774	3431	0.198657	0	1.53E-24
[OPEN] Successes after uptrend	95	0.411255	1776	0.22778	1.48E-11	1.35E-10	183	0.472868	1776	0.22778	0	5.45E-28	93	0.344444	1651	0.191398	8.16E-11	7.28E-10
[HIGH] Successes regardless of trend	283	0.567134	6541	0.37864	0	2.09E-17	486	0.586957	6541	0.37864	0	4.57E-33	236	0.472946	5477	0.317121	3.72E-14	2.9E-13
[HIGH] Successes after uptrend	123	0.532468	2965	0.380274	9.45E-07	3.89E-06	220	0.568475	2965	0.380274	1.21E-14	1.86E-13	120	0.444444	2728	0.316253	2.95E-06	1.19E-05
	7 Day Moving Average 25% of Body						7 Day Moving Average 50% of Body						7 Day Moving Average 75% of Body					
[CLOSE] Successes regardless of trend	106	0.212425	3058	0.17706	0.019246	0.048099	185	0.22343	3058	0.17706	0.000237	0.000801	242	0.221409	3058	0.17706	6.13E-05	0.000249
[CLOSE] Successes after uptrend	46	0.17037	1505	0.174473	0.570485	0.92551	83	0.196682	1505	0.174473	0.114644	0.268918	108	0.193548	1505	0.174473	0.117548	0.275581
[OPEN] Successes regardless of trend	193	0.386774	3431	0.198657	0	1.53E-24	350	0.422705	3431	0.198657	0	7.79E-54	458	0.41903	3431	0.198657	0	1.02E-66

[OPEN] Successes after uptrend	93	0.344444	1651	0.191398	8.16E-11	7.28E-10	164	0.388626	1651	0.191398	0	9.55E-23	217	0.388889	1651	0.191398	0	5.24E-29
[HIGH] Successes regardless of trend	236	0.472946	5477	0.317121	3.72E-14	2.9E-13	413	0.498792	5477	0.317121	0	1.77E-27	541	0.494968	5477	0.317121	0	8.81E-34
[HIGH] Successes after uptrend	120	0.444444	2728	0.316253	2.95E-06	1.19E-05	199	0.471564	2728	0.316253	3.42E-12	3.95E-11	263	0.471326	2728	0.316253	0	5.11E-14
10 Day Moving Average 25% of Body						10 Day Moving Average 50% of Body						10 Day Moving Average 75% of Body						
[CLOSE] Successes regardless of trend	81	0.162325	2452	0.142021	0.096925	0.224816	145	0.175121	2452	0.142021	0.003181	0.009246	189	0.172919	2452	0.142021	0.001715	0.005466
[CLOSE] Successes after uptrend	32	0.120301	1189	0.137664	0.79443	0.471327	65	0.151515	1189	0.137664	0.202511	0.459612	82	0.148282	1189	0.137664	0.234307	0.523671
[OPEN] Successes regardless of trend	156	0.312625	2778	0.160904	0	4.00E-19	287	0.346618	2778	0.160904	0	9.73E-44	378	0.345837	2778	0.160904	0	2.30E-55
[OPEN] Successes after uptrend	68	0.255639	1303	0.150863	9.01E-07	4.72E-06	132	0.307692	1303	0.150863	0	6.79E-18	166	0.300181	1303	0.150863	0	2.73E-20
[HIGH] Successes regardless of trend	191	0.382766	4476	0.259253	1.53E-10	8.86E-10	342	0.413043	4476	0.259253		2.04E-22	452	0.413541	4476	0.259253	0	9.23E-29
[HIGH] Successes after uptrend	91	0.342105	2183	0.25275	0.000399	0.001281	165	0.384615	2183	0.25275	1.64E-10	1.65E-09	210	0.379747	2183	0.25275	3.17E-12	5.86E-11

Table 1. Proportion of successful predictions of a market top for the Bearish Engulfing pattern compared to the proportion of all market tops (t-tests of proportions and chi squared test for independence)

SUCCESS /STATS	# Candle Pattern Success	% Candle Pattern Success	# All Candles Success	% All Candles Success	p-value		# Candle Pattern Success	% Candle Pattern Success	# All Candles Success	% All Candles Success	p-value		# Candle Pattern Success	% Candle Pattern Success	# All Candles Success	% All Candles Success	p-value	
					t-test	chi-square test					t-test	chi-square test					t-test	chi-square test
	3 Day Moving Average 25% of Body						3 Day Moving Average 50% of Body						3 Day Moving Average 75% of Body					
[CLOSE] Successes regardless of trend	211	0.38018	6372	0.368771	0.288737	0.614578	356	0.385699	6372	0.368771	0.143232	0.315842	469	0.396785	6372	0.368771	0.022955	0.05767
[CLOSE] Successes after downtrend	36	0.382979	1664	0.372593	0.417512	0.921683	73	0.405556	1664	0.372593	0.180182	0.413588	102	0.4	1664	0.372593	0.182682	0.41612
[OPEN] Successes regardless of trend	362	0.652252	6948	0.402107	0	7.02E-32	607	0.657638	6948	0.402107	0	5.92E-53	784	0.663283	6948	0.402107	0	3.68E-69
[OPEN] Successes after downtrend	57	0.606383	1561	0.34953	8.82E-08	4.61E-07	108	0.6	1561	0.34953	9.11E-13	1.14E-11	159	0.623529	1561	0.34953	0.00E+00	1.69E-18
[LOW] Successes regardless of trend	396	0.713514	9850	0.570056	4.35E-12	2.31E-11	666	0.72156	9850	0.570056	0	1.49E-19	858	0.725888	9850	0.570056	0	1.17E-25
[LOW] Successes after downtrend	63	0.670213	2439	0.546126	0.007837	0.022146	125	0.694444	2439	0.546126	3.21E-05	0.00012	179	0.701961	2439	0.546126	2.89E-07	1.55E-06
	5 Day Moving Average 25% of Body						5 Day Moving Average 50% of Body						5 Day Moving Average 75% of Body					
[CLOSE] Successes regardless of trend	169	0.304505	5200	0.301013	0.428843	0.896973	289	0.313109	5200	0.301013	0.211514	0.457275	376	0.318105	5200	0.301013	0.100085	0.228068
[CLOSE] Successes after downtrend	53	0.315476	1655	0.311559	0.456349	0.981379	96	0.334495	1655	0.311559	0.200738	0.452651	126	0.33871	1655	0.311559	0.129088	0.301332
[OPEN] Successes regardless of trend	317	0.571171	5833	0.337656	0	7.73E-30	526	0.569881	5833	0.337656	0	6.74E-47	671	0.567682	5833	0.337656	0	1.64E-57
[OPEN] Successes after downtrend	110	0.654762	1788	0.336596	0.00E+00	2.89E-17	177	0.616725	1788	0.336596	0.00E+00	6.47E-22	226	0.607527	1788	0.336596	0.00E+00	8.16E-26
[LOW] Successes regardless of trend	352	0.634234	8336	0.482547	4.3E-13	2.67E-12	585	0.633803	8336	0.482547	0	4.56E-19	753	0.637056	8336	0.482547	0	1.19E-24
[LOW] Successes after downtrend	116	0.690476	2549	0.479857	2.32E-08	1.16E-07	190	0.662021	2549	0.479857	3.26E-10	2.64E-09	247	0.663978	2549	0.479857	5.88E-13	9.54E-12
	7 Day Moving Average 25% of Body						7 Day Moving Average 50% of Body						7 Day Moving Average 75% of Body					
[CLOSE] Successes regardless of trend	142	0.255856	4601	0.2664	0.712915	0.613891	250	0.270856	4601	0.2664	0.379725	0.794822	325	0.274958	4601	0.2664	0.252863	0.542235
[CLOSE] Successes after downtrend	51	0.291429	1543	0.27593	0.323227	0.714651	89	0.315603	1543	0.27593	0.068048	0.166646	116	0.32312	1543	0.27593	0.022731	0.061173
[OPEN] Successes regardless of trend	289	0.520721	5222	0.302357	0	1.03E-27	479	0.51896	5222	0.302357	0	3.10E-43	609	0.515228	5222	0.302357	0	3.70E-52
[OPEN] Successes after downtrend	105	0.6	1734	0.310086	0.00E+00	1.05E-15	161	0.570922	1734	0.310086	0.00E+00	1.12E-19	204	0.568245	1734	0.310086	0.00E+00	8.29E-24
[LOW] Successes regardless of trend	317	0.571171	7501	0.434312	3.89E-11	2.12E-10	530	0.574215	7501	0.434312	0	9.92E-17	679	0.57445	7501	0.434312	0	8.56E-21

[LOW] Successes after downtrend	111	0.634286	2406	0.430258	2.50E-08	1.28E-07	174	0.617021	2406	0.430258	1.19E-10	1.03E-09	223	0.62117	2406	0.430258	1.38E-13	2.45E-12
10 Day Moving Average 25% of Body						10 Day Moving Average 50% of Body						10 Day Moving Average 75% of Body						
[CLOSE] Successes regardless of trend	123	0.221622	3983	0.230698	0.694118	0.653719	214	0.231853	3983	0.230698	0.466817	0.96727	273	0.230964	3983	0.230698	0.491323	0.988319
[CLOSE] Successes after downtrend	40	0.236686	1241	0.237603	0.511167	0.948757	74	0.272059	1241	0.237603	0.090913	0.220344	91	0.262248	1241	0.237603	0.140375	0.328466
[OPEN] Successes regardless of trend	256	0.461261	4565	0.264408	0	1.50E-24	420	0.455038	4565	0.264408	0	1.80E-36	534	0.451777	4565	0.264408	0	6.23E-44
[OPEN] Successes after downtrend	85	0.502959	1404	0.268811	3.30E-12	3.76E-11	134	0.492647	1404	0.268811	0.00E+00	1.90E-15	160	0.461095	1404	0.268811	0.00E+00	1.91E-14
[LOW] Successes regardless of trend	286	0.515315	6602	0.382392	5.83E-11	3.27E-10	470	0.509209	6602	0.382392	0	1.78E-14	602	0.509306	6602	0.382392	0	6.60E-18
[LOW] Successes after downtrend	93	0.550296	1958	0.37488	1.23E-06	5.56E-06	149	0.547794	1958	0.37488	1.92E-09	1.57E-08	181	0.521614	1958	0.37488	8.20E-09	7.24E-08

Table 2. Proportion of successful predictions of a market bottom for the Bullish Engulfing pattern compared to the proportion of all market bottoms (t-tests of proportions and chi squared test for independence)

Anova: Single Factor--Criterion

SUMMARY

Groups	Count	Sum	Average	Variance
Percent CLOSE	24	5.411162	0.225465	0.003688
Percent HIGH	24	12.38876	0.516198	0.010275
Percent OPEN	24	10.21849	0.42577	0.008939

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.062602	2	0.531301	69.59779	2.84E-17	3.129644
Within Groups	0.526737	69	0.007634			
Total	1.589339	71				

Anova: Single Factor--Percent Body

SUMMARY

Groups	Count	Sum	Average	Variance
Percent body 25	24	8.803475	0.366811	0.021977
Percent body 50	24	9.633885	0.401412	0.022923
Percent body 75	24	9.581051	0.39921	0.023418

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.018014	2	0.009007	0.395512	0.674852	3.129644
Within Groups	1.571325	69	0.022773			
Total	1.589339	71				

Anova: Single Factor--Trend

SUMMARY

Groups	Count	Sum	Average	Variance
Percent with Trend	36	13.13756	0.364932	0.020431
Percent RT	36	14.88085	0.413357	0.023772

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.042209	1	0.042209	1.909755	0.171385	3.977779
Within Groups	1.54713	70	0.022102			

Total	1.589339	71
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Table 3. ANOVA results for the Bearish Engulfing with highlighted effects with critical F-statistic and p values at $\alpha = 0.05$ showing that the only effect on success rate is the factor Criterion

Anova: Single Factor--Criterion						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Percent CLOSE	24	7.46285	0.310952	0.003382		
Percent LOW	24	14.895	0.620625	0.005061		
Percent OPEN	24	13.50969	0.562904	0.0047		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.301668	2	0.650834	148.5591	9.89E-26	3.129644
Within Groups	0.302287	69	0.004381			
Total	1.603955	71				

Anova: Single Factor--Percent Body						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Percent body 25	24	11.93775	0.497406	0.025229		
Percent body 50	24	11.97111	0.498796	0.022091		
Percent body 75	24	11.95868	0.498278	0.022416		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.37E-05	2	1.18E-05	0.00051	0.999491	3.129644
Within Groups	1.603931	69	0.023245			
Total	1.603955	71				

Anova: Single Factor--trend						
SUMMARY						

Groups	Count	Sum	Average	Variance		
Percent RT	36	17.5091	0.486364	0.023862		
Percent with Trend	36	18.35843	0.509956	0.021679		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.010019	1	0.010019	0.439988	0.509307	3.977779
Within Groups	1.593936	70	0.022771			
Total	1.603955	71				

Table 4. ANOVA results for the Bullish Engulfing with highlighted effects with critical F-statistic and p values at $\alpha = 0.05$ showing that the only effect on success rate is the factor Criterion

Percent of Body		25%			50%			75%			
Criterion	Sample	N	Mean	StDev	N	Mean	StDev	N	Mean	StDev	
3-day	CLOSE	All	12368	0.01112	0.0106	12368	0.0112	0.0106	12368	0.0112	0.0106
		Engulf	341	0.01079	0.00958	544	0.01095	0.00939	727	0.01115	0.0099
		T-Test of difference p-value		0.76	0.2943			0.45			
	OPEN	All	12011	0.0132	0.0121	12011	0.0132	0.0121	12011	0.0132	0.0121
		Engulf	216	0.00844	0.00735	322	0.00866	0.00754	434	0.00889	0.00791
		T-Test of difference p-value		4.24E-09	1.10E-11			9.50E-14			
5-day	HIGH	All	9034	0.00978	0.0091	9034	0.00978	0.0091	9034	0.00978	0.0091
		Engulf	170	0.00819	0.0068	245	0.00812	0.00689	334	0.00843	0.00733
		T-Test of difference p-value		0.01173	0.0019			0.004			
	CLOSE	All	13553	0.0147	0.0133	13553	0.0147	0.0133	13553	0.0147	0.0133
		Engulf	371	0.0138	0.0112	605	0.0143	0.0117	807	0.0146	0.0125
		T-Test of difference p-value		0.098	0.2335			0.4175			
	OPEN	All	13163	0.0163	0.0144	13163	0.0163	0.0144	13163	0.0163	0.0144
		Engulf	265	0.01074	0.00865	411	0.01144	0.0095	556	0.0118	0.0102
		T-Test of difference p-value		1.90E-10	5.60E-12			1.60E-13			
7-day	HIGH	All	10734	0.0129	0.0116	10734	0.0129	0.0116	10734	0.0129	0.0116
		Engulf	216	0.01052	0.0082	342	0.01079	0.0088	464	0.01099	0.00969
	T-Test of difference p-value		0.0013	0.0004			0.0002				
7-day	CLOSE	All	14213	0.0175	0.0154	14213	0.0175	0.0154	14213	0.0175	0.0154

		Engulf	393	0.0169	0.0134	643	0.0171	0.0136	851	0.0173	0.0141
		T-Test of difference p-value			0.2223			0.2587			0.356
10-day	OPEN	All	13841	0.019	0.0163	13841	0.019	0.0163	13841	0.019	0.0163
		Engulf	306	0.0133	0.0108	478	0.0136	0.0114	635	0.0139	0.0117
	HIGH	T-Test of difference p-value			5.90E-10			3.60E-13			3.60E-15
		All	11794	0.0154	0.0137	11794	0.0154	0.0137	11794	0.0154	0.0137
		Engulf	263	0.0127	0.0105	415	0.0128	0.0108	552	0.0129	0.0113
		T-Test of difference p-value			0.0008			6.00E-05			1.00E-05
10-day	CLOSE	All	14813	0.0212	0.0179	14813	0.0212	0.0179	14813	0.0212	0.0179
		Engulf	418	0.0204	0.0157	683	0.0208	0.0161	904	0.0209	0.0164
	OPEN	T-Test of difference p-value			0.183			0.2832			0.312
		All	14487	0.0225	0.0185	14487	0.0225	0.0185	14487	0.0225	0.0185
		Engulf	343	0.0166	0.0127	541	0.0171	0.0136	715	0.0173	0.0137
		T-Test of difference p-value			2.20E-09			9.30E-12			6.40E-14
	HIGH	All	12789	0.0188	0.0161	12789	0.0188	0.0161	12789	0.0188	0.0161
		Engulf	308	0.0188	0.0161	486	0.0161	0.013	641	0.0161	0.0133
		T-Test of difference p-value			4.00E-04			1.30E-04			1.50E-05

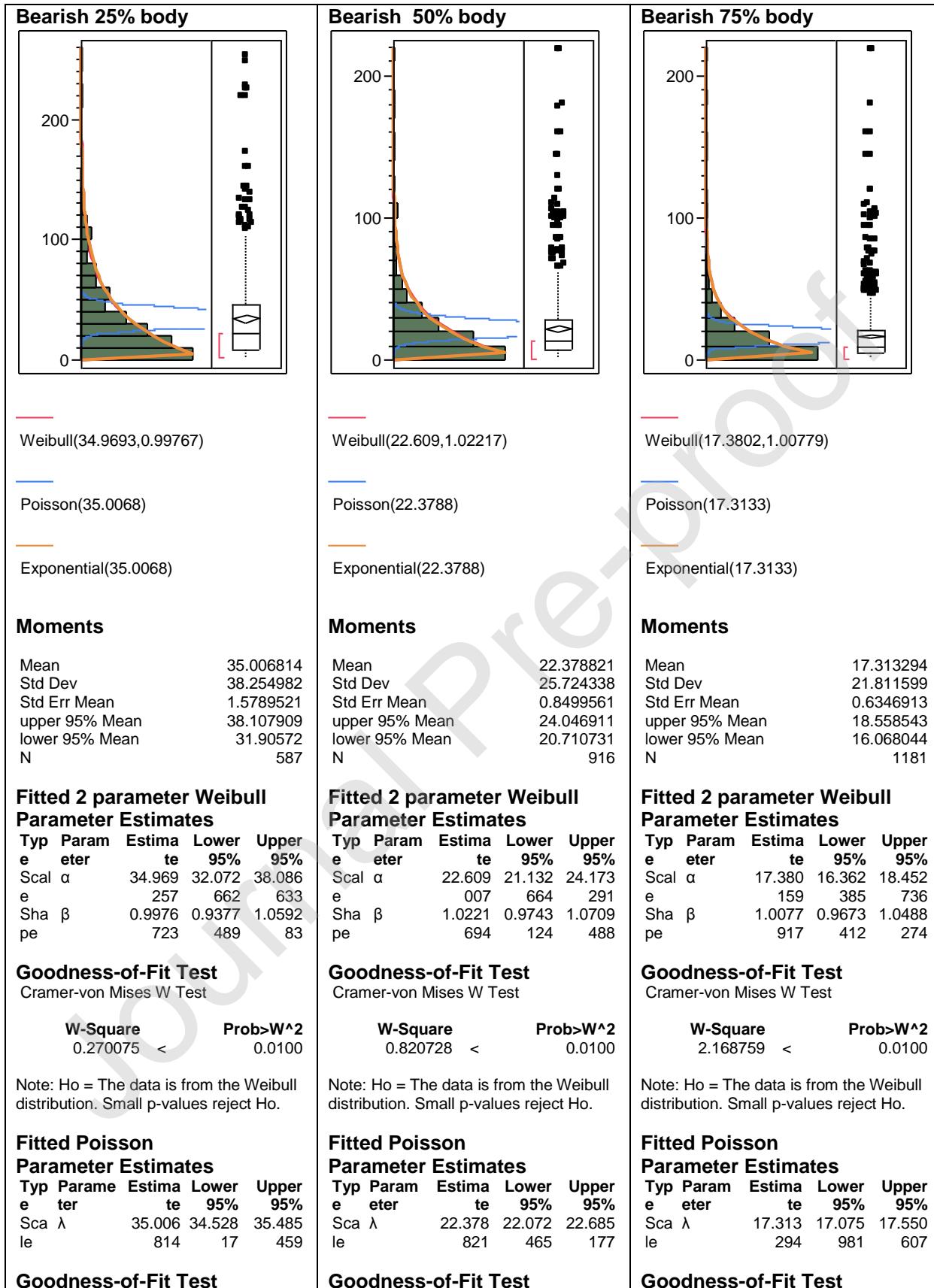
Table 5. Data and t-statistics for Bearish Engulfing inferential analysis of average percent of failure (with highlighted p-values indicating where the percentage of failure for the engulfing candle is smaller at $\alpha = 0.05$)

Percent of Body		25%			50%			75%			
Criterion	Sample	N	Mean	StDev	N	Mean	StDev	N	Mean	StDev	
3-day	CLOSE	All	10907	-0.00088	0.0093	10907	-0.00088	0.0093	10907	-0.00088	0.0093
		Engulf	344	-0.00112	0.0093	567	-0.00094	0.00837	713	-0.00088	0.00818
		T-Test of difference p-value		0.3187	0.44			0.5			
	OPEN	All	10331	0.001	0.0111	10331	0.001	0.0111	10331	0.001	0.0111
		Engulf	193	-0.00321	0.00834	316	-0.00372	0.00841	398	-0.00376	0.00843
		T-Test of difference p-value		8.10E-08	3.60E-14			0.00E+00			
5-day	LOW	All	7429	-0.00292	0.00949	7429	-0.00292	0.00949	7429	-0.00292	0.00949
		Engulf	159	-0.00424	0.00822	257	-0.00504	0.00816	324	-0.00519	0.00831
		T-Test of difference p-value		0.041	2.00E-04			1.10E-05			
	CLOSE	All	12075	-0.0051	0.0117	12075	-0.0051	0.0117	12075	-0.0051	0.0117
		Engulf	386	-0.0055	0.0108	634	-0.0049	0.0106	806	-0.005	0.0103
		T-Test of difference p-value		0.254	0.663			0.594			
	OPEN	All	11442	-0.0036	0.0129	11442	-0.0036	0.0129	11442	-0.0036	0.0129
		Engulf	238	-0.00749	0.00949	397	-0.008	0.00967	511	-0.00825	0.00967
		T-Test of difference p-value		1.90E-06	0.00E+00			0.00E+00			
7-day	LOW	All	8939	-0.0074	0.0116	8939	-0.0074	0.0116	8939	-0.0074	0.0116
		Engulf	203	-0.00896	0.00953	338	-0.00959	0.00959	429	-0.0098	0.00959
	CLOSE	T-Test of difference p-value		0.029	3.10E-04			1.30E-05			
All		12670	-0.0083	0.0136	12670	-0.0083	0.0136	12670	-0.0083	0.0136	
Engulf		413	-0.0085	0.0123	673	-0.0079	0.0123	857	-0.0079	0.012	

		T-Test of difference p-value		0.384		0.772		0.799
	OPEN	All	12049	-0.007	0.0146	12049	-0.007	0.0146
		Engulf	266	-0.0105	0.0111	444	-0.0112	0.0117
	LOW	T-Test of difference p-value			5.10E-05		1.10E-09	
		All	9770	-0.0108	0.0136	9770	-0.0108	0.0136
10-day	CLOSE	Engulf	238	-0.0123	0.0112	393	-0.0129	0.0119
		T-Test of difference p-value			0.046		1.30E-03	
		All	13282	-0.0124	0.0162	13282	-0.0124	0.0162
		Engulf	432	-0.0121	0.014	709	-0.0116	0.0141
	OPEN	T-Test of difference p-value			0.648		0.099	
		All	12700	-0.0113	0.0169	12700	-0.0113	0.0169
		Engulf	299	-0.014	0.0119	503	-0.0147	0.0129
		T-Test of difference p-value			3.00E-03		4.10E-06	
	LOW	All	10663	-0.015	0.0161	10663	-0.015	0.0161
		Engulf	269	-0.0157	0.0119	453	-0.0166	0.0131
	T-Test of difference p-value				2.39E-02		1.90E-02	
								2.60E-03

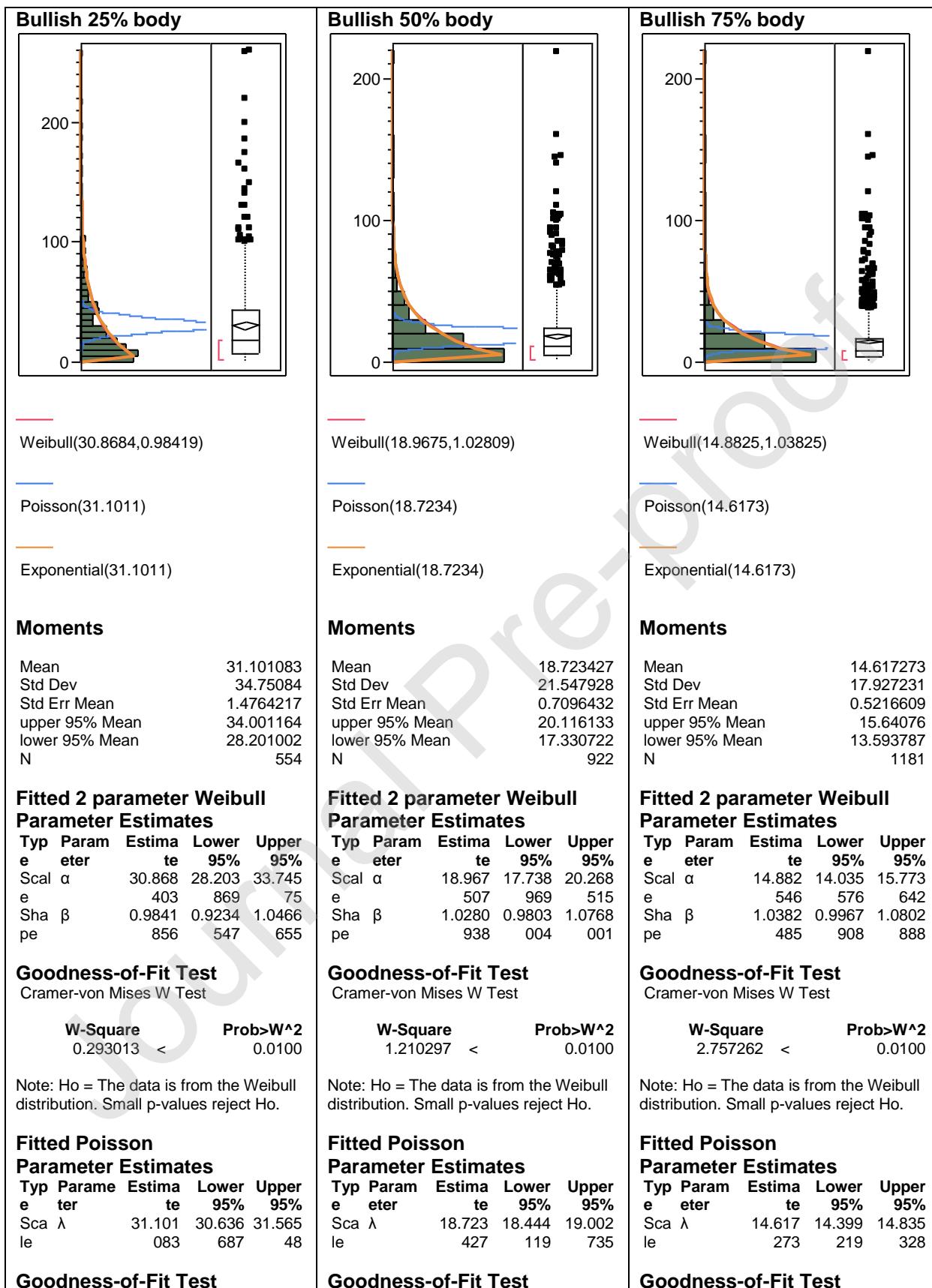
Table 6. Data and t-statistics for Bullish Engulfing inferential analysis of average percent of failure (with highlighted p-values indicating where the percentage of failure for the engulfing candle is smaller at $\alpha = 0.05$)

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Pearson ChiSquared	Pearson ChiSquared	Pearson ChiSquared			
X2 3.005e+121	Prob>X2 0.0000	X2 5.895e+129	Prob>X2 0.0000	X2 5.727e+151	Prob>X2 0.0000
Note: Ho = The data is from the Poisson distribution. Small p-values reject Ho.	Note: Ho = The data is from the Poisson distribution. Small p-values reject Ho.	Note: Ho = The data is from the Poisson distribution. Small p-values reject Ho.			
Fitted Exponential Parameter Estimates	Fitted Exponential Parameter Estimates	Fitted Exponential Parameter Estimates			
Typ Param Estimat e r 95% Lower 95% Upper 95%	Typ Param Estimat e r 95% Lower 95% Upper 95%	Typ Param Estimat e r 95% Lower 95% Upper 95%			
Sca σ 35.006 32.32 37.998 le 814 12 402	Sca σ 22.378 20.990 23.892 le 821 033 878	Sca σ 17.313 16.362 18.339 le 293 288 449			
Goodness-of-Fit Test	Goodness-of-Fit Test	Goodness-of-Fit Test			
Kolmogorov's D	Kolmogorov's D	Kolmogorov's D			
D 0.051616	Prob>D 0.0154	D 0.081126 <	Prob>D 0.0100	D 0.105709 <	Prob>D 0.0100
Note: Ho = The data is from the Exponential distribution. Small p-values reject Ho.	Note: Ho = The data is from the Exponential distribution. Small p-values reject Ho.	Note: Ho = The data is from the Exponential distribution. Small p-values reject Ho.			

Table 7. Bearish Engulfing inter-arrival time distributions



Pearson ChiSquared	Pearson ChiSquared	Pearson ChiSquared			
X2 2.038e+138	Prob>X2 0.0000	X2 2.901e+144	Prob>X2 0.0000	X2 1.025e+166	Prob>X2 0.0000
Note: Ho = The data is from the Poisson distribution. Small p-values reject Ho.	Note: Ho = The data is from the Poisson distribution. Small p-values reject Ho.	Note: Ho = The data is from the Poisson distribution. Small p-values reject Ho.			
Fitted Exponential Parameter Estimates	Fitted Exponential Parameter Estimates	Fitted Exponential Parameter Estimates			
Typ Param Estima te Lower 95% Upper 95%	Typ Param Estima te Lower 95% Upper 95%	Typ Param Estima te Lower 95% Upper 95%			
Sca σ 31.101 28.648 33.841	Sca σ 18.723 17.565 19.985	Sca σ 14.617 13.814 15.483			
le 083 829 396	le 427 115 865	le 273 358 636			
Goodness-of-Fit Test	Goodness-of-Fit Test	Goodness-of-Fit Test			
Kolmogorov's D	Kolmogorov's D	Kolmogorov's D			
D 0.056867 < 0.0100	D 0.098057 < 0.0100	D 0.125336 < 0.0100			
Note: Ho = The data is from the Exponential distribution. Small p-values reject Ho.	Note: Ho = The data is from the Exponential distribution. Small p-values reject Ho.	Note: Ho = The data is from the Exponential distribution. Small p-values reject Ho.			

Table 8. Bullish Engulfing inter-arrival time distributions

	CLOSE Regardless s of Trend	CLOSE with Trend	OPEN Regardless s of Trend	OPEN with Trend	HIGH Regardless s of Trend	HIGH with Trend	CLOSE Regardless s of Trend	CLOSE with Trend	OPEN Regardless s of Trend	OPEN with Trend	HIGH Regardless s of Trend	HIGH with Trend	CLOSE Regardless of Trend	CLOSE with Trend	OPEN Regardless s of Trend	OPEN with Trend	HIGH Regardless s of Trend	HIGH with Trend
Criterion	3 day MA 25% of Body						3 day MA 50% of Body						3 day MA 75% of Body					
# Successes s 1999- 2010	22	4	56	9	60	10	41	6	104	12	112	14	57	10	141	21	153	24
# of Bearish Engulfing 1999- 2010	87	15	87	15	87	15	168	30	168	30	168	30	231	49	231	49	231	49
% successes s 1999- 2010	0.252873	0.266666	0.643678		0.689655	0.666666	0.244047	0.2	0.619047		0.666666	0.466666	0.2467532	0.204081	0.610389	0.428571	0.662337	0.489795
	563	667	161	0.6	172	667	619	619		0.4	667	667	47	63	61	429	662	918
# Successes s 1950- 1998	130	30	207	44	246	63	228	55	366	87	418	112	289	81	470	136	548	177
# of Bearish Engulfing 1950- 1998	378	119	378	119	378	119	599	187	599	187	599	187	781	277	781	277	781	277
% successes s 1950- 2018	0.343915	0.252100	0.547619	0.369747	0.650793	0.529411	0.380634	0.294117	0.611018	0.465240	0.697829	0.598930	0.3700384	0.292418	0.601792	0.490974	0.701664	0.638989
	344	84	48	899	651	765	391	65	364	642	716	481	12	77	574	729	533	17
Two Tailed z- test of proporti ons (p- value)	0.102633	0.902763	0.103157	0.085672	0.490849	0.314443	0.001043	0.287091	0.850245	0.505414	0.439823	0.172931	0.0005200	0.203843	0.814456	0.420321	0.255088	
	079	805	497	913	917	377	37	74	535	343	52	457	26	31	409	964	004	0.0477

	5 day MA 25% of Body						5 day MA 50% of Body						5 day MA 75% of Body					
# Successes s 1999- 2010	21	9	48	21	51	22	33	13	91	41	98	45	46	21	119	58	131	63
# of Bearish Engulfing	87	38	87	38	87	38	168	72	168	72	168	72	231	104	231	104	231	104

1999-2010 % successes 1999-2010 # Successes 1950-1998 # of Bearish Engulfing 1950-1998 % successes 1950-2018 Two Tailed z-test of proportions (p-value)	0.241379 31 104 34 172 66 212 91 0.196428 571 0.180555 56 0.541666 667 0.569444 444 0.583333 333 0.625 0.1991341 99 0.201923 08 0.515151 515 0.557692 308 0.567099 567 0.605769 231	0.236842 105 138 579 586206 897 0.578947 368 0.368715 084 0.560846 561 0.508379 888 0.302170 284 0.264084 51 0.499165 275 0.443661 972 0.587646 077 0.552816 901 0.006923 736 0.142239 53 0.330160 161 0.056106 014 0.920091 023 0.269504 019 0.2906530 09 0.256684 49 0.491677 337 0.451871 658 0.580025 608 0.553475 936	0.189944 134 455 084 0.667004 742 0.429028 574 0.0059026 32 0.250583 78 0.530752 219 0.055933 151 0.726827 628 0.341361 642
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	7 day MA 25% of Body						7 day MA 50% of Body						7 day MA 75% of Body					
# Successes 1999-2010 # of Bearish Engulfing 1999-2010 % successes 1999-2010 # Successes 1950-1998 # of Bearish	21	6	43	21	48	23	30	10	78	38	86	41	43	17	104	52	117	58
	87	44	87	44	87	44	168	79	168	79	168	79	231	112	231	112	231	112
# Successes 1999-2010 # Successes 1950-1998 # of Bearish	0.241379 31 636 874 0.477272 727 0.551724 138 0.522727 273 0.178571 429 0.126582 28 0.464285 714 0.481012 658 0.511904 762 0.518987 342 0.1861471 86 0.151785 71 0.450216 45 0.464285 714 0.506493 506 0.517857 143	0.136363 636 0.494252 874 0.477272 727 0.551724 138 0.522727 273 0.178571 429 0.126582 28 0.464285 714 0.481012 658 0.511904 762 0.518987 342 0.1861471 86 0.151785 71 0.450216 45 0.464285 714 0.506493 506 0.517857 143	0.006923 736 0.142239 53 0.330160 161 0.056106 014 0.920091 023 0.269504 019 0.0059026 32 0.250583 78 0.530752 219 0.055933 151 0.726827 628 0.341361 642															
	83	39	137	66	174	90	148	71	249	116	301	146	188	88	324	153	390	190
# of Bearish	378	206	378	206	378	206	599	310	599	310	599	310	781	405	781	405	781	405

Engulfing 1950- 1998 % successe s 1950- 2018	0.219576 72	0.189320 388	0.362433 862	0.320388 35	0.460317 46	0.436893 204	0.247078 464	0.229032 26	0.415692 821	0.374193 548	0.502504 174	0.470967 742	0.2407170 29	0.217283 95	0.414852 753	0.377777 778	0.499359 795	0.469135 802
Two Tailed z- test of proporti ons (p- value)	0.659924 516	0.406549 574	0.022852 562	0.047350 341	0.123811 492	0.299055 531	0.063055 13	0.045285 16	0.260385 147	0.083077 73	0.829483 39	0.445707 808	0.0825686 11	0.127260 59	0.339190 978	0.097626 718	0.848919 87	0.360990 149

# Successes 1999- 2010 # of Bearish Engulfing 1999- 2010 % successe s 1999- 2010 # Successes 1950- 1998 # of Bearish Engulfing 1950- 1998 % successe s 1950- 2018	10 day MA 25% of Body						10 day MA 50% of Body						10 day MA 75% of Body					
	18	5	37	16	42	19	26	9	66	31	75	36	36	14	89	39	102	47
# of Bearish Engulfing 1999- 2010	87	44	87	44	87	44	168	81	168	81	168	81	231	109	231	109	231	109
% successe s 1999- 2010	0.206896 552	0.113636 364	0.425287 356	0.363636 364	0.482758 621	0.431818 182	0.154761 905	0.111111 11	0.392857 143	0.382716 049	0.446428 571	0.444444 444	0.1558441 56	0.128440 37	0.385281 385	0.357798 165	0.441558 442	0.431192 661
# of Bearish Engulfing 1950- 1998	62	27	110	47	138	65	116	55	205	92	247	247	147	67	269	118	325	152
% successe s 1950- 1998	378	201	378	201	378	201	599	312	599	312	599	599	781	399	781	399	781	399
% successe s 1950- 2018	0.164021 164	0.134328 358	0.291005 291	0.233830 846	0.365079 365	0.323383 085	0.193656 093	0.176282 05	0.342237 062	0.294871 795	0.412353 923	0.412353 923	0.1882202 3	0.167919 8	0.344430 218	0.295739 348	0.416133 163	0.380952 381
Two Tailed z- test of proporti ons (p- value)	0.339398 287	0.712179 267	0.015152 15	0.074357 103	0.042177 567	0.169895 699	0.251378 507	0.156948 44	0.225127 379	0.128729 719	0.429036 784	0.582374 973	0.2613678 81	0.318373 56	0.253968 099	0.214014 943	0.491844 567	0.340940 368

Table 9. Two tests of proportions comparing the success rates for the Bearish Engulfing pattern for the decade 1999-2010 with the prior 5 decades 1950-2018

Journal Pre-proof

	CLOSE Regardless s of Trend	CLOSE with Trend	OPEN Regardless of Trend	OPEN with Trend	LOW Regardless s of Trend	LOW with Trend	CLOSE Regardless s of Trend	CLOSE with Trend	OPEN Regardless s of Trend	OPEN with Trend	LOW Regardless s of Trend	LOW with Trend	CLOSE Regardless of Trend	CLOSE with Trend	OPEN Regardless s of Trend	OPEN with Trend	LOW Regardless s of Trend	LOW with Trend				
Criterion	3 day MA 25% of Body							3 day MA 50% of Body							3 day MA 75% of Body							
# Successes 1999-2010	34	8	70	13	76	14	61	16	121	26	129	27	73	17	150	31	163	33				
# of Bullish Engulfing 1999-2010	104	19	104	19	104	19	182	35	182	35	182	35	234	46	234	46	234	46				
% successes 1999-2010	0.326923	0.42105	0.6730769	0.68421	0.730769	0.73684	0.335164	0.45714	0.664835	0.74285	0.708791	0.7714	0.31196581	0.36956	0.641025	0.67391	0.696581	0.7173				
1	3	2	1	2	2	2	8	3	2	7	2	3	2	5	6	3	2	9				
# Successes 1950-1998	164	24	266	39	290	44	270	52	439	76	484	91	363	76	572	114	627	131				
# of Bullish Engulfing 1950-1998	417	70	417	70	417	70	671	136	671	136	671	136	855	188	855	188	855	188				
% successes 1950-2018	0.393285	0.34285	0.6378896	0.55714	0.695443	0.62857	0.402384	0.38235	0.654247	0.55882	0.721311	0.6691	0.42456140	0.40425	0.669005	0.60638	0.733333	0.6968				
4	7	9	3	6	1	1	5	3	4	4	5	2	4	5	8	3	3	1				
Two Tailed z-test of proportions (p-value)	0.212266	0.52874	0.5023084	0.31892	0.480812	0.37967	0.098838	0.42009	0.789640	0.04780	0.739015	0.2431	0.00184086	0.66650	0.422360	0.39775	0.264340	0.7846				
	3	2	4	3	8	8	4	7	9	2	6	3	2	9	8	5	5	4				
	5 day MA 25% of Body							5 day MA 50% of Body							5 day MA 75% of Body							
# Successes 1999-2010	20	6	64	21	67	22	43	16	105	36	110	39	53	18	129	44	138	39				
# of Bullish Engulfing 1999-2010	104	30	104	30	104	30	182	58	182	58	182	58	234	76	234	76	234	58				
% successes 1999-2010	0.192307	0.6153846	0.6153846	0.644230	0.73333	0.73333	0.236263	0.27586	0.576923	0.604395	0.6724	0.6724	0.22649572	0.23684	0.551282	0.57894	0.589743	0.6724				
7	0.2	2	0.7	8	3	3	7	2	1	0.62069	6	1	6	2	1	7	6	1				
# Successes 1950-1998	143	45	234	84	261	88	231	77	382	133	430	142	303	102	491	169	556	142				
# of Bullish Engulfing 1950-1998	417	131	417	131	417	131	671	218	671	218	671	218	855	277	855	277	855	218				
% successes 1950-2018	0.342925	0.34351	0.5611510	0.64122	0.625899	0.67175	0.344262	0.35321	0.569299	0.61009	0.640834	0.6513	0.35438596	0.36823	0.61010	0.650292	0.6513					
7	1	8	1	3	6	6	3	1	6	2	6	8	5	1	0.574269	8	4	8				
Two Tailed z-test of proportions (p-value)	0.003038	0.12748	0.3172983	0.54203	0.729097	0.42902	0.005650	0.26803	0.573110	0.88295	0.365664	0.7644	0.00021951	0.03219	0.529203	0.62277	0.3413					
	9	3	4	8	4	9	2	3	4	4	2	0.7644	2	2	5	9	0.087823	6				
	7 day MA 25% of Body							7 day MA 50% of Body							7 day MA 75% of Body							
# Successes 1999-2010	12	3	54	44	57	19	33	10	90	29	93	30	41	12	111	37	117	39				
# of Bullish Engulfing 1999-2010	103	35	103	76	103	35	181	59	181	59	181	59	233	75	233	75	233	75				
% successes 1999-2010	0.116504	0.08571	0.5242718	0.57894	0.553398	0.54285	0.182320	0.16949	0.497237	0.49152	0.513812	0.5084	0.17596566		0.476394	0.49333	0.502145					
9	4	4	7	1	7	7	4	2	6	5	2	7	5	0.16	8	3	9	0.52				
# Successes 1950-1998	53	46	219	83	239	86	205	76	357	127	398	137	268	99	457	159	512	174				
# of Bullish Engulfing 1950-1998	234	129	417	129	417	129	671	207	671	207	671	207	855	162	855	261	855	261				
% successes 1950-2018	0.226495	0.35658	0.5251798	0.64341	0.573141	0.66666	0.305514	0.36715	0.532041	0.61352	0.593144	0.6618	0.31345029	0.61111	0.534502	0.60919	0.598830	0.6666				
7	9	6	1	5	7	7	2	0.36715	7	7	6	4	2	1	9	5	4	7				

Two Tailed z-test of proportions (p-value)	0.00190 0.018397	2	0.9868153 8	0.35850 5	0.717082 0.17587	0.001044 7	0.00419 1	0.405358 2	0.09322 2	0.055263 4	0.0315 7	3.69853E-05 9.61E-11	0.115461 2	0.07284 8	0.008070 3	0.0201 3		
10 day MA 25% of Body																		
# Successes 1999-2010	9	2	49	18	53	18	27	10	81	30	85	30	32	10	99	33	106	34
# of Bullish Engulfing 1999-2010	103	39	103	39	103	39	181	67	181	67	181	67	233	81	233	81	233	81
% successes 1999-2010	0.087378	0.05128	0.4757281	0.46153	0.514563	0.46153	0.149171	0.14925	0.447513	0.44776	0.469613	0.4477	0.13733905	0.12345	0.424892	0.40740	0.454935	0.4197
# Successes 1950-1998	6	2	6	8	1	8	3	4	8	1	3	6	6	7	7	7	6	5
# of Bullish Engulfing 1950-1998	107	35	193	62	214	69	175	61	314	99	353	113	227	77	402	120	455	139
% successes 1950-2018	0.257211	0.28688	0.4639423	0.50819	0.514423	0.56557	670	194	670	194	670	194	854	249	854	249	854	249
Two Tailed z-test of proportions (p-value)	0.000212 1	0.00233 2	0.8300281 4	0.61194 3	0.997968 8	0.25644 7	0.00880 0.001672	0.001672 7	0.612795 6	0.37731 3	0.171472 7	0.0561 2	4.50457E-05 0.00097	0.00097 9	0.213484 1	0.2427 0.2427	0.035055 2	0.0301 8

Table 10. Two tests of proportions comparing the success rates for the Bullish Engulfing pattern for the decade 1999-2010 with the prior 5 decades 1950-2018

	CLOSE Regardless s of Trend	CLOSE with Trend	OPEN Regardless s of Trend	OPEN with Trend	HIGH Regardless s of Trend	HIGH with Trend	CLOSE Regardless s of Trend	CLOSE with Trend	OPEN Regardless s of Trend	OPEN with Trend	HIGH Regardless s of Trend	HIGH with Trend	CLOSE Regardless s of Trend	CLOSE with Trend	OPEN Regardless s of Trend	OPEN with Trend	HIGH Regardless s of Trend	HIGH with Trend			
Criterion	3 day MA 25% of Body							3 day MA 50% of Body							3 day MA 75% of Body						
# Successes 2010-2020	8	3	22	9	25	9	16	7	37	15	44	15	21	8	48	17	57	19			
# of bearish engulfing candles 2010-2020	38	13	38	13	38	13	64	22	64	22	64	22	85	31	85	31	85	31			
% successes 2010-2020	0.210526	0.23076	0.578947	0.69230	0.657894	0.69230	0.31818		0.68181		0.68181		0.247058	0.25806	0.564705	0.54838	0.670588	0.61290			
# Successes 1950-1998	130	30	207	44	246	63	130	30	207	44	246	63	130	30	207	44	246	63			
# of bearish engulfing candles 1950-1998	378	119	378	119	378	119	378	119	378	119	378	119	378	119	378	119	378	119			
% successes 1950-2018	0.343915	0.25210		0.36974	0.650793	0.52941	0.343915	0.25210		0.36974	0.650793	0.52941	0.085230	0.25210		0.36974	0.650793	0.52941			
Two Tailed z-test of proportions (p-value)	0.095967	0.86607	0.711330	0.02428	0.930220	0.26273		0.51748		0.00641	0.567525	0.18652		0.94578	0.612621	0.07130	0.728782	0.40556			
	6	4	9	2	8	3	0.139602	8	0.649943	2	9	4	0.00052	5	4	9	5	3			
	5 day MA 25% of Body							5 day MA 50% of Body							5 day MA 75% of Body						
# Successes 2010-2020	6	3	17	10	23	12	13	7	30	18	38	20	17	9	85	46	47	24			
# of bearish engulfing candles 2010-2020	38	19	38	19	38	19	64	35	64	35	64	35	85	46	0.435294	0.45652					
% successes 2010-2020	0.157894	0.15789	0.447368	0.52631	0.605263	0.63157	0.203125	0.2	0.46875	6	0.59375	9	0.2	2	0.19565	207	44	0.552941	0.52173		
# Successes 1950-1998	130	30	207	44	246	63	130	30	207	44	246	63	130	30	378	119	246	63			
# of bearish engulfing candles 1950-1998	378	119	378	119	378	119	378	119	378	119	378	119	378	119	378	119	378	119			
% successes 1950-2018	0.343915	0.25210		0.36974	0.650793	0.52941	0.343915	0.25210		0.36974	0.650793	0.52941	0.343915	0.25210	0.060909	0.30636	0.650793	0.52941			
Two Tailed z-test of proportions (p-value)	0.019794	0.37134		0.19410	0.575687	0.40640	0.025982	0.52595	0.241982	0.12534	0.378547	0.66113	0.010011	0.44409	0.530752	0.05593	0.090825	0.92946			
	5	4	0.237336	1	1	7	9	7	9	8	6	1	4	4	2	3	1	5			
	7 day MA 25% of Body							7 day MA 50% of Body							7 day MA 75% of Body						
# Successes 2010-2020	5	4	16	11	17	12	9	4	27	16	29	17	13	5	34	18	37	20			
# of bearish engulfing candles 2010-2020	38	27	38	27	38	27	64	40	64	40	64	40	85	50	85	50	85	50			
% successes 2010-2020	0.131578	0.14814	0.421052	0.40740	0.447368	0.44444	0.140625	0.1	0.421875	0.4	0.453125	0.425	0.152941				0.435294				
# Successes 1950-1998	130	30	207	44	246	63	130	30	207	44	246	63	130	30	207	44	246	63			
# of bearish engulfing candles 1950-1998	378	119	378	119	378	119	378	119	378	119	378	119	378	119	378	119	378	119			
% successes 1950-2018	0.343915	0.25210		0.36974	0.650793	0.52941	0.001198	0.25210		0.36974	0.650793	0.52941	0.343915	0.25210		0.36974	0.650793	0.52941			
	3	1	0.547619	8	7	2	7	1	0.547619	8	7	2	3	1	0.547619	8	7	2			

Two Tailed z-test of proportions (p-value)	0.0077	0.24859 5	0.135876 7	0.71541 8	0.013177 4	0.42516 8	0.063055 1	0.04238 4	0.062352 5	0.73274 3	0.002559 6	0.25320 6	0.000574 6	0.02593 8	0.013835 0.013835	0.90447 4	0.000230 8	0.12454 2
10 day MA 25% of Body																		
# Successes 2010-2020	4	2	13	9	14	10	5	2	19	13	21	14	7	2	22	13	25	14
# of bearish engulfing candles 2010-2020	38	25	38	25	38	25	64	42	64	42	64	42	85	54	85	54	85	54
% successes 2010-2020	0.105263	0.342105	0.368421	0.368421	0.368421	0.368421	0.04761	0.04761	0.30952	0.30952	0.33333	0.33333	0.082352	0.03703	0.258823	0.24074	0.294117	0.25925
# Successes 1950-1998	2	0.08	3	0.36	1	0.4	0.078125	0.078125	0.296875	0.296875	0.328125	0.328125	9	7	5	1	6	9
# of bearish engulfing candles 1950-1998	130	30	207	44	246	63	130	30	207	44	246	63	130	30	207	44	246	63
% successes 1950-2018	0.343915	0.25210	0.547619	0.36974	0.650793	0.52941	0.343915	0.343915	0.25210	0.25210	0.650793	0.650793	0.343915	0.343915	0.25210	0.36974	0.650793	0.52941
Two Tailed z-test of proportions (p-value)	0.002690 5	0.05989 2	0.015551 3	0.92680 1	0.000609 5	0.23937 8	0.00430 1.961E-05	0.000206 5	0.48289 4	1.1 E-06 1	0.02874 1.8 E-06	0.00073 6	0.000001 5	0.09436 9	1.6 E-09 1.6 E-09	0.00092		

Table 11. Two tests of proportions comparing the success rates for the Bearish Engulfing pattern for the decade 2010-2020 with the prior 5 decades 1950-2018

	CLOSE Regardless of Trend	CLOSE with Trend	OPEN Regardless of Trend	OPEN with Trend	LOW Regardless of Trend	LOW with Trend	CLOSE Regardless of Trend	CLOSE with Trend	OPEN Regardless of Trend	OPEN with Trend	LOW Regardless of Trend	LOW with Trend	CLOSE Regardless of Trend	CLOSE with Trend	OPEN Regardless of Trend	OPEN with Trend	LOW Regardless of Trend	LOW with Trend			
Criterion	3 day MA 25% of Body							3 day MA 50% of Body							3 day MA 75% of Body						
# Successes 2010-2020	13	4	25	5	30	5	25	5	43	6	49	6	32	9	56	13	62	13			
# of bullish engulfing candles 2010-2020	38	5	38	5	38	5	64	7	64	7	64	7	82	16	82	16	82	16			
% successes 2010-2020	0.3421052	0.657894	0.657894	0.7894736	0.7894736		0.71428	0.71428	0.85714	0.85714	0.85714	0.85714	0.6829268	0.6829268	0.756097	0.756097					
# Successes 1950-1998	6	0.8	7	1	8	1	0.390625	6	0.671875	3	0.765625	3	0.3902439	0.5625	0.8125	6	0.8125				
# of bullish engulfing candles 1950-1998	164	24	266	39	290	44	164	24	266	39	290	44	164	24	266	39	290	44			
% successes 1950-2018	417	70	417	70	417	70	417	70	417	70	417	70	417	70	417	70	417	70			
Two Tailed z-test of proportions (p-value)	0.3932853	0.34285	0.637889	0.55714	0.6954436	0.62857	0.3932853	0.34285	0.6378896	0.55714	0.695443	0.62857	0.3932853	0.34285	0.6378896	0.55714	0.695443	0.62857			
	7	7	7	3	5	1	7	7	9	3	6	1	7	7	9	3	6	1			
	0.7322716	0.42371	0.805769	0.31731	0.2244578	0.09179	0.9676353	0.05314	0.5973774	0.12463	0.251769	0.22690	0.9588843	0.10310	0.4358275	0.05945	0.270712	0.16031			
	8	1	2	1	7	8	1	5	5	2	3	7	6	7	4	7	7	5			
	5 day MA 25% of Body							5 day MA 50% of Body							5 day MA 75% of Body						
# Successes 2010-2020	6	2	18	5	23	6	15	3	35	6	40	7	19	6	45	11	52	13			
# of bullish engulfing candles 2010-2020	38	8	38	8	38	8	64	9	64	9	64	9	82	17	82	17	82	17			
% successes 2010-2020	0.1578947	0.473684	0.473684	0.6052631	0.6052631		0.234375	3	0.546875	7	0.625	8	0.2317073	0.35294	0.5487804	0.64705	0.634146	0.76470			
# Successes 1950-1998	4	0.25	2	0.625	6	0.75	164	24	266	39	290	44	164	24	266	39	290	44			
# of bullish engulfing candles 1950-1998	164	24	266	39	290	44	164	24	266	39	290	44	164	24	266	39	290	44			
% successes 1950-2018	417	70	417	70	417	70	417	70	417	70	417	70	417	70	417	70	417	70			
Two Tailed z-test of proportions (p-value)	0.3932853	0.34285	0.637889	0.55714	0.6954436	0.62857	0.3932853	0.34285	0.6378896	0.55714	0.695443	0.62857	0.3932853	0.34285	0.6378896	0.55714	0.695443	0.62857			
	7	7	7	3	5	1	7	7	9	3	6	1	7	7	9	3	6	1			
	0.0040853	0.59763	0.045417	0.71386	0.2507286	0.49760	0.0143334	0.95478	0.1612291	0.53219	0.258203	0.37839	0.0055119	0.93745	0.1279441	0.50117	0.274522	0.28948			
	7	9	8	8	5	5	2	1	2	1	8	3	8	9	1	5	5	1			
	7 day MA 25% of Body							7 day MA 50% of Body							7 day MA 75% of Body						
# Successes 2010-2020	6	2	17	4	22	6	12	3	31	5	37	7	16	5	39	8	47	10			
# of bullish engulfing candles 2010-2020	38	11	38	11	38	11	64	13	64	13	64	13	82	20	82	20	82	20			
% successes 2010-2020	0.1578947	0.18181	0.447368	0.36363	0.5789473	0.54545	0.1875	9	0.484375	5	0.578125	2	0.1951219	0.4756097	0.573170						
	4	8	4	6	7	5	1	9	1	2	1	8	5	0.25	6	0.4	7	0.5			

# Successes 1950-1998	164	24	266	39	290	44	164	24	266	39	290	44	164	24	266	39	290	44
# of bullish engulfing candles 1950-1998	417	70	417	70	417	70	417	70	417	70	417	70	417	70	417	70	417	70
% successes 1950-2018	0.3932853	0.34285	0.637889	0.55714	0.6954436	0.62857	0.3932853	0.34285	0.6378896	0.55714	0.695443	0.62857	0.3932853	0.34285	0.6378896	0.55714	0.695443	0.62857
Two Tailed z-test of proportions (p-value)	0.0040853 7	0.28754	0.020409 3	0.23188 3	0.1386273 4	0.59802 9	0.0014611 9	0.42823 6	0.0186303 9	0.25236 9	0.061053 2	0.53986 5	0.0006355 0.43323	0.43323 4	0.0058558 5	0.21468 1	0.030646 1	0.30062 3

	10 day MA 25% of Body						10 day MA 50% of Body						10 day MA 75% of Body					
# Successes 2010-2020	6	3	15	5	20	6	12	3	27	5	33	6	14	4	34	7	41	8
# of bullish engulfing candles 2010-2020	38	9	38	9	38	9	64	11	64	11	64	11	82	17	82	17	82	17
% successes 2010-2020	0.1578947	0.33333	0.394736	0.55555	0.5263157	0.66666	0.27272	0.1875	0.421875	5	0.515625	5	0.1707317	0.23529	0.4146341	0.41176	0.47058	
# Successes 1950-1998	164	24	266	39	290	44	164	24	266	39	290	44	164	24	266	39	290	44
# of bullish engulfing candles 1950-1998	417	70	417	70	417	70	417	70	417	70	417	70	417	70	417	70	417	70
% successes 1950-2018	0.3932853	0.34285	0.637889	0.55714	0.6954436	0.62857	0.3932853	0.34285	0.6378896	0.55714	0.695443	0.62857	0.3932853	0.34285	0.6378896	0.55714	0.695443	0.62857
Two Tailed z-test of proportions (p-value)	0.0020426 9	0.95478 1	0.003150 2	0.0321949 0.9928	0.82338 3	0.0014611 9	0.64646 2	0.0009750 7	0.52540 6	0.004345 8	0.59802 4	0.0001201 1	0.39448 5	0.0001604 4	0.28143 0.28143	0.000618 1	0.23344 2	

Table 12.Two tests of proportions comparing the success rates for the Bullish Engulfing pattern for the decade 2010-2020 with the prior 5 decades 1950-2018

Data Analysis				
Index	S&P 500			
Time Periods	1950-2018	1950-1998	1999-2010	2010-2020
Frequency	Daily			
Candlestick Patterns	Bullish Engulfing	Bearish Engulfing		

Parameters				
Days after	3	5	7	10
Percentage of body engulfing	25%	50%	75%	
Previous trend	With trend	Regardless of trend		

Statistical Analysis	
Section 5.1	Descriptive analysis of success proportions for engulfing candle versus all candles
Section 5.2	Inferential analysis of success proportions for engulfing candle versus all candles Tests for independence between candle signals Tests for comparing success proportions between candle signals and no signals
Section 5.3	ANOVA Inferential Analysis of factors
Section 5.4	Inferential Analysis for percent errors of failures
Section 5.5	Exploratory distributional analysis of inter-arrival times for Bullish and Bearish Engulfing patterns
Section 5.6	Comparing success rates of 1999-2010 and 2010-2020 vs 1950-1998

Bearish Engulfing - Summary Results		
Forecasting power	Significant	Not significant
Previous trend		X
Percentage of body engulfing		X
OPEN, HIGH	X	
CLOSE		X
Duration. The longer the time frame, the lower the forecasting power	X	

Bullish Engulfing - Summary Results		
Forecasting power	Significant	Not significant
Previous trend		X
Percentage of body engulfing		X
OPEN, LOW	X	
CLOSE		X
Duration. The longer the time frame, the lower the forecasting power	X	

Table 13. Summary data, parameters, statistical analysis and some results**Chart 1.** Success proportions for the Bearish Engulfing pattern versus the success proportions for all candles



Chart 2. Success proportions for the Bullish Engulfing pattern versus the success proportions for all candles



Chart 3. Success rates for Bearish Engulfing pattern comparing decades 1999-2010 and 2010-2020 against the previous 5 decades 1950-1998



Chart 4. Success rates for Bullish Engulfing pattern comparing decades 1999-2010 and 2010-2020 against the previous 5 decades 1950-1998