

# Evaluating the Predictive Power of Candlestick Patterns in the Real Estate Financial Market

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## ABSTRACT

This study examines the predictive reliability of four candlestick patterns—Bullish Engulfing, Bearish Engulfing, Hammer, and Hanging Man—in the real estate financial market using historical price data from the Vanguard Real Estate ETF (VNQ) from 2008 to 2024. Given real estate's lower liquidity and slower price adjustments compared to stock markets, bullish patterns were expected to demonstrate higher predictive accuracy, while bearish patterns were anticipated to be less reliable due to the gradual nature of real estate price declines. The results show that the Hammer pattern had the highest accuracy (59.86%), followed by Bullish Engulfing (54.35%), while Bearish Engulfing (42.39%) and Hanging Man (41.56%) exhibited lower reliability. Further analysis segmented by TNX (10-Year Treasury Yield) trends revealed that the Hammer pattern was more effective during declining interest rates, while the Bullish Engulfing pattern performed better when rates were rising. These findings suggest that macroeconomic conditions play a significant role in the reliability of candlestick signals, underscoring the value of tracking interest rate trends. Although candlestick patterns offer some predictive insight, their effectiveness is closely tied to broader economic conditions. Incorporating macroeconomic indicators, such as interest rate trends, alongside technical analysis can enhance accuracy and reliability. These insights can help investors and analysts make better-timed decisions by showing when certain candlestick patterns have a greater reliability. By paying attention to interest rate trends alongside technical signals, the real estate market can be approached with a greater sense of confidence.

**Keywords:** Candlestick patterns; Bullish Engulfing; Bearish Engulfing; Hanging Man; Pattern reliability; Technical analysis

## INTRODUCTION

Candlestick patterns are a crucial tool in market analysis, offering visual insights into price dynamics

through their relationship to open, close, high, and low prices. Although widely used in stock and forex markets, their applicability and reliability in the real estate market remain less explored. Given the unique nature of real estate assets, characterized by less liquidity and slower price adjustments, understanding candlestick reliability in this context is essential. This research addresses that gap by evaluating how well candlestick patterns predict price movements in the real estate market.

The study investigates whether candlestick patterns

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can reliably forecast price movements in the real estate market and how their effectiveness compares to other factors.

This study sought to evaluate the predictive reliability of four candlestick patterns—Bullish Engulfing, Bearish Engulfing, Hammer, and Hanging Man—in the real estate financial market, using historical VNQ price data from 2008 to 2024. Drawing on evidence from the literature, including studies by Caginalp and Laurent (3) and Goo, Chen, and Chang (22), the hypothesis was that bullish candlestick patterns, particularly the Hammer and Bullish Engulfing formations, would demonstrate predictive accuracies above 50%, thereby offering meaningful insights into future price movements. In contrast, we expected that bearish patterns would exhibit lower reliability. This hypothesis was based on prior research indicating that real estate markets—characterized by slower price adjustments and lower liquidity—may be more conducive to detecting bullish reversals compared to bearish declines.

The first objective is to identify whether candlestick patterns are common in the real estate market trading. This objective focuses on the frequency and circumstances under which four specific candlestick patterns—bearish engulfing, bullish engulfing, hammer, and hanging man—occur in real estate trading. These patterns are widely recognized in technical analysis for their ability to signal potential trend reversals or continuations. Understanding their prevalence in the real estate market can provide valuable insights.

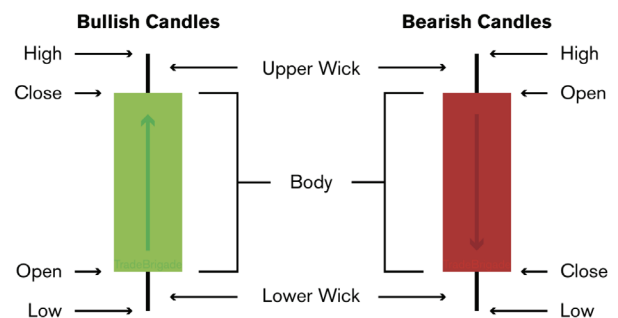
The next research objective is to evaluate the reliability of these patterns in predicting price changes. Candlestick patterns are valued for their potential to forecast market movements. This objective evaluates the effectiveness of these patterns in forecasting short-term price movements within the real estate sector. The study will assess the predictive success rates of these patterns by comparing their historical signals against actual price movements, revealing their strengths and limitations in the real estate context.

## LITERATURE REVIEW

### Definition and History of Candlestick Patterns

Candlestick charting originated in Japan in the 18th century and was pioneered by Munehisa Homma, a rice trader who used historical price data to forecast future price movements (6). The technique was later adapted for modern financial markets, particularly in stock trading, where it became a key component

of technical analysis. Candlestick patterns visually represent market sentiment by displaying the open, high, low, and closing prices of an asset over a specific period. These patterns are categorized as reversal patterns, which indicate a potential trend change, and continuation patterns, which suggest the existing trend will persist. Traders use them to predict short-term price movements and inform buy or sell decisions. The increasing computational power of trading software has enhanced the ability to recognize and analyze these patterns in real time. The difference between bullish and bearish candles are shown in Figure 1.



**Figure 1.** Bullish Candle vs. Bearish Candle.

### Common Patterns Used in Financial Markets

Several key candlestick patterns have been extensively studied for their predictive power in financial markets. The bullish and bearish engulfing patterns indicate a potential reversal, where a large candle engulfs the previous smaller candle, suggesting a shift in market momentum. Studies by Lu, Shiu, and Liu (23) found that bullish engulfing patterns exhibited significant predictive power in stock markets. Similarly, the hammer and hanging man patterns, which are single-candle formations, are used to identify potential market bottoms and tops. Research by Goo, Chen, and Chang (22) suggests that hammer patterns are more effective in predicting short-term market reversals when the low price is used as a temporary bottom.

Other commonly analyzed patterns include the doji and shooting star. The doji represents market indecision, while the shooting star signals potential reversals. Horton (20) found that doji patterns lacked profitability compared to a simple buy-and-hold strategy. While these patterns are widely accepted in stock and foreign exchange markets, their application to real estate trading remains underexplored.

### Candlestick Patterns in Real Estate Markets

Real estate markets, characterized by low liquidity and infrequent trading, experience slower price adjustments than more volatile stock markets. Because of real estate's longer investment cycles, candlestick patterns—designed for short-term trading—may have limited applicability in this context. However, some researchers have attempted to apply candlestick patterns to real estate-based financial instruments, such as Real Estate Investment Trusts (REITs) and housing indices. A study on Japanese candlestick patterns in the residential real estate market (1) found that price trends in real estate do not follow the same predictable pattern observed in equity markets. Notably, there were cases where downward candlestick formations still resulted in rising prices, contradicting the assumptions made in traditional financial markets.

Previous studies examining candlestick pattern reliability in stock markets have produced mixed results, raising questions about their applicability in real estate. Caginalp and Laurent (3) tested eight three-day candlestick reversal patterns on S&P 500 stocks and found significant short-term profitability, suggesting that these patterns held predictive value in traditional financial markets. This profitability was achieved by using these patterns as signals to enter trades held for several days rather than simply relying on a same-day close exceeding the open to capture shifts in market sentiment. In contrast, Marshall, Young, and Rose (9) tested 14 candlestick patterns using a bootstrapping methodology on Dow Jones Industrial Average (DJIA) stocks and found no predictive power or financial value. Similar results were found by Marshall, Young, and Chang (12), who tested candlestick patterns on the Tokyo Stock Exchange and concluded that they provided no consistent profitability. These discrepancies in findings suggest that candlestick pattern reliability may be highly dependent on market structure, liquidity, and other external factors.

Further analysis by Goo, Chen, and Chang (22) examined 26 candlestick patterns on the Taiwan Mid-Cap 100 and found that bearish patterns performed best over three to four days, while bullish patterns showed effectiveness over longer periods, typically nine to ten days. Zhu, Atri, and Yegen (14) found that certain candlestick patterns were effective in Chinese exchanges, with bearish harami patterns being particularly useful for low-liquidity stocks, while bullish engulfing and piercing patterns performed well for highly liquid, small-cap stocks. These findings indicate that market

conditions, such as liquidity and asset type, may significantly influence the effectiveness of candlestick patterns.

### Factors Affecting the Reliability of Candlestick Patterns

The effectiveness of candlestick patterns in real estate markets is influenced by broader market conditions, such as volatility and market cycles. While stock markets exhibit frequent and often sharp price fluctuations, real estate markets are characterized by slower-moving trends with fewer short-term price reversals. The study by Sciendo (1) indicated that in real estate markets, downward candlestick patterns did not always lead to expected price declines, as factors such as housing demand, mortgage rates, and macroeconomic conditions played a significant role in price movement. The presence of long transaction periods and illiquidity in real estate further limits the applicability of candlestick patterns, which traditionally rely on quick market reactions.

The reliability of candlestick analysis is also affected by the method of pattern recognition, whether performed manually or using software-based algorithms. Advances in machine learning and pattern recognition tools have allowed traders in financial markets to identify candlestick patterns more consistently. Chmielewski, Janowicz, Kaleta, and Orlowski (4) applied k-nearest neighbor classifier techniques to candlestick patterns on the Warsaw Stock Exchange and found no evidence of profitability, though they noted that practicing traders might use candlestick analysis differently than in academic studies. This suggests that while algorithmic trading models may struggle to extract profitability from candlestick patterns, human intuition and market experience could still play a role in their perceived effectiveness.

One of the primary limitations of candlestick analysis in real estate is the absence of the high-frequency trading environment seen in equity and forex markets. Unlike stocks, where traders react instantly to price movements, real estate transactions involve lengthy negotiations, mortgage approvals, and regulatory considerations, leading to a slower reaction time. The study by Horton (20) found that while candlestick patterns such as stars, crows, and dojis showed no significant profitability in stock markets compared to a buy-and-hold strategy, these patterns may be even less effective in real estate due to its unique market dynamics.

Additionally, candlestick patterns may fail to account for external shocks such as economic crises, interest

rate fluctuations, or policy changes that heavily impact real estate pricing. According to research analyzed in ResearchGate (11), many candlestick studies have been limited to local stock exchanges, and their implementation in global markets may be influenced by anomalous factors such as geopolitical instability or sudden economic downturns. These factors suggest that while candlestick patterns may provide some insight into short-term price movements in real estate indices or REITs, their reliability in predicting direct real estate transactions remains questionable.

The existing literature on candlestick patterns presents a mixed perspective on their reliability across different financial markets. While some studies suggest that these patterns hold predictive power in stock markets, others argue that their effectiveness is negligible. When applied to real estate markets, additional challenges arise due to the illiquid nature of real estate assets, longer investment cycles, and market-specific factors such as interest rates and economic conditions. Moreover, the effectiveness of candlestick analysis may vary based on the tools used, with machine learning techniques showing little advantage over traditional manual interpretation. Given these limitations, further research is necessary to assess whether candlestick patterns can be adapted to real estate trading or if alternative technical analysis methods should be explored.

## METHODOLOGY

### Selection of Candlestick Patterns

This study focuses on four widely recognized candlestick patterns: Bullish Engulfing, Bearish Engulfing, Hammer, and Hanging Man. These patterns have been extensively tested in stock markets for their

ability to signal price reversals (6) and are frequently used in technical analysis. These patterns were selected due to their prominence in financial literature and potential relevance to real estate instruments like REITs. Bullish and Bearish Engulfing patterns are often associated with significant trend reversals, while Hammer and Hanging Man patterns are used to detect shifts in market sentiment. Given that real estate investments typically exhibit lower volatility and longer holding periods than stocks, this study evaluates whether these candlestick formations maintain predictive reliability in a real estate market context.

### Defining Reliability

In this study, reliability is defined as the statistical accuracy of candlestick patterns in predicting future price movements. A pattern is considered reliable if it consistently leads to price changes in the expected direction with statistical significance. The study measures reliability through four key metrics: pattern occurrence frequency, correct predictions, accuracy rate, and market condition influence. Table 1 provides deeper description into each metric.

By applying these metrics, this study aims to determine whether candlestick patterns offer meaningful predictive insights for real estate securities or if their effectiveness is limited in this market.

### Research Design

A quantitative research approach was employed to analyze the historical price movements of real estate-related financial instruments using candlestick pattern recognition. The study utilizes VNQ as a representative dataset, given its liquidity, broad exposure to REITs, and availability of historical pricing data. The methodology

**Table 1.** Definitions of evaluation metrics used in the study, including how pattern frequency, accuracy, and market conditions were measured

Metrics Definition	
1) Pattern Occurrence Frequency	Quantifies how often each pattern appears in historical real estate market data
2) Correct Predictions	counts the number of times the price moved in the expected direction following a pattern's occurrence
3) Accuracy Rate	Accuracy rate refers to the proportion of instances in which a candlestick pattern correctly predicted the price direction, relative to its total occurrences.
4) Market Condition Influence	Assessing how macroeconomic factors, particularly interest rate movements, impact the predictive accuracy of these patterns

involves a backtesting framework wherein candlestick patterns are identified in historical price data, and their subsequent price movements are analyzed. The analysis was conducted using Python programming, allowing for automated pattern detection and statistical evaluation of reliability. To ensure replicability, specific detection rules were used to identify each pattern. For the Hammer and Hanging Man formations, the candle's real body was required to be shorter than 30 percent of the total candle length, with the upper shadow also limited to 30 percent or less, and a lower wick that extended significantly beneath the body. These thresholds ensured that only well-defined examples were captured. For Bullish and Bearish Engulfing patterns, the second candle had to fully engulf the previous day's body. In a Bullish Engulfing pattern, this meant the second day's open was lower and the close was higher than the first day's body, signaling a potential reversal to the upside. Conversely, in a Bearish Engulfing pattern, the second day's open was higher and the close was lower than the first day's body, indicating a possible reversal to the downside. These pattern definitions closely follow widely accepted technical analysis standards and were translated directly into algorithmic thresholds in the Python code.

### Data Collection

**Sources of Data.** The primary dataset was obtained from Yahoo Finance, covering historical price data for VNQ from January 2008 to January 2024. This 16-year timeframe includes multiple economic cycles, such as the 2008 financial crisis, the post-crisis recovery (2010–2019), the COVID-19 market disruption (2020–2021), and recent interest rate hikes (2022–2023). By incorporating these varied economic periods, the study ensures that findings reflect different market conditions and volatility regimes, which may affect the reliability of candlestick patterns. Figure 2 show hammer candle stick pattern on VNQ price data.

### Analysis of Candlestick Patterns

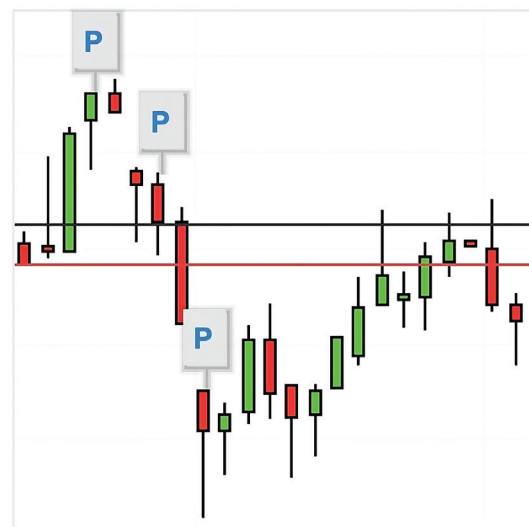
**Identification of Key Patterns.** To detect candlestick patterns, a rule-based algorithm was developed using Python (pandas and NumPy libraries). The algorithm systematically scans historical VNQ price data to identify occurrences of four key candlestick patterns: Bullish Engulfing, Bearish Engulfing, Hammer, and Hanging Man. Bullish Engulfing patterns were defined by a larger bullish candle fully engulfing the previous bearish candle, while Bearish Engulfing patterns required a larger bearish candle to engulf a preceding

bullish candle. Hammer formations were identified based on their characteristic small body and long lower shadow, signaling potential price reversals. Similarly, Hanging Man formations were detected as inverted Hammer-like structures following an uptrend, indicating possible price declines.

<https://github.com/RiyaPallikonda/Real-Estate-Candle-Stick-Project---/tree/main>

### Method to Evaluate Reliability

Once identified, the predictive reliability of each candlestick pattern was evaluated using statistical measures based on subsequent daily price performance. The code calculates the percentage change in VNQ's closing price from one day to the next and classifies that change as positive or negative. For each pattern occurrence, the actual outcome used for evaluation is taken from two trading days later by shifting the next-day performance value. Patterns are considered correctly predictive if the observed performance two days after the pattern matches the expected direction—for example, Bullish Engulfing and Hammer patterns are deemed correct if followed by a price increase, while Bearish Engulfing and Hanging Man patterns are correct if followed by a decline. This two-day lag was selected to strike a practical balance between overly noisy short-term volatility and longer-term price movements that



**Figure 2.** Hammer seen at bottom-most P on chart (Other P represent recognizable candlestick patterns in this section of the VNQ).

may reflect unrelated market factors. Next-day prices are often influenced by random news shocks and high volatility, making them unreliable for gauging the true effect of a pattern (21). On the other hand, extending the evaluation window too far risks allowing new information to swamp the original signal. Candlestick patterns are short-term by nature, and their predictive value tends to fade after just a few days. Two days, therefore, provides a brief confirmation window that filters out one-day anomalies while still staying within the timeframe the pattern was expected to influence.

## RESULTS

### Findings on Pattern Reliability

This study evaluates the predictive reliability of four candlestick patterns—Hammer, Bullish Engulfing, Bearish Engulfing, and Hanging Man—within the VNQ from 2008 to 2024. The analysis focuses on two perspectives:

(1) VNQ-only accuracy, which measures how well each pattern predicts future price movement based solely on VNQ performance, and

(2) TNX-segmented accuracy, which assesses the same patterns in the context of macroeconomic shifts by dividing the results based on the direction of the TNX trend.

This dual approach helps capture both technical and macroeconomic influences on pattern reliability and forms the basis for further interpretation and significance testing.

### Patterns with High Reliability

The Hammer candlestick pattern emerged as the most reliable indicator among the four tested patterns. It appeared 416 times over the 16-year period and correctly predicted price increases in 249 instances, yielding an accuracy rate of 59.86%. A one-tailed binomial test confirmed that this accuracy is statistically significant ( $p = 0.000034$ ), suggesting that the Hammer pattern provides a meaningful edge in forecasting bullish reversals within the real estate market. This result supports the notion that Hammer formations—typically signaling reversals after a downtrend—align well with the gradual recovery tendencies of real estate markets, where price rebounds tend to be more sustained and visible.

The Bullish Engulfing pattern appeared 138 times and accurately predicted upward movements in 75 cases, yielding an accuracy rate of 54.35%. Although this result

did not achieve statistical significance ( $p = 0.175$ ), the accuracy still exceeded 50%, suggesting a directional tendency worth noting. Given the Bullish Engulfing pattern's structure—where a bullish candle overtakes the previous bearish one—it may reflect a shift in investor sentiment that often coincides with market recoveries. While not definitive, the pattern's modest performance may still hold heuristic value, especially in conjunction with other indicators.

### Patterns with Lower Reliability

In contrast to the more promising bullish formations, the Bearish Engulfing and Hanging Man patterns demonstrated lower raw accuracy rates. The Bearish Engulfing pattern appeared 184 times and correctly predicted downward price movements in 78 instances, resulting in an accuracy rate of 42.39%. The Hanging Man pattern occurred 409 times, predicting correctly in 170 cases, yielding an accuracy rate of 41.56%. At first glance, these figures may suggest that bearish candlestick formations have limited predictive reliability in the VNQ real estate market.

However, statistical significance testing using a binomial test revealed that both of these patterns produce results that are meaningfully different from random chance. The Bearish Engulfing pattern produced a p-value of approximately 0.0462, and the Hanging Man pattern yielded a p-value of approximately 0.00075, both statistically significant at the 0.10 threshold. This suggests that although the direction of prediction is generally bearish and often incorrect in practice, these patterns still deviate from randomness in a consistent way—just not always in the expected direction.

This insight is especially important: the statistical significance may reflect that these patterns consistently signal market indecision or volatility, rather than guaranteed declines. In this context, the patterns could be seen as heuristic flags for shifts in sentiment or upcoming movement—just not reliably downward as traditionally interpreted. While their low accuracy would not make them reliable standalone trading signals, their consistent deviation from randomness indicates that they may still have value when interpreted in combination with other technical or fundamental indicators.

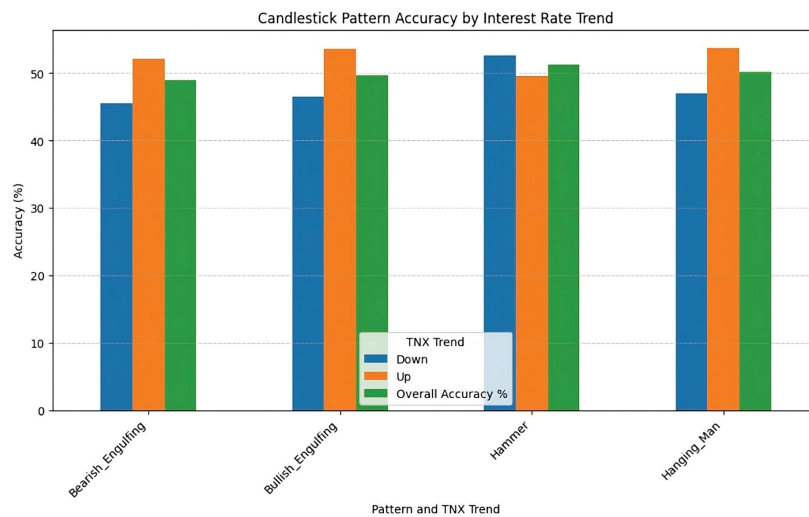
### Comparison with trends in TNX (10-year treasury yield)

As part of the results, this subsection evaluates whether the predictive accuracy of candlestick patterns varies depending on broader macroeconomic conditions

— specifically, the trend of the TNX. The TNX trend was classified using a 50-day simple moving average: if the TNX closing value on the day of a pattern occurrence was above its 50-day SMA, the trend was considered upward; if below, downward. The accuracy rates reported here are based on this segmentation and reflect the patterns’ predictive reliability within specific interest rate environments, rather than in the general VNQ market. As such, the results in this subsection should not be interpreted as contradicting the VNQ-only accuracy rates reported earlier. Rather, they provide additional contextual insight into how candlestick patterns perform under differing macroeconomic trends.

While these TNX-segmented results show variations in accuracy based on interest rate direction, statistical tests revealed that none of the patterns’ performances were significantly different from random chance (50%)

at the 0.10 threshold. Nevertheless, some directional patterns are observable — for example, the Bullish Engulfing pattern performed better when interest rates were rising (53.58%), and the Hammer pattern performed better when TNX was falling (52.67%). Although these differences are not statistically significant, they highlight potential context-dependent effects that may guide further research. In particular, the tendency for certain bullish patterns to perform better during specific TNX trends could reflect shifts in investor behavior under different monetary conditions. These findings reinforce that candlestick reliability is not purely pattern-dependent, but may be influenced by broader economic signals like interest rates. Table 2 summarizes TNX-segmented results in tabular format. Figure 3 summarizes TNX-segmented results in a graph.



**Figure 3.** Candlestick pattern accuracy segmented by TNX trend. Bars represent prediction accuracy (%) under upward and downward TNX trends, with the third bar showing the average across both conditions. \*accuracy means the number of times that the candlestick pattern was able to correctly predict market trend.

**Table 2.** Accuracy of each candlestick pattern based on TNX trend direction

Pattern	TNX Trend Down (%)	TNX Trend Up (%)	Combined TNX-Segmented Accuracy (%)
Bearish Engulfing	45.59	52.10	48.98
Bullish Engulfing	46.48	53.58	49.66
Hammer	52.67	49.62	51.24
Hanging Man	46.97	53.78	50.20

The final column shows the average of both trend conditions and does not reflect VNQ-only accuracy.

## Summary of Findings

This study evaluated the predictive reliability of four candlestick patterns—Hammer, Bullish Engulfing, Bearish Engulfing, and Hanging Man—using daily price data for VNQ from 2008 to 2024. When tested within the VNQ dataset alone, the Hammer pattern appeared 416 times and correctly predicted price increases in 249 instances, resulting in an accuracy rate of 59.86%. The Bullish Engulfing pattern showed an accuracy of 54.35% (75 correct out of 138). In contrast, the Bearish Engulfing and Hanging Man patterns showed lower predictive success, with accuracy rates of 42.39% (78 correct out of 184) and 41.56% (170 correct out of 409), respectively. A second analysis segmented these same patterns based on the direction of the TNX, calculated using a 50-day moving average. The Hammer pattern showed an overall TNX-segmented accuracy of 51.24%, Bullish Engulfing at 49.66%, Bearish Engulfing at 48.98%, and Hanging Man at 50.20%. Within this segmentation, the Hammer pattern performed better during periods when the TNX trend was down (52.67%), while Bullish Engulfing performed better when the TNX trend was up (53.58%). Statistical tests (binomial tests) were conducted for all TNX-segmented accuracy rates to evaluate whether any were significantly different from chance (50%). None of the patterns showed statistical significance at the 0.10 level, regardless of TNX trend direction.

## DISCUSSION

The results partially support the initial hypothesis. The Hammer pattern achieved a statistically significant accuracy of 59.86% ( $p \approx 0.000034$ ), validating its role as a potentially effective indicator of bullish reversals in the VNQ real estate market. This aligns with prior research (19) suggesting that reversal patterns can capture sustained upward shifts—especially in sectors like real estate where recoveries often unfold gradually. In contrast, while the Bullish Engulfing pattern showed a moderately elevated accuracy of 54.35%, it did not meet statistical significance ( $p \approx 0.175$ ). Still, its tendency to outperform random chance may suggest some heuristic value in contexts where bullish momentum is forming. Bearish patterns such as Bearish Engulfing (42.39% accuracy,  $p \approx 0.0462$ ) and Hanging Man (41.56% accuracy,  $p \approx 0.00075$ ) showed low raw reliability but statistically significant deviation from randomness. This suggests that while these patterns often fail to predict declines as traditionally expected, they may still reflect consistent market responses—such

as volatility, sentiment shifts, or price hesitation—rather than directional declines. As such, these bearish patterns may serve better as contextual signals than standalone sell indicators. The TNX-segmented analysis provided additional macroeconomic perspective. None of the patterns' accuracy rates under different TNX trends reached statistical significance at the 0.10 threshold. However, slight directional tendencies were observed: the Hammer pattern performed better when TNX was falling (52.67%), while Bullish Engulfing performed better when TNX was rising (53.58%). Although not statistically significant, these trends hint that interest rate environments may influence pattern effectiveness, especially for bullish signals. This supports the broader conclusion that candlestick reliability is context-dependent, influenced not only by pattern structure but also by prevailing macroeconomic conditions like interest rate trends.

Although the predictive edge of candlestick patterns was modest overall, the Hammer pattern showed statistically significant results in the VNQ-only analysis, suggesting it may offer meaningful insight in forecasting bullish reversals. However, no patterns demonstrated statistically significant accuracy when segmented by interest rate trends, which highlights the limitations of using these signals in isolation. It is recommended that candlestick patterns be used as part of a broader, integrated framework that incorporates both technical analysis and macroeconomic indicators such as interest rates. Future studies should consider expanding the dataset to include direct real estate transaction data and explore hybrid models that blend technical, fundamental, and sentiment-based indicators. Additionally, analyzing how external shocks—such as policy changes or economic crises—affect pattern reliability could provide deeper insight into the specific conditions under which these signals are most effective.

## CONCLUSION

In conclusion, while this study confirms that certain candlestick patterns—particularly the Hammer formation—demonstrate meaningful predictive value in the real estate market when analyzed in isolation (VNQ-only), their overall reliability remains limited. The Hammer pattern's statistically significant performance supports its potential as a bullish indicator, aligning with the general tendency for real estate markets to recover gradually after declines. However, when examined under segmented interest rate conditions using TNX

trends, none of the candlestick patterns—including the Hammer—achieved statistical significance. This suggests that while certain patterns may show directional tendencies depending on the interest rate environment, their performance in these contexts may not meaningfully exceed random chance.

Nonetheless, the comparison across TNX trends revealed modest but observable differences—such as the Hammer pattern performing better during falling interest rates, and the Bullish Engulfing pattern showing higher accuracy during rising rates. These patterns, though not statistically significant, hint at the role macroeconomic conditions may play in shaping the effectiveness of technical indicators. The findings reinforce the need for a more integrated approach that combines candlestick analysis with broader market signals such as interest rates, monetary policy, and economic sentiment.

Several limitations of this study should be acknowledged. First, while the use of VNQ as a proxy for the real estate market is defensible due to its composition of real estate investment trusts (REITs), it is ultimately an equity instrument. As such, its behavior may resemble that of broader stock indices more than the performance of direct real estate assets. This distinction limits the generalizability of the findings to the physical real estate market. Second, although pattern identification was based on rule-based algorithms, subtle features of candlestick formations—such as shadow positioning, trend context, and psychological market interpretation—may be oversimplified in this approach. These details are often important for human traders but can be difficult to capture programmatically. Lastly, external factors such as policy interventions, economic shocks, or abrupt shifts in market sentiment may influence outcomes in ways not fully captured in the model.

Future research should aim to address these limitations. This includes incorporating datasets that reflect broader segments of the real estate market (e.g., multiple REITs, housing indices, or individual transaction data), and adopting more advanced recognition tools such as machine learning models that can detect subtle visual or contextual patterns beyond rigid rules. Further exploration of additional macroeconomic variables—like unemployment rates, GDP growth, or inflation—could provide deeper insight into when and why candlestick patterns work. By expanding the scope and tools used in analysis, future work may uncover conditions under which technical indicators deliver more reliable results in real estate forecasting.

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