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EMPIRICAL MEASUREMENT OF FINANCIAL UNCERTAINTY

JOSÉ GERARDO DE LA VEGA MENESES
Universidad Popular Autónoma del Estado de Puebla
Puebla, México
https://orcid.org/0000-0001-6748-5901

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ABSTRACT

This project explores the behavior of the CBOE Volatility Index (VIX) through data analysis in Python, providing investors with a structured way to interpret market uncertainty. The VIX, commonly called the "Fear Index," captures expected volatility in the S&P 500 and serves as a key indicator of market sentiment.

Using Python tools such as YFinance and Pandas, historical data is extracted, organized, and examined. The study applies visual and statistical techniques—including moving averages, Bollinger Bands, and candlestick representations—to identify recurring patterns and shifts in volatility conditions. Additional evaluation of daily returns and trend segmentation helps distinguish between stable and turbulent market phases.

By translating raw financial data into meaningful insights, this approach supports better risk assessment and strategic planning. Python enables efficient processing of large datasets, making it easier to navigate and interpret the complexity of financial markets characterized by constant change.

Keywords: VIX, Python, analysis.

JEL CODES: C63; G17; G10

1.0 INTRODUCTION

Since its launch in 1993, the CBOE Volatility Index (VIX) has become a widely recognized benchmark for interpreting market sentiment, particularly in relation to the S&P 500. Often referred to as the "Fear Index," it is used to summarize investor expectations of future market volatility over a 30-day horizon (Huang, Schlag, Shaliastovich & Thimme, 2019).

The index is derived from S&P 500 option prices, which allows it to directly reflect how market participants collectively price uncertainty and risk. Over time, its usefulness led to the development of similar volatility measures in other regions, such as the VSTOXX for the EURO STOXX 50 and the VDAX-NEW for Germany's DAX index, enabling broader international comparisons of market volatility conditions (Andreou & Ghysels, 2021).

The introduction of VIX futures in 2004 expanded its role beyond a mere indicator, turning volatility into a tradable asset. This development enabled investors to implement strategies based on expected changes in uncertainty, such as taking long positions during anticipated

market stress or short positions during calmer periods. Despite these opportunities, volatility trading remains highly risky due to the potential for abrupt and significant market movements.

1.1 General Objective

Use Python to study the behavior of the CBOE Volatility Index (VIX) over a ten-year period by collecting historical data and generating visual representations such as price evolution graphs, return series, candlestick charts, moving averages, and Bollinger Bands, with the goal of supporting more informed investment decisions.

1.2 Specific Objectives

The process begins by retrieving historical VIX data from Yahoo Finance through the YFinance library, building a structured dataset for further analysis. Next, a trend visualization is created to display daily movements of the VIX over a 10-year period, allowing key patterns and long-term behavior to be observed.

After that, daily percentage changes in the VIX are computed and plotted using line charts, making it possible to detect fluctuations and recurring patterns in volatility. Finally, the analysis classifies VIX movements according to their daily returns, presenting the results in a pie chart that helps illustrate different volatility regimes and identify periods of elevated market stress.

2.0 THEORETICAL FRAMEWORK

The CBOE Volatility Index (VIX) is a key metric in financial markets that represents the expected level of volatility perceived by market participants. Frequently called the “Fear Index,” it is derived from S&P 500 (SPX) options and offers a forward-looking estimate of market fluctuations over a 30-day period. Because it effectively captures changes in investor risk perception, the VIX has become an essential reference for analysts and traders involved in portfolio management, hedging strategies, and speculative decisions (Wang, 2019). This theoretical framework seeks to clarify how the VIX operates, its significance, and its application in investment contexts.

The VIX itself is constructed as a measure of implied volatility based on S&P 500 options, providing insight into market expectations of future price variability. It is computed using a broad set of options with different strike prices and expiration dates, which allows it to reflect aggregated views of anticipated risk. As noted by the Chicago Board Options Exchange (CBOE), implied volatility represents the expected magnitude of future movements in the underlying index, making the VIX particularly responsive to shifts in investor sentiment and market expectations (Pati, Barai & Rajib, 2018).

By analyzing VIX data, investors can infer market participants' expectations regarding risk and uncertainty in the near future. This makes it a key indicator for assessing market sentiment and the potential direction of prices. In situations of high uncertainty or crisis, the VIX tends to spike, while in periods of stability, its values are usually low (Chen, Liang, & Umar 2021).

The VIX measures implied volatility in the options market, meaning its value is based on investors' future expectations about the movement of the S&P 500 index. It is calculated using

a complex formula that takes into account a variety of option prices, both call and put, at different strike prices and expiration dates. Simply put, the VIX captures the cost of options that investors are willing to pay to protect themselves against future volatility (Yoon, Ruan & Zhang, 2022).

The methodology used to calculate the VIX involves aggregating the premiums of various options within a defined range of strike prices and expiration dates. This process allows for the creation of an accurate picture of market participants' expectations of future volatility. Furthermore, the index is constantly updated during trading hours, making it a real-time reflection of market psychology (Cheng, 2019).

The VIX plays a crucial role in assessing risk and uncertainty in financial markets. Its value is closely linked to fluctuations in the S&P 500, as the implied volatility of options on this index is based on investors' expectations of future price movements (Smales, 2022). Generally, when the VIX rises, it signifies that the market anticipates larger movements in stock prices, which is often associated with feelings of fear or uncertainty.

Over time, analysts have observed an inverse relationship between the VIX and the S&P 500. That is, when the S&P 500 experiences significant declines, the VIX tends to rise, and when the market stabilizes or grows, the VIX tends to fall. This is because volatility and stock performance are closely correlated: in times of high volatility, investors seek options as a way to protect their portfolios against potential losses (Bardgett, Gourier & Leippold, 2019).

The VIX value is calculated using a formula that incorporates the prices of S&P 500 options with varying expiration dates. These options are grouped into contracts with near-term expiration dates, and both call and put options are considered to obtain an accurate estimate of expected volatility (Tong & Huang, 2021). To determine the VIX, a weighted average of implied volatility is calculated, yielding a value that reflects the anticipated volatility for the next trading month.

VIX values are expressed in percentage points, and typically, the VIX is expected to range between 15- and 20-points during periods of low volatility. However, when the market experiences a crisis or uncertainty, the VIX can exceed 30 points, indicating a heightened perception of risk. A VIX above 30 can be associated with panic in financial markets, as occurred during the 2008 global financial crisis (Hapau, 2023).

Since its introduction in 1993, the VIX has undergone several significant changes in its methodology and its relationship to the market. Originally, the VIX was calculated using options on the S&P 100 index, but in 2003, the CBOE decided to expand the calculation to include options on the S&P 500, making the index more representative of the overall market (Shah, 2024). This modification improved the accuracy of the VIX as an indicator of volatility and risk, and it has since become the leading volatility indicator in international financial markets.

The relationship between the VIX and the S&P 500 is fundamental to understanding how financial markets behave under different circumstances. In general, the VIX tends to behave inversely to the S&P 500: when the market is trending upward or is stable, the VIX usually remains low, while when the market experiences sharp declines, the VIX tends to rise. This

relationship reflects the fact that investors seek protection from volatility by buying options when they perceive an increase in risk (Miljkovic & SenGupta, 2018).

The VIX has become established as a barometer of anxiety in the markets. When its value exceeds 30 points, it can indicate that investors are anticipating significant instability. Conversely, when the VIX is below 20 points, the perception is that the market is relatively stable and investors are confident about the near future (Reisizadeh, Fallah, Shams & Zomoredian, 2025).

Although the VIX cannot be traded directly as an underlying asset, investors can trade it through derivative products such as futures, options, and exchange-traded funds (ETFs) that are designed to replicate its movements. These products allow investors to profit from changes in volatility without having to purchase the options directly (Avellaneda & Papanicolaou, 2018).

The VIX is useful in risk hedging strategies, especially during times of uncertainty. For example, investors can buy put options on the S&P 500 when the VIX is low to protect their portfolios in case volatility increases and stock prices fall. The VIX can also be useful for portfolio diversification, given its inverse behavior compared to traditional assets like stocks. The VIX has a significant influence on option prices, as higher implied volatility generally leads to higher option premiums. This is because investors are willing to pay more for the right to buy or sell an underlying asset when they perceive greater uncertainty in the market (Abid, Dhaoui, Goutte, & Guesmi, 2020). Consequently, the VIX is used as an indicator of the potential profitability of options and as a tool for planning trading strategies.

One of the most important functions of the VIX is its ability to serve as a hedging tool during times of high uncertainty. Investors can use the VIX as an indicator to anticipate potential market downturns and take defensive positions, such as buying put options or acquiring financial instruments that benefit from volatility (Kaeck & Seeger, 2020). This strategy can be particularly useful during periods of financial crisis or when high risks are perceived in the global economy. The CBOE Volatility Index (VIX) is an essential tool in financial market analysis, as it provides a clear view of investors' volatility and risk expectations. Through its calculation based on S&P 500 options, the VIX allows for anticipating market movements and assessing market sentiment. Although it cannot be traded directly, derivative products exist that allow investors to use the VIX as a hedging or speculative strategy. Understanding the VIX is crucial for investors seeking to navigate financial markets successfully, especially in environments of high uncertainty (Doran, 2020).

Technical analysis is an approach used in financial markets to predict future price movements by studying historical market data, primarily prices and trading volumes. This type of analysis is based on the premise that prices move in trends and that these trends can be identified and capitalized on by investors. Through graphical and mathematical tools, technical analysts seek to identify recurring patterns, allowing them to make predictions about price movements. Although it originated in the stock market, technical analysis has expanded to a wide variety of markets, including foreign exchange and derivatives (Nti, Adekoya, & Weyori, 2020).

One of the most popular tools in technical analysis is the candlestick chart, which provides a visual representation of an asset's price movements over a specific period. A candlestick chart

consists of four key prices: the opening price, the closing price, the high price, and the low price. Each candlestick is composed of a body and two wicks. The body represents the difference between the opening and closing prices, while the wicks indicate the highest and lowest prices reached during the period. If the closing price is higher than the opening price, the candlestick is usually white or green, indicating an upward trend; conversely, if the closing price is lower than the opening price, the candlestick is black or red, indicating a downward trend (Mersal & Kutucu, 2024). Candlestick charts are highly valued by technical analysts because of the wealth of information they can convey visually and concisely. These charts allow for the identification of market behavior patterns, such as bullish engulfing patterns, hammers, or shooting stars, which can indicate potential changes in market direction. Analyzing these patterns can provide buy or sell signals. Furthermore, candlestick charts are useful for identifying support and resistance levels, which are crucial for strategic decision-making in financial markets (Santur, 2022).

On the other hand, moving averages are another fundamental tool in technical analysis. A moving average is an indicator that smooths out the daily price fluctuations of an asset to show a clearer trend. There are different types of moving averages, the most common being the simple moving average (SMA) and the exponential moving average (EMA). The simple moving average calculates the average price of an asset over a specific period, while the exponential moving average gives more weight to more recent prices, making it more sensitive to price changes (Aycel & Santur, 2022). Moving averages are widely used to identify short-, medium-, and long-term trends, as they smooth out market volatility and provide a reference point for price direction. One of the most common applications of moving averages is the moving average crossover. This pattern occurs when a short-term moving average crosses above or below a long-term moving average, which can be interpreted as a buy or sell signal. A bullish crossover occurs when the short-term moving average crosses above the long-term moving average, indicating that the price may continue its upward trend. Conversely, a bearish crossover occurs when the short-term moving average crosses below the long-term moving average, suggesting that the price may continue its downward trend (Kuo & Chou, 2021). Furthermore, moving averages can also be used to identify dynamic support and resistance levels, which improves trading decisions in the markets.

Bollinger Bands are another popular technical indicator used to measure market volatility. Developed by John Bollinger in the 1980s, they consist of three lines: a 20-day simple moving average, an upper band two standard deviations above the moving average, and a lower band two standard deviations below the moving average. Bollinger Bands expand when market volatility increases and contract when volatility decreases (Gong, Gong, Luo, & Yang, 2024). This indicator is particularly useful for identifying overbought or oversold conditions. When the price reaches the upper band, it may indicate that the asset is overbought, which could suggest a potential trend reversal. Similarly, when the price reaches the lower band, it may signal that the asset is oversold, which could also precede an upward reversal. Bollinger Bands not only help identify overbought and oversold levels, but they are also useful for anticipating potential market breakouts. When the price approaches the upper or lower bands, it may be nearing a turning point, which could lead to a widening of the price range. If the price moves outside the bands, it could signal the start of a new trend (Gold, 2018). This indicator is used by both short-term traders and long-term investors to measure volatility and adjust their entry and exit strategies.

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Taken together, technical analysis, candlestick charts, moving averages, and Bollinger Bands are powerful tools that enable investors to make informed decisions in the financial markets (Joshi & Modi, 2024). These tools not only provide an objective way to interpret market movements but also allow for the identification of trends, patterns, and critical levels that may be indicative of future price swings. While technical analysis does not guarantee consistently accurate results, its effectiveness increases when used in conjunction with other analytical approaches and within the context of a well-defined strategy. In conclusion, technical analysis and its tools, such as candlestick charts, moving averages, and Bollinger Bands, are essential for studying the financial markets. These tools allow investors to identify market behavior patterns, measure volatility, and make more informed investment decisions. Understanding and correctly applying these techniques can significantly improve the odds of success in the markets, especially when used in combination with sound risk management and a well-founded strategy.

3.0 METHODOLOGY

The behavior of the CBOE Volatility Index (VIX) was analyzed over a 10-year period using Python programming. A command was designed to download and process historical VIX data from Yahoo Finance, generating various visualizations and calculations useful for investors seeking a better understanding of market volatility. The process followed for data acquisition, analysis, and visualization is detailed below. The first step in the methodology was to obtain historical VIX data, covering the period from January 1, 2014, to December 31, 2024. The Yfinance Python library was used for this purpose, providing fast and efficient access to historical financial data. The Yfinance download function was configured to retrieve the standard columns from financial datasets, including the Open, High, Low, and Close prices. This data was stored in a Pandas Python dataframe for further processing and analysis. Once the data was obtained, a line chart was generated showing the evolution of the VIX closing value over the 10-year period. This chart is essential for visualizing fluctuations in market volatility, as well as for identifying key moments when the index showed significant peaks or drops. It is expected that, in certain events, such as financial crises or situations of high uncertainty, the VIX evolution chart will show behavior with large oscillations. Visualizing these movements allows investors to identify patterns that may indicate future changes in the market trend. In addition to the evolution chart, the daily percentage change of the VIX was calculated, which facilitates measuring the relative changes of the index with respect to its value of the previous day. This is done by calculating the percentage variation between consecutive values in a time series. Once the daily percentage changes were calculated, another line chart was generated to visualize its behavior over the analyzed period. This chart provides a clear representation of the times when the VIX experienced large fluctuations in its value, which can be indicative of periods of high volatility or market uncertainty. To provide a more detailed analysis of VIX trends, the daily percentage changes were classified into different categories: negligible changes, positive changes, negative changes, large changes, and bullish or bearish trends. This classification allows the VIX's behavior to be segmented based on the magnitude of the changes, helping to identify trends and patterns. The results of this classification were represented in a pie chart, which shows the distribution of the different categories over the 10-year period. This visualization facilitates data interpretation by providing a clear picture of the frequency of each type of trend. Another key component of the analysis was the generation of a candlestick chart, which shows the open, close, high, and low

values of the VIX for each day of the analyzed period. This type of chart is especially useful for traders, as it provides a detailed visualization of the index's daily fluctuations and allows them to identify trend reversal or continuation signals. Candlestick charts offer a clear visual representation of the relationship between opening and closing prices, as well as the intensity of the fluctuations, providing valuable information for trading decisions. In addition to the candlestick charts, two simple moving averages (SMAs) of 50 and 100 days were calculated to smooth out daily fluctuations and observe the overall medium- and long-term trend of the VIX. Moving averages are widely used indicators in technical analysis to identify trends and buy or sell signals. In this case, visualizing the two moving averages alongside the VIX closing price allows for the identification of crossovers between the lines, which can indicate potential market entry or exit points. A crossover of the short-term (50-day) moving average above the long-term (100-day) moving average could be interpreted as a buy signal for VIX-linked securities, while a crossover in the opposite direction could be a sell signal. Finally, Bollinger Bands were calculated, consisting of a 20-day moving average accompanied by two bands located two standard deviations above and below the moving average. Bollinger Bands are a useful tool for visualizing market volatility, as their expansion and contraction reflect changes in the intensity of price swings. In this study, Bollinger Bands were used to identify overbought or oversold conditions for VIX-linked financial instruments. Furthermore, if the VIX value approaches or touches the upper or lower bands, it could indicate that the market is in a phase of high volatility or extreme conditions. This information is crucial for investors, as it allows them to adjust their investment strategies based on expectations of future market movements. In summary, the methodology employed in this research combined the use of computational tools in Python with technical analysis techniques to examine the behavior of the VIX over the past 10 years. Through the acquisition and processing of historical data, the generation of interactive charts, and the calculation of indicators such as moving averages and Bollinger Bands, a comprehensive view of market volatility was provided. These analyses and visualizations allow investors to identify key patterns and trends, which can facilitate informed decision-making in an uncertain financial environment.

4.0 RESULTS OBTAINED

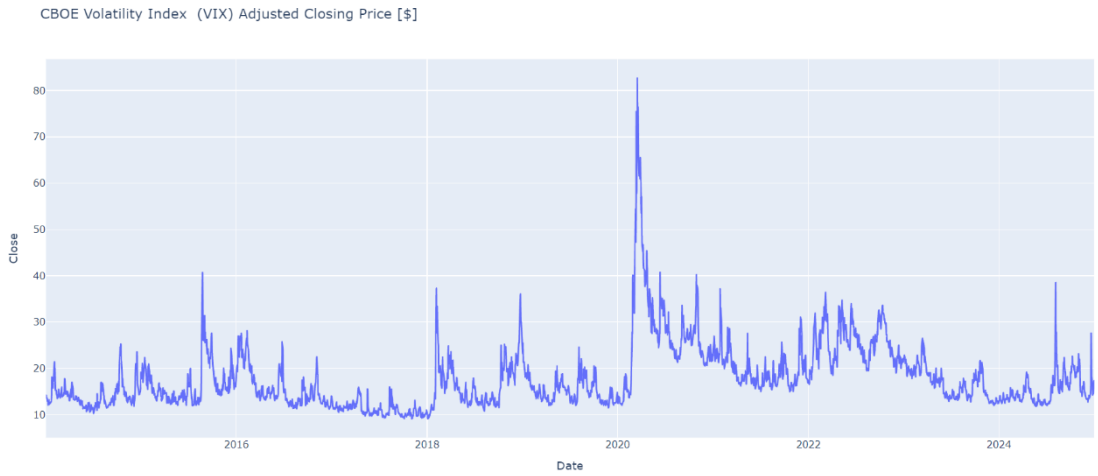
In this research work, a Python code was developed, which is shown in Annex 1, to develop the analysis of the CBOE Volatility Index (VIX) through Python.

The main results and their interpretations are shown below.

4.1 Line graph

Figure 1 illustrates the linear graph of the CBOE Volatility Index (VIX) over 10 years. A VIX of 80, as seen in February and March 2020, reflects extreme volatility and panic in the markets, with investors anticipating large price movements and global uncertainty. This high level typically occurs during times of economic crisis or disruptive events. In contrast, a VIX of 10 in early 2024 indicates calm and confidence in the markets, with expectations of lower volatility and more predictable movements. This difference highlights the contrast between a market marked by fear and uncertainty, and a more stable one, with less fear of drastic changes.

Figure 1. Line graph of the CBOE Volatility Index (VIX): 2014-2024

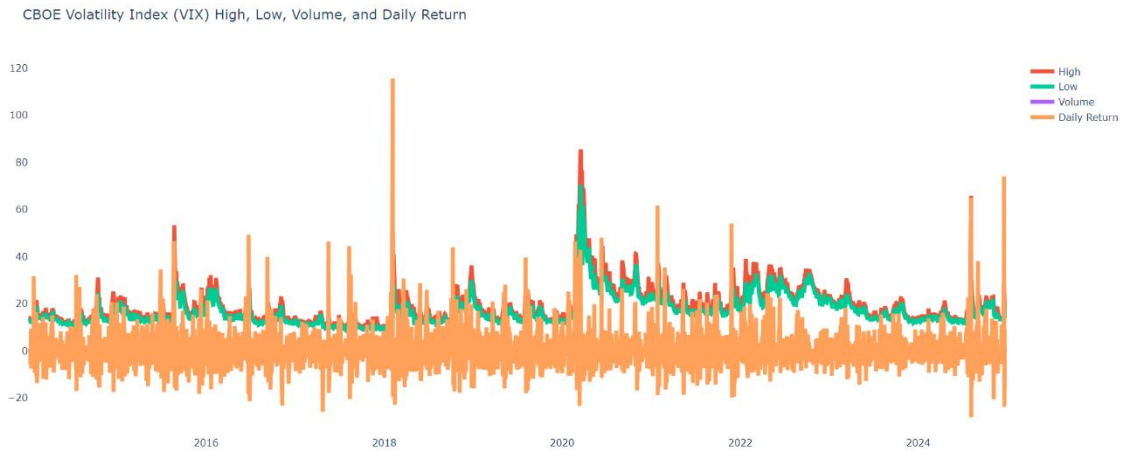


Source: Original work, created with Python

4.2 Chart of highs, lows and daily percentage change

Figure 2 illustrates the line graph of the CBOE Volatility Index (VIX), highlighting the highs, lows, and daily percentage change. A 45% increase in daily change reflects a sharp rise in volatility expectations, indicating significant market turmoil, as observed during certain periods in 2018, 2020, 2022, and 2024. This type of change typically occurs during crises or unexpected events, causing investors to anticipate sharp price movements. The graph's behavior suggests increased risk, which raises the demand for safe-haven assets such as government bonds or gold.

Figure 2. Graph of high points, lows and daily percentage change of the CBOE Volatility Index (VIX): 2014-2024



Source: Original work, created with Python

4.3 Pie chart showing the distribution of trends

Figure 3 illustrates a pie chart showing the distribution of trends in the CBOE Volatility Index (VIX), with different categories of changes in volatility:

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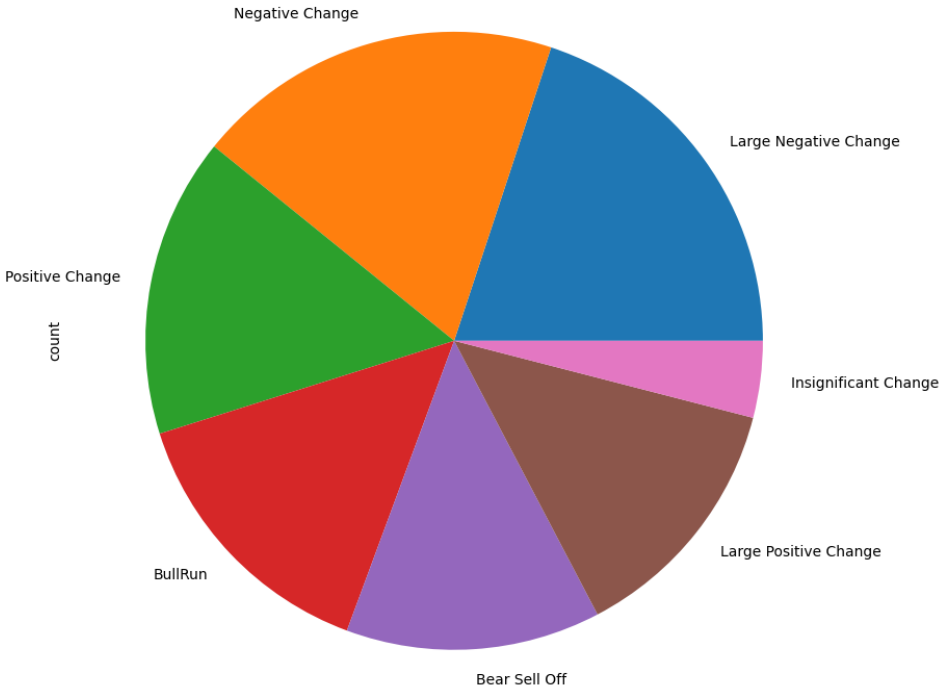
- Negative Change: A decrease in volatility, indicating that the market is calmer and investors perceive less risk, reflecting a stable environment.
- Large Negative Change: A sharp drop in volatility, signaling a significant improvement in market sentiment and a recovery or consolidation phase.
- Insignificant Change: Little variation in volatility, indicating market stability with no expectations of sharp movements.
- Large Positive Change: A dramatic increase in volatility, indicating uncertainty or fear in the market, with a possible fall in asset prices.
- Bear Sell Off: Reflects an increase in volatility due to massive selling during a bear market, increasing fear among investors.
- Bull Run: Low volatility, suggesting a sustained bull market and investor confidence.
- Positive Change: A slight increase in volatility, indicating mild market concern or adjustment, without an imminent crisis.

This chart helps to identify market sentiment and adjust investment strategies according to the level of uncertainty or confidence.

Figure 3. Pie chart showing the distribution of trends in the CBOE Volatility Index (VIX): 2014-2024



Source: Original work, created with Python

4.1 Candlestick chart

Figure 4 illustrates an interactive candlestick chart showing historical prices of the VIX index, with rising and falling days represented in different colors.

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- Green Days (Upward): When the VIX shows a green candle, it indicates that volatility has increased that day. This reflects a greater sense of uncertainty and an expectation of sharp movements in the financial markets. Investors may be anticipating more volatility and adjustments in asset prices.
- Red Days (Downward): When the VIX shows a red candle, it means that volatility has decreased. This suggests that investors perceive less risk and there is greater confidence in the market. A decrease in the VIX could be related to a phase of optimism or stability.

This candlestick chart helps visualize the dynamics of volatility in the market, providing a clear representation of changes in investor sentiment.

Figure 4. Candlestick chart of the CBOE Volatility Index (VIX): 2014-2024

Source: Original work, created with Python

4.5 50 and 100 day simple moving averages (SMAs)

Figure 5 illustrates an interactive chart showing the 50- and 100-day simple moving averages (SMAs) for the VIX index, with three lines: the closing price, the 50-day SMA, and the 100-day SMA. Key interpretations are described below:

Moving Average Crossover:

Bullish crossover (Golden Cross): This occurs when the 50-day SMA crosses above the 100-day SMA. In the VIX, this suggests an increase in expected volatility, reflecting growing uncertainty in financial markets and anticipating more risk and fluctuations.

Bearish crossover (Death Cross): This occurs when the 50-day SMA crosses below the 100-day SMA. This signals a decrease in anticipated volatility, which could imply that markets are entering a more stable phase and investors perceive less risk.

Position of the Moving Averages:

VIX above both moving averages: Indicates high volatility compared to past trends, suggesting a more uncertain or risky market.

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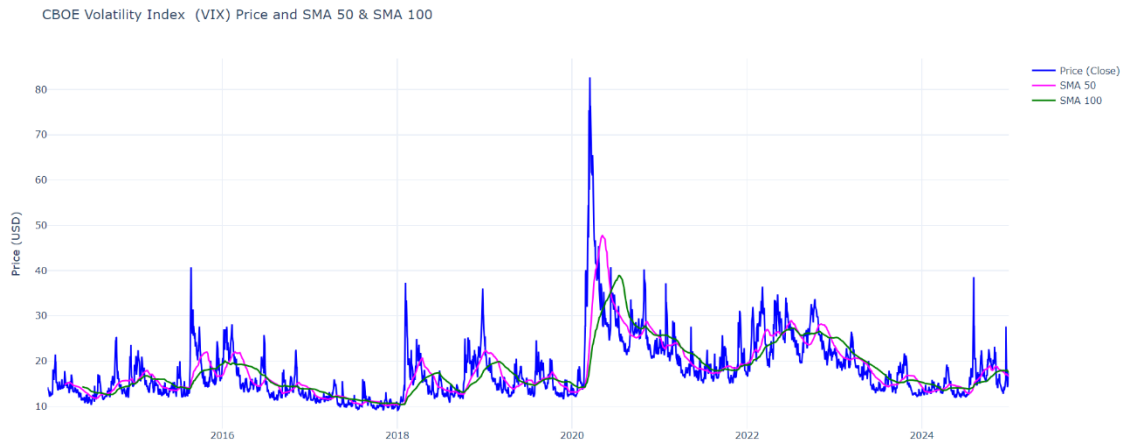
VIX below both moving averages: Indicates a decrease in volatility, reflecting a calmer and more stable market.

Divergences:

VIX rises while moving averages fall: This may indicate an increase in volatility, but with a long-term bearish trend, suggesting a possible reversal.

VIX falls while moving averages rise: This indicates that volatility is decreasing, but the long-term trend remains bullish, which could reflect a phase of optimism.

Figure 5. 50- and 100-day simple moving averages (SMAs) of the CBOE Volatility Index (VIX): 2014-2024



Source: Original work, created with Python

Consequently, this moving average chart allows visualization of the short- and long-term trends of the VIX, helping investors adjust their expectations about volatility and risk in the markets.

4.6 Bollinger Bands and Market Volatility

Figure 6 illustrates an interactive chart of the VIX index with Bollinger Bands, including the 20-day simple moving average (SMA 20) and upper and lower bands, with different line styles to show the evolution of volatility in the market. The key interpretations are described below:

VIX crossing the Upper Band (Overbought):

Interpretation: The VIX crossing above the upper band indicates extreme upward volatility, reflecting a market with high uncertainty and fear. This phenomenon suggests that asset prices are experiencing large fluctuations.

Recommended action: Investors may consider that volatility has reached unsustainable levels, which could be a signal to take profits or protect their portfolios, anticipating a possible correction.

VIX crossing the Lower Band (Overwind):

Interpretation: The VIX crossing below the lower band suggests low volatility and a relatively calm market, indicating low uncertainty and high investor confidence.

Recommended action: If the VIX is in the lower band, investors may be underestimating the risk, which could suggest the need for hedging strategies in anticipation of a possible trend reversal.

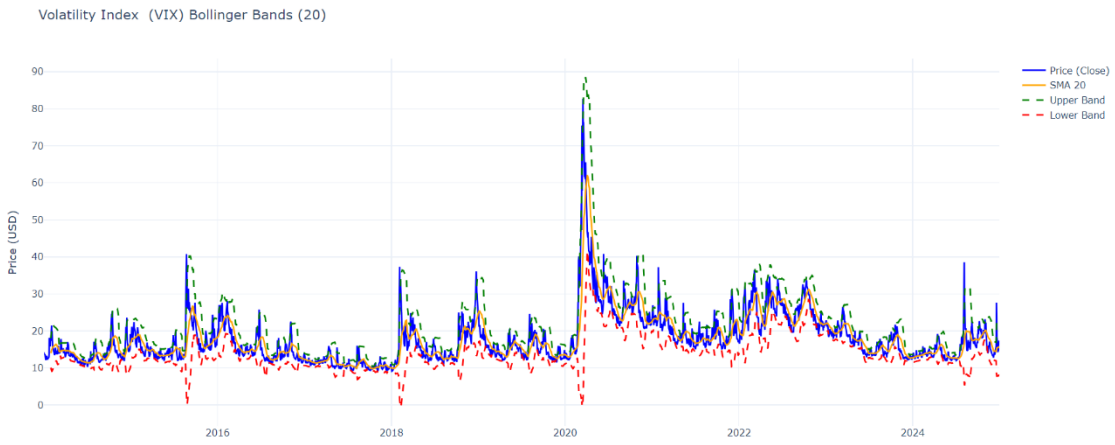
VIX playing or returning to the Mid Band (Normalization):

Interpretation: When the VIX approaches or returns to the mid-band, it is interpreted as a normalization of volatility, indicating that the market is reaching equilibrium, with more predictable volatility.

Recommended action: Investors may view this move as a sign of market stabilization, allowing for a more balanced assessment for future investment decisions.

This analysis using Bollinger Bands helps investors identify conditions of extreme or normalized volatility, allowing them to adjust their strategies according to market movement expectations.

Figure 6. Bollinger Bands and Market Volatility of the CBOE Volatility Index (VIX): 2014-2024



Source: Original work, created with Python

5.0 CONCLUSION AND DISCUSSION

Analyzing the CBOE Volatility Index (VIX) using programming tools like Python offers investors a deeper understanding of volatility dynamics in financial markets. The VIX, often referred to as the "Fear Index," is a key indicator of market expectations regarding future volatility. By using Python and its specialized libraries, such as Yfinance, Plotly, and Pandas, it's possible to access, process, and visualize large volumes of historical VIX data, providing analysts with an efficient and accurate way to interpret this data. Through the implementation

of charts such as VIX trend lines, daily percentage changes, candlesticks, moving averages, and Bollinger Bands, this analytical approach allows investors to identify patterns of behavior, assess risks, and make informed decisions. Moving averages and Bollinger Bands, in particular, provide valuable insights into market trends and volatility, helping to predict potential price movements. Furthermore, classifying trends based on daily percentage changes allows for categorizing VIX fluctuations, providing a clear view of periods of high or low volatility. The ability to perform this analysis in real time and with historical data reinforces the importance of advanced data analysis tools like Python in the financial sector. Programming not only facilitates the manipulation of large datasets but also optimizes strategic decision-making in volatile and constantly changing financial markets. Thus, VIX analysis using Python is not only a relevant tool for understanding market volatility but also a fundamental resource for investors seeking to adapt to changing market conditions and protect their assets against potential crises or periods of uncertainty.

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APPENDIX 1

Python programming code

```
import pandas as pd
import numpy as np
import datetime as dt
import yfinance as yf # Make sure you have yfinance installed

# Create action object
stock = yf.Ticker('^VIX')

# Specify the date range
start_date = dt.datetime(2014, 1, 1)
end_date = dt.datetime(2024, 12, 31)

try:
# Download the data
   data = stock.history(start=start_date, end=end_date)

   if data.empty:
print("No data was found for the specified date range.")
   else:

# Reset index and save as CSV
      data = data.reset_index()
      file_path = r'C:\historical_data_VIX.csv'
      data.to_csv(file_path, index=False)
print(f"CSV file successfully saved to {file_path}!")

except FileNotFoundError:
print("The specified file path is not valid. Please check the directory.")

except Exception as e:
print(f"An error occurred: {e}")

# Read and display the saved CSV file
try:
```


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```
    VIX_df = pd.read_csv(r'C:\historical_data_VIX.csv')
    print(VIX_df)
except FileNotFoundError:
print("The CSV file is not found in the specified path. Check if it was created correctly.")
except Exception as e:
print(f"An error occurred while reading the CSV file: {e}")
import plotly.express as px

# Create the line graph
fig = px.line(
    VIX_df,
    x='Date',
    y='Close',
    title='CBOE Volatility Index  (VIX) Adjusted Closing Price [$]'
)

# Show the graph
fig.show()

def plot_financial_data(df, title):
    fig = px.line(title = title)
for i in VIX_df.columns[1:]:
    fig.add_scatter(x = VIX_df['Date'], y = VIX_df[i], name = i)
    fig.update_traces(line_width = 5)
    fig.update_layout({'plot_bgcolor': "white"})
fig.show()

VIX_df['Daily Return'] = VIX_df['Close'].pct_change(1) * 100
VIX_df['Daily Return'].replace(np.nan, 0, inplace=True)
print(VIX_df)

def plot_financial_data(VIX_df, title):
    fig = px.line(title=title)
    for i in VIX_df.columns[1:]:
        fig.add_scatter(x=VIX_df['Date'], y=VIX_df[i], name=i)
        fig.update_traces(line_width=5)
        fig.update_layout({'plot_bgcolor': "white"})
    fig.show()

# Graph only the 'High', 'Low', 'Volume' and 'Daily Return' columns
plot_financial_data(
    VIX_df[['Date', 'High', 'Low', 'Volume', 'Daily Return']],
    'CBOE Volatility Index (VIX) High, Low, Volume, and Daily Return'
)

def percentage_return_classifier(percentage_return):
    if percentage_return > -0.3 and percentage_return <= 0.3:
```


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```
        return 'Insignificant Change'
    elif percentage_return > 0.3 and percentage_return <= 3:
        return 'Positive Change'
    elif percentage_return > -3 and percentage_return <= -0.3:
        return 'Negative Change'
    elif percentage_return > 3 and percentage_return <= 7:
        return 'Large Positive Change'
    elif percentage_return > -7 and percentage_return <= -3:
        return 'Large Negative Change'
    elif percentage_return > 7:
        return 'BullRun'
    elif percentage_return <= -7:
        return 'Bear Sell Off'

VIX_df['Trend'] = VIX_df['Daily Return'].apply(percentage_return_classifier)
print(VIX_df)

trend_summary = VIX_df['Trend']. value_counts()
print(trend_summary)
import matplotlib.pyplot as plt
plt.figure(figsize = (8,8))

trend_summary.plot(kind = 'pie', y = 'Trend');
plt.show()

import pandas as pd
import numpy as np
import datetime as dt
import yfinance as yf  # Ensure you have yfinance installed

# Create a stock object
stock = yf.Ticker('^VIX')
# Specify the date range
start_date = dt.datetime(2014, 1, 1)
end_date = dt.datetime(2024, 12, 31)

try:
    # Download the data
    data = stock.history(start=start_date, end=end_date)
    if data.empty:
        print("No data found for the specified date range.")
    else:
        # Reset the index and save to CSV
        data = data.reset_index()
        file_path = r'C:\historical_data_VIX.csv'
        data.to_csv(file_path, index=False)
        print(f"CSV file successfully saved at {file_path}!")
```


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```
except FileNotFoundError:
    print("The specified file path is not valid. Please verify the directory.")

except Exception as e:
    print(f"An error occurred: {e}")

# Read and display the saved CSV file
try:
    VIX_df = pd.read_csv(r'C:\historical_data_VIX.csv')
    print(VIX_df)
except FileNotFoundError:
    print("The CSV file is not found at the specified path. Verify if it was created correctly.")
except Exception as e:
    print(f"An error occurred while reading the CSV file: {e}")

# Calculate Daily Return
VIX_df['Daily Return'] = VIX_df['Close'].pct_change(1) * 100
print(VIX_df)

# Replace NaN values in Daily Return with 0
VIX_df['Daily Return'].replace(np.nan, 0, inplace=True)
print(VIX_df)

# Function to classify percentage returns
def percentage_return_classifier(percentage_return):
    if -0.3 < percentage_return <= 0.3:
        return 'Insignificant Change'
    elif 0.3 < percentage_return <= 3:
        return 'Positive Change'
    elif -3 < percentage_return <= -0.3:
        return 'Negative Change'
    elif 3 < percentage_return <= 7:
        return 'Large Positive Change'
    elif -7 < percentage_return <= -3:
        return 'Large Negative Change'
    elif percentage_return > 7:
        return 'BullRun'
    elif percentage_return <= -7:
        return 'Bear Sell Off'

# Apply the classifier to the 'Daily Return' column
VIX_df['Trend'] = VIX_df['Daily Return'].apply(percentage_return_classifier)
print(VIX_df)

import plotly.graph_objects as go

# Set 'Date' as the index if it's not already
```


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```
VIX_df.set_index('Date', inplace=True)

# Create the candlestick chart using plotly
fig = go.Figure(data=[go.Candlestick(
    x=VIX_df.index,
    open=VIX_df['Open'],
    high=VIX_df['High'],
    low=VIX_df['Low'],
    close=VIX_df['Close'],
    increasing_line_color='green',  # Color for days when the stock closes higher
    decreasing_line_color='red'  # Color for days when the stock closes lower
)])

# Add titles and labels
fig.update_layout(
    title='CBOE Volatility Index  (VIX) Candlestick Chart',
    xaxis_title='Date',
    yaxis_title='Price (USD)',
    template='plotly_white'  # Use a white theme for the background
)

# Show the figure
fig.show()

import plotly.graph_objects as go
# Calculate the Simple Moving Averages (SMA)
VIX_df['SMA 50'] = VIX_df['Close'].rolling(window=50).mean()
VIX_df['SMA 100'] = VIX_df['Close'].rolling(window=100).mean()
# Create the figure with Price (Close) and SMA lines
fig = go.Figure()
# Plot the Close Price
fig.add_trace(go.Scatter(x=VIX_df.index,  y=VIX_df['Close'],  mode='lines',  name='Price (Close)', line=dict(color='blue')))
# Plot the SMA 50 line
fig.add_trace(go.Scatter(x=VIX_df.index, y=VIX_df['SMA 50'], mode='lines', name='SMA 50', line=dict(color='magenta')))
# Plot the SMA 100 line
fig.add_trace(go.Scatter(x=VIX_df.index, y=VIX_df['SMA 100'], mode='lines', name='SMA 100', line=dict(color='green')))
# Add titles and labels
fig.update_layout(
    title= 'CBOE Volatility Index  (VIX) Price and SMA 50 & SMA 100',
    xaxis_title='Date',
    yaxis_title='Price (USD)',
    template='plotly_white'  # Use a white theme for the background
)
# Show the figure
```


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```
fig.show()
# Calculate the 20-day simple moving average (SMA) for the Close price (Middle Band)
VIX_df['SMA 20'] = VIX_df['Close'].rolling(window=20).mean()

# Calculate the rolling standard deviation for the Close price
VIX_df['Rolling Std Dev'] = VIX_df['Close'].rolling(window=20).std()
# Calculate the Upper and Lower Bollinger Bands
VIX_df['Upper Band'] = VIX_df['SMA 20'] + (VIX_df['Rolling Std Dev'] * 2)
VIX_df['Lower Band'] = VIX_df['SMA 20'] - (VIX_df['Rolling Std Dev'] * 2)
# Plot the Close price and Bollinger Bands using Plotly
import plotly.graph_objects as go
fig = go.Figure()
# Plot the Close Price
fig.add_trace(go.Scatter(x=VIX_df.index, y=VIX_df['Close'], mode='lines', name='Price (Close)', line=dict(color='blue')))
# Plot the SMA 20 (Middle Band)
fig.add_trace(go.Scatter(x=VIX_df.index, y=VIX_df['SMA 20'], mode='lines', name='SMA 20', line=dict(color='orange')))
# Plot the Upper Bollinger Band
fig.add_trace(go.Scatter(x=VIX_df.index, y=VIX_df['Upper Band'], mode='lines', name='Upper Band', line=dict(color='green', dash='dash')))
# Plot the Lower Bollinger Band
fig.add_trace(go.Scatter(x=VIX_df.index, y=VIX_df['Lower Band'], mode='lines', name='Lower Band', line=dict(color='red', dash='dash')))
# Add titles and labels
fig.update_layout(
    title=' Volatility Index  (VIX) Bollinger Bands (20)',
    xaxis_title='Date',
    yaxis_title='Price (USD)',
    template='plotly_white'  # Use a white theme for the background
)

# Show the figure
fig.show()
```

