

Impact of Macroeconomics Variables on Stock Market Indices During the period 2010-2020

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Abstract. The primary goal of this research is to look at the influence of numerous macroeconomic variables on stock market indexes, with a particular focus on the NASDAQ. The ARIMA model was utilized to observe the NASDAQ stock price time series and forecast future prices. By analysing data from 2010 to 2020, the research revealed the links between NASDAQ stock prices and macroeconomic factors such as the CPI, interest rates, inflation rates, and unemployment rates. Results indicated a pronounced negative linear relationship between unemployment rates and the NASDAQ closing price, whereas the relationships with other macroeconomic variables were more intricate. Additionally, residual analysis of the model confirmed its commendable fit to the data. The data sources for this study are all from Yahoo Finance and Federal Research Economic Data. The findings contribute to a deeper understanding of how macroeconomic conditions influence stock market behaviour and offer valuable insights for investors, policymakers, and economists. By carefully selecting the model, time frame, and transformation methods, the study presents a well-rounded view of the complex interplay between the stock market and the broader economy.

Keywords: Macroeconomics, Econometrics, Financial Economics, Time Series, Modelling.

1. Introduction

1.1. Research Background and Significance

Driven by the dual forces of globalization and technological innovation, the volatility and uncertainty of capital markets have intensified, posing unprecedented challenges for investors and policymakers. Particularly in the past decade, from 2010 to 2020, the global economy has navigated through various tumultuous events, including but not limited to the recovery post-financial crisis, geopolitical tensions, and the rise of emerging markets. Against this backdrop, understanding how macroeconomic variables influence stock market indices, especially significant indices like the NASDAQ, becomes paramount. Traditional economic theories and empirical studies have unveiled many potential associations between macroeconomic factors and the stock market. However, as time progresses, these associations might evolve or be influenced by other emerging factors. Gay discovered that in the long run, stock price indices are all positively correlated with output growth and negatively correlated with the aggregate price level by examining the short-run and long-run relationships between their stock indexes and macroeconomic factors including GDP, CPI, interest rates, and exchange rates [1]. Additionally, given the unique economic environment of the past decade, a re-evaluation and understanding of these relationships are especially pressing. Thus, the primary motivation of this study is to provide investors, market analysts, and policymakers with a comprehensive perspective, enabling them to grasp market dynamics more effectively.

1.2. Literature review

The behaviour of stock prices and their relationship with macroeconomic factors has been a focus of attention for economists, policymakers, and the investment community over the past decades. Stock prices, as well as market indicators, have been identified as one of the best indicators of changes in financial markets by both economic theory and empirical studies. For example, Chen and his team show empirically how fluctuations in macroeconomic factors have an impact on future dividend and discount rates, which can further change the price of a stock [2]. In studying the dynamics of U.S. stock prices, Smith observed that stock prices typically move lower in the months before a recession

begins, and there is usually a short-term rise in stock prices near the end of the recession [3]. According to Goswami and Jung's research, stock price volatility is related to innovations in economic variables [4].

In exploring the link between stock markets and macroeconomic factors, most researchers tend to select specific countries or geographical areas as the focus of their studies. For example, one study specifically focuses on the interactions between the stock markets of the BRIC countries (i.e., Brazil, Russia, India, and China) and macroeconomic factors, such as exchange rates and oil prices, over the period from 1999 to 2006 [1]. This research revealed that macroeconomic issues such as currency rates and oil prices impacted the stock market indexes of the BRIC nations. Furthermore, the research period for Egypt and Tunisia was from January 1998 to January 2014, and a causal association was discovered between the market index and the CPI, exchange rate, interest rates, and money supply [5]. Whereas in developing Asian countries such as China and India, researchers are concerned with how key macroeconomic variables, such as money supply, crude oil prices, inflation rates, and industrial production, affect the stock markets in these countries [6]. Stock prices and macroeconomics indices not only reflect present economic circumstances, but also have the capacity to anticipate future economic activity, making them one of the most significant indicators of economic activity changes [7]. Fama and Chen et al. also investigated the association between macroeconomic factors and stock market performance [2,8,9]. Fama discovered a significant positive relationship between common stock returns and actual economic indicators (e.g., capital expenditures, industrial production, real GNP, money supply, lagged inflation, and interest rates) [8]. Chen and his team observed that the economic variables associated with stock returns include inflation, aggregate production, risk premiums to maturity, short-term interest rates, and fluctuations in default risk premiums [2]. In addition to the regions mentioned above, for countries like Malaysia, the relationship between the FTSE Bursa Malaysia Hijrah Shariah Index (FBMHS) and the major macroeconomic variables in Malaysia has attracted extensive attention from researchers [10]. In their team's study, the macroeconomic factors they considered included interest rates, money supply, consumer price index, and exchange rates.

In general, the correlations between macroeconomic variables and stock markets vary by country and region, but all strongly reflect changes in economic activities. To better understand these relationships, it is crucial to conduct in-depth empirical research. Such research not only helps investors to make more informed decisions, but also provides policymakers with valuable advice on how to stabilise stock markets and the economy.

1.3. Research contents and Framework

The objective of this study is to provide a detailed analysis of the association between macroeconomic factors and the NASDAQ index between 2010 and 2020 using the ARIMA model in order to fill the research gap in this area in the existing literature. We will first detail the methodology of data collection and processing, followed by the application of the model to analyse the data and an in-depth discussion of the conclusions drawn. The framework of this study is that, first, descriptive statistics will be analysed for the relevant macroeconomic variables to set the stage for subsequent model construction. Subsequently, an ARIMA model will be constructed to forecast NASDAQ stock prices. Based on the model, this study will exhaustively examine the interactions between a variety of macroeconomic factors and NASDAQ stock prices and will attempt to explain the economic mechanisms behind these interrelationships. Finally, the findings will be summarised and their implications for practice and future research will be discussed.

2. Methodology

The research primarily employs the ARIMA model. Firstly, by constructing an ARIMA model, the study visualizes the NASDAQ stock price time series and forecasts future prices. The appropriateness of using this model to predict future stock price trends is determined by assessing the

model's fitting degree to the data. This part of the study also includes an in-depth analysis of residuals to ensure that no significant patterns or correlations are left unexplained.

This research offers a comprehensive analysis of the relationship between NASDAQ stock prices and key macroeconomic variables over a decade, employing ARIMA model. The selection of a ten-year span for this data is rooted in the fact that the chosen data set consists entirely of monthly data categories. Utilizing only a five-year time frame would result in a smaller sample size, leading to less convincing conclusions and greater potential for error. By extending the research sample size, the robustness and reliability of the findings are enhanced. The study emphasizes the importance of sample size in achieving robust results, and the use of both original and logarithmically transformed data provides nuanced insights into the nature of these relationships.

3. Results

As shown in the figure 1, the observation of an ARIMA (0,1,0) model applied to the NASDAQ stock price data reveals an overall upward trend in the market. The forecasts generated by this model are quite reasonable, consistently landing within the confidence interval, around the middle of the range. This could signify a strong degree of accuracy and confidence in the prediction, making it an effective tool for forecasting NASDAQ's future prices. Initially, the forecasted values are higher than the actual test values. However, as time progresses, the growing test values surpass the predictions. This might suggest a more robust growth in the actual stock prices compared to what the model anticipated. It could be a sign of an underlying force driving the prices higher or simply a characteristic of the data that was not captured by the model. The ARIMA (0,1,0) model's analysis of NASDAQ stock prices shows a clear upward trajectory. Its forecasts are found to be reasonable and are well-aligned within the confidence interval. Despite initially predicting higher values, the model's forecasts were eventually overtaken by the actual growing test values. This could signal an even stronger bullish trend in the NASDAQ market. The findings from this analysis may be used by investors and market analysts to make informed decisions, recognizing the limitations and strengths of the ARIMA (0,1,0) model in capturing the underlying trends.

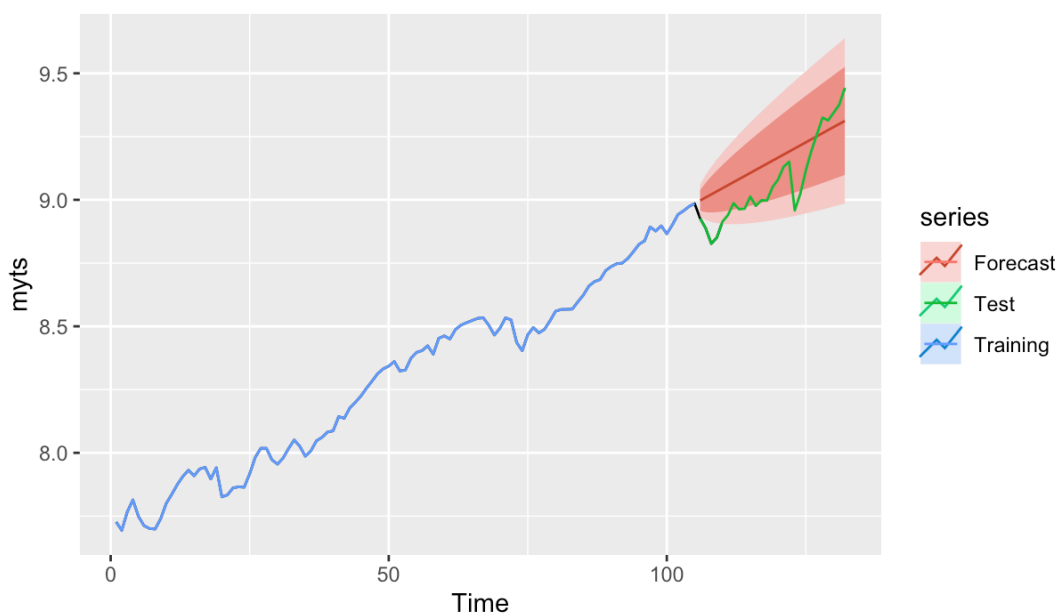


Fig. 1 Trends and forecasts from the ARIMA model

The residuals are fluctuating around zero, with the maximum value exceeding 0.05 and the minimum value less than 0.1. This behaviour indicates that the model's errors are relatively small and fluctuate around zero, a desirable property for a well-fitted model. An important observation is the absence of any noticeable seasonality or cyclic patterns in the residuals. This suggests that the model has accurately captured the main trends in the data without leaving any systematic, unexplained

patterns in the errors. It aligns with the ARIMA (0,1,0) structure, where no autoregressive or moving average terms are incorporated to capture seasonal or cyclical behaviours. The ACF test, where the lag values remain within the range of -0.2 to 0.2 and do not exceed the critical value, further supports the conclusion that the residuals are behaving as white noise. White noise refers to a series of random and independent errors with constant variance, reflecting that the model has appropriately captured the underlying structure of the data without any remaining autocorrelation. A histogram of the residuals indicates conformity to a normal distribution, although not perfectly aligning with the normal distribution curve. This subtle deviation from normality may or may not be significant depending on the context and the specific requirements for the analysis. However, a close alignment with normality is generally a positive indication of the model's goodness of fit. The analysis of the residuals from the ARIMA (0,1,0) model reveals a well-behaved pattern. The fluctuations around zero, the lack of seasonality or cyclic patterns, as well as the characteristics of the white noise, demonstrate the suitability of the model and the data. The slight deviation from perfect normality may warrant further investigation but does not necessarily undermine the model's validity. Overall, the residual analysis supports the use of the ARIMA (0,1,0) model for forecasting and emphasizes its ability to capture the essential dynamics of the NASDAQ stock prices without leaving significant unexplained patterns in the residuals (in Figure 2).

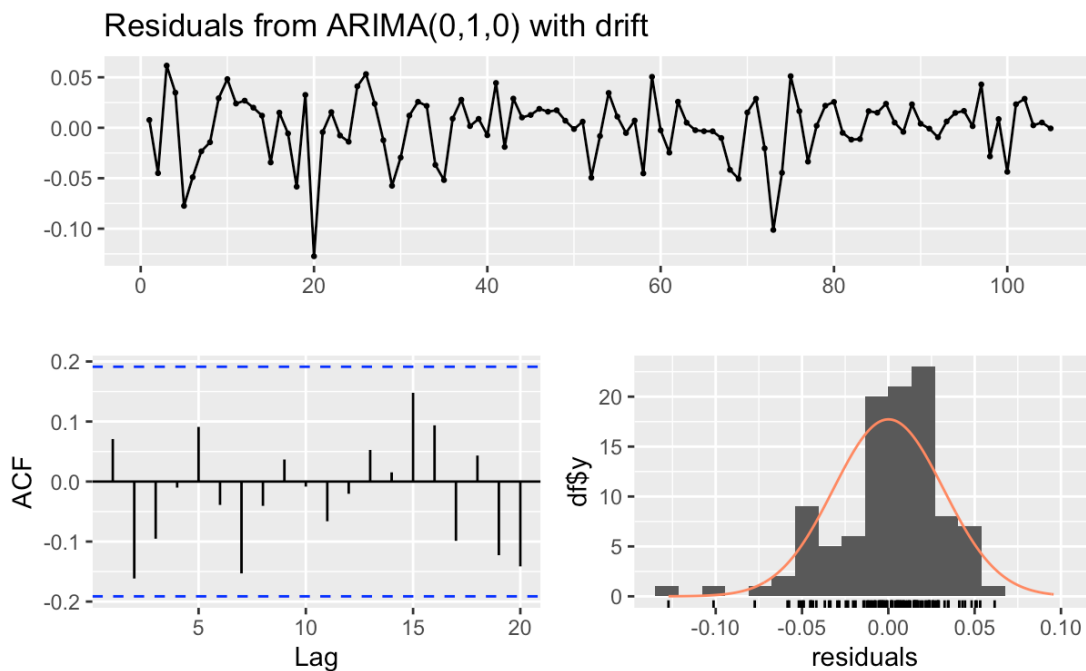


Fig. 2 Residuals from ARIMA (0,1,0) with drift

Analysing the scatter plot (Figure 3 and Figure 4) drawn from the original data, a certain linear relationship exists between the Consumer Price Index (CPI) and the NASDAQ closing price, but this relationship is not prominent. The reason is that the data points in the scatter plot are relatively scattered and not clustered, making the degree of association between the two appear low. This dispersed distribution may imply that the direct relationship between CPI and the NASDAQ closing price is not strong or that there may be other interfering factors.

Since no clear linear relationship was found, it was decided to perform a logarithmic transformation on this set of data. Logarithmic transformation can often reveal underlying trends in the data and help minimize the impact of outliers. When comparing the original and logarithmically transformed data, we can observe that the logarithm of NASDAQ and CPI presents a negative correlation with a downward trend. This trend might align more with economic logic, as an increase in CPI may indicate rising inflation, which could suppress the stock market. It is worth noting that a large portion of the data in the scatter plot has been identified as outliers. These outliers may stem from errors in data collection, special events, or other atypical behaviours.

The relationship between CPI and the NASDAQ closing price, analysed through both the original and logarithmically transformed data, reveals some interesting insights. The original data shows a weak linear relationship, while the logarithmic transformation unveils a more complex negative correlation trend. The presence of outliers reminds us to be cautious in analysing and interpreting these relationships. Overall, this analysis offers valuable insights into how CPI influences the stock market, but further research may be needed to fully understand these complex dynamics.

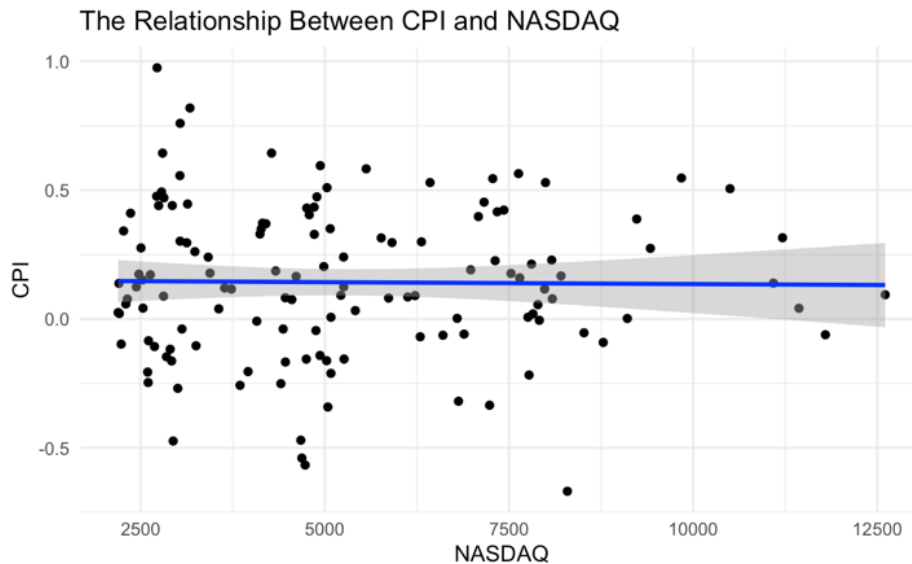


Fig. 3 The Relationship Between CPI and NASDAQ

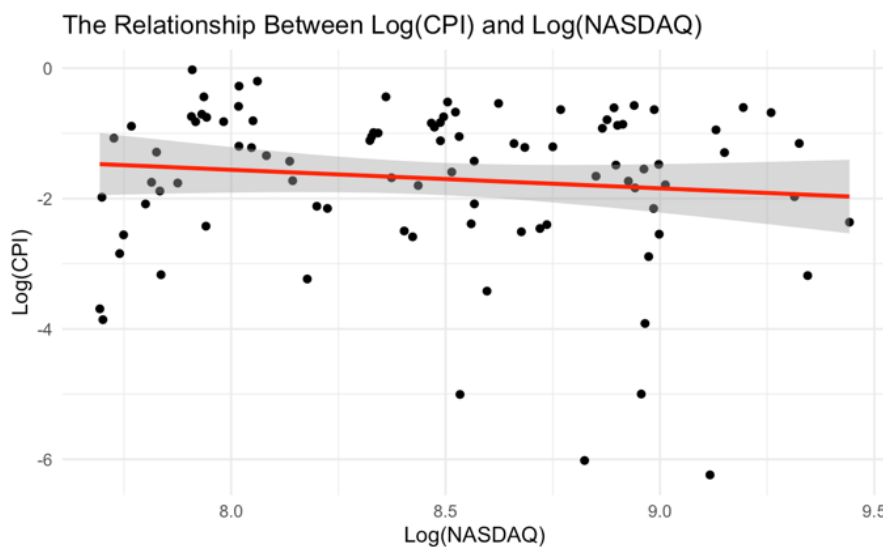


Fig. 4 The Relationship Between Log (CPI) and Log (NASDAQ)

Examining Figure 5 and Figure 6, the relationship between interest rates and the NASDAQ closing price does not demonstrate a clear linear pattern. The data points are dispersed, similar to what was observed with the CPI, indicating that the association between the two variables might be weak or overshadowed by other factors. Given the lack of a distinct linear relationship in the original data, a logarithmic transformation was applied. Logarithmic transformations are often used to uncover hidden trends and relationships in data, especially when the original data does not exhibit a clear pattern. Upon comparing the original and logarithmically transformed data, a positive correlation emerges between the logarithm of the NASDAQ and interest rates, characterized by an upward trend. This positive relationship might be interpreted in several ways within an economic context. For example, rising interest rates could be indicative of a robust economy, where the central bank might be increasing rates to curb inflation. This economic strength may be reflected in higher stock market

prices, explaining the positive correlation observed. However, it is critical to comprehend that the link between stock prices and interest rates can be complicated and multifaceted. While a positive correlation was observed in the log-transformed data, other factors and economic conditions might influence this relationship. Conclusion The analysis of interest rates and the NASDAQ closing price reveals an intricate relationship that is not immediately apparent in the original data. While the original scatter plot does not show a clear linear relationship, the logarithmic transformation exposes a positive correlation, presenting an upward trend. This finding could offer insights into the dynamics between monetary policy (as reflected in interest rates) and stock market behaviour. Still, a comprehensive understanding of this relationship may require further investigation, considering various economic scenarios and potential confounding variables. The positive correlation in the log-transformed data opens new avenues for exploration and adds depth to the understanding of how interest rates may influence the stock market.

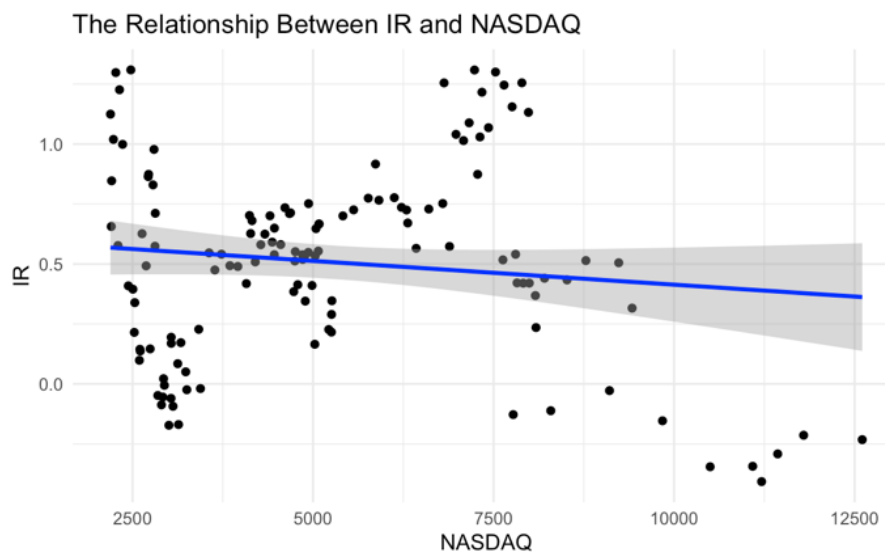


Fig. 5 The Relationship Between IR and NASDAQ

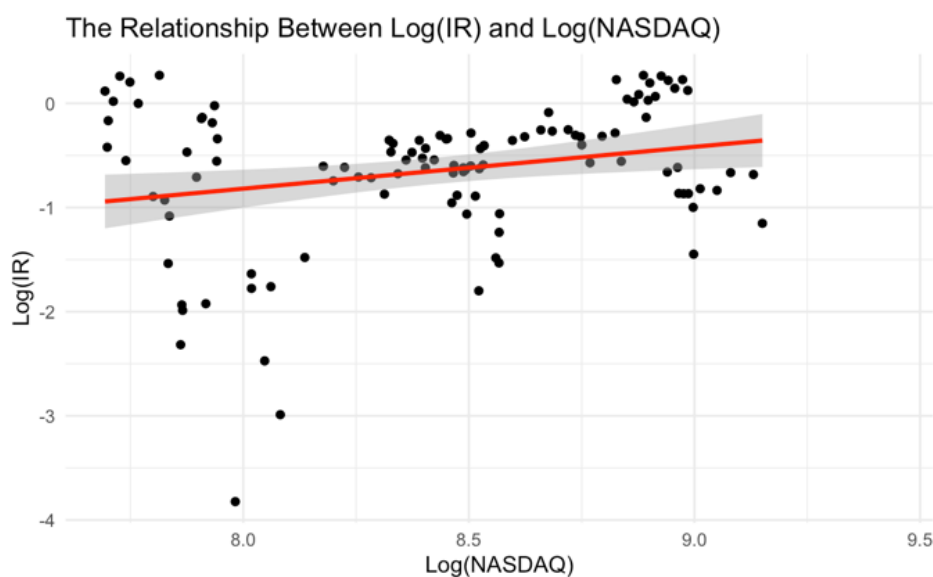


Fig. 6 The Relationship Between Log (IR) and Log (NASDAQ)

When evaluating the scatter plot derived from the original data, a slight negative linear relationship between inflation rates and the NASDAQ closing price can be discerned. This suggests that as inflation rises, the NASDAQ closing price may tend to decrease, and vice versa (in Figure 7). However, the relationship becomes more pronounced upon applying a logarithmic transformation to the data. The logarithmically transformed data reveals a clearer and stronger negative correlation

between the NASDAQ and inflation rates. This is evident in the steeper slope of the trend line, indicating a significant inverse relationship (in Figure 8). In economic terms, a substantial negative slope suggests that for each percentage increase in inflation, there's a proportionally larger decrease in the NASDAQ closing price. Several economic theories can explain this observed relationship. High inflation can erode purchasing power, reduce consumer spending, and increase the cost of goods, all of which can negatively impact corporate profits. Furthermore, inflation can lead to uncertainty in the economy, making investors more risk-averse and leading them to pull out of equities, thereby affecting stock prices.

Moreover, central banks might respond to high inflation by raising interest rates, which can further dampen economic activity and stock market performance. When interest rates are high, borrowing costs increase for companies, potentially leading to reduced investments, and slower growth. This combination of factors might be driving the observed negative relationship between inflation rates and the NASDAQ closing price. The analysis of inflation rates and the NASDAQ closing price unveils an intriguing inverse relationship. While the original data shows a hint of this negative correlation, the relationship is amplified and becomes more evident in the log-transformed data. The pronounced negative slope in the transformed data underscores the potential adverse effects of rising inflation on stock market performance. This finding enriches our comprehension of macroeconomic influences on equity markets and emphasizes the importance of considering inflationary trends when making investment decisions.

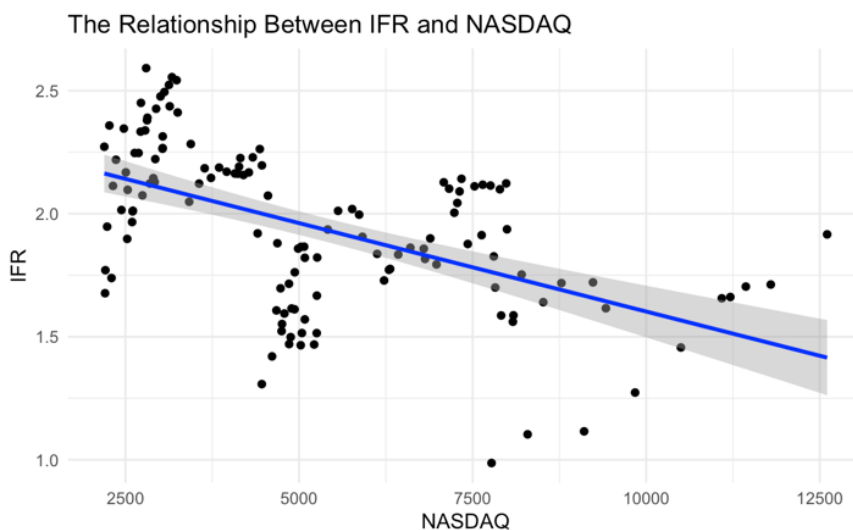


Fig. 7 The Relationship Between IFR and NASDAQ

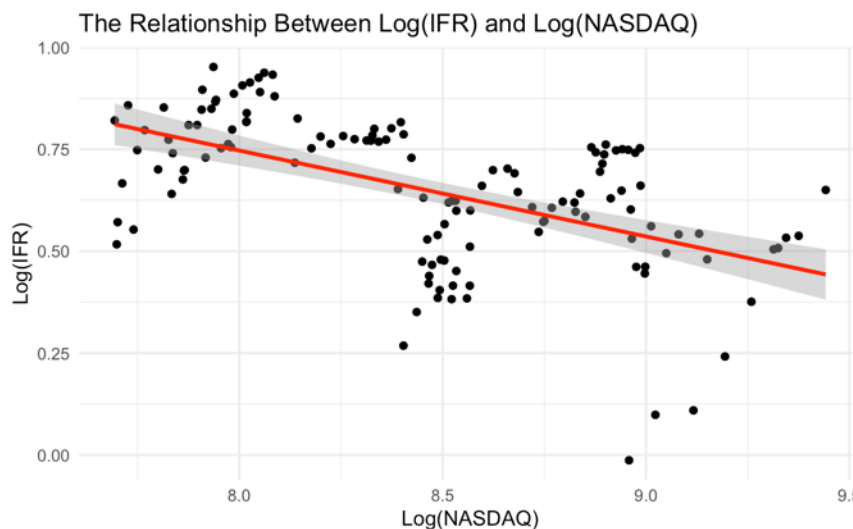


Fig. 8 The relationship Between Log (IFR) and Log (NASDAQ)

From the scatter plot drawn using the original data, the relationship between unemployment rates and the NASDAQ closing price is found to be quite significant. The Figure 9 reveals a very apparent negative linear relationship, with most points distributed within the confidence interval. This suggests that a rise in unemployment rates may be related with a fall in the NASDAQ closing price, and vice versa. What's more intriguing is that this negative linear relationship becomes even more pronounced when a logarithmic transformation is applied to the data (in Figure 10). The slope in the log-transformed data is the steepest among all, signifying an extremely strong inverse relationship between unemployment rates and the NASDAQ closing price. Economically, this observation makes sense. An increase in unemployment rates is often a sign of economic slowdown or recession. During periods of rising unemployment, consumer spending may decline, and the profit outlook for companies might become bleak. These factors could lead to a loss of investor confidence in the stock market, thereby affecting stock prices. Moreover, higher unemployment rates might prompt government and central banks to take measures to stimulate the economy, such as lowering interest rates or increasing government spending. However, these measures might take time to take effect, and during this period, the stock market may be under pressure.

In summary, the negative linear relationship between unemployment rates and the NASDAQ closing price is vividly illustrated in both the original and log-transformed data. This strong inverse relationship likely reflects the profound connection between unemployment rates and the health of the stock market. Especially, the slope in the log-transformed data emphasizes the strength and consistency of this relationship. This finding underscores the importance of considering unemployment rates and other macroeconomic indicators when assessing stock market trends and making investment decisions. It also illustrates the complicated interplay between macroeconomic variables and stock market performance, which might assist in better understanding and forecasting future stock market movements.

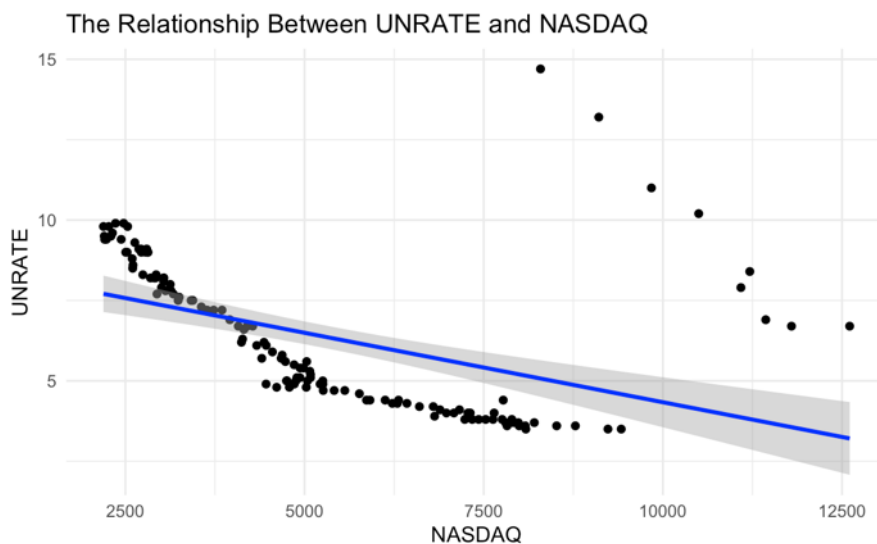


Fig. 9 The Relationship Between Unemployment Rate and NASDAQ

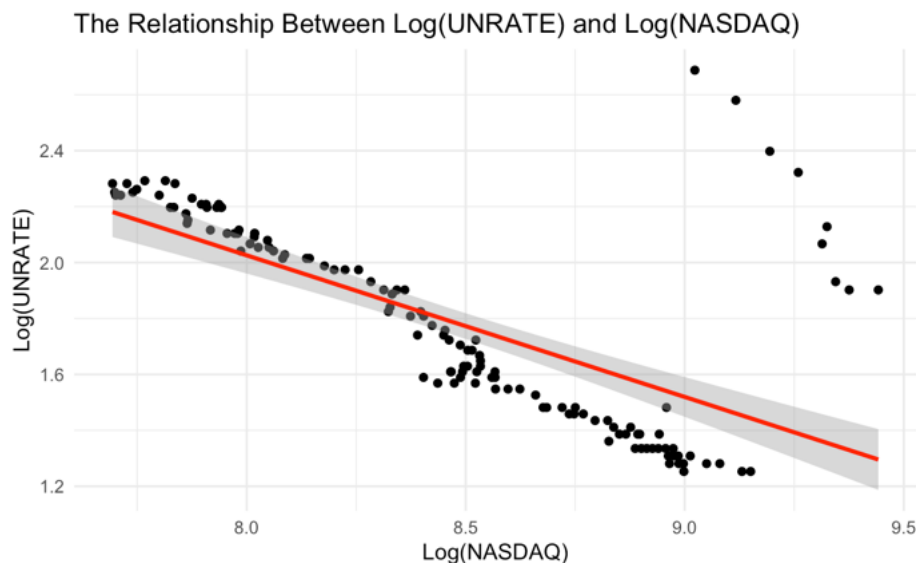


Fig. 10 The Relationship Between Unemployment Rate and NASDAQ

4. Discussion

The ARIMA (0,1,0) model's application to NASDAQ stock prices revealed an upward trend, with forecasts consistently within the confidence interval. Initially predicting higher values, the model was overtaken by actual growing test values, possibly signalling a stronger bullish trend than anticipated.

The residuals' analysis supported the model's effectiveness, showing fluctuations around zero and no noticeable seasonality or cyclic patterns. The white noise characteristics and close alignment with normality (despite slight deviations) further emphasized the model's good fit.

Both CPI and inflation rates showed negative linear relationships with the NASDAQ closing price. While the relationships were similar, the clarity and strength of these relationships varied. Logarithmic transformation enhanced these relationships, emphasizing the possible economic implications of inflation on the stock market. Unlike CPI and inflation rates, interest rates showed a positive linear relationship with NASDAQ after logarithmic transformation. This distinct pattern may reflect the complex dynamics between monetary policy and market behaviour. The clearest and strongest relationship was observed with unemployment rates, revealing a pronounced negative linear relationship. This might underline the fundamental connection between labour market health and stock market performance. The relationships observed through scatter plots can be related to broader economic theories and practices. Understanding how these macroeconomic variables interact with stock prices provides a window into the complex interplay of economic forces.

For the outliers, special events or atypical behaviour can produce prominent outliers in the data. For example, financial crises such as the 2008 global financial crisis may lead to sharp declines in stock market prices. Similarly, major policy changes, such as sudden interest rate adjustments or trade restrictions, may trigger a market reaction. Natural disasters, such as hurricanes or earthquakes, may also affect specific industries or the economy, leading to unusual fluctuations in data. These events are often difficult to predict and may have a significant impact in a short period of time. As a result, they may create significant outliers in the data.

5. Conclusion

This research investigated the delicate interplay between macroeconomic factors and the NASDAQ, which focused on the decade from 2010 to 2020. By applying the ARIMA model, we discovered the relationship between these key economic indicators and the NASDAQ closing price and predicted a continued upward trend in stock prices going forward. The study confirms that there is a clear correlation between the stock market and macroeconomic factors which play a key role in

explaining the volatility of the stock market. A significant finding is that the unemployment rate has a specific negative linear association with the NASDAQ, highlighting the fundamental link between labour market health and stock market performance. Additionally, other macroeconomic variables, such as the CPI and inflation, have intricate effects when juxtaposed with the NASDAQ, revealing complex dynamics. Notably, while certain macroeconomic variables show a clearer linear correlation with the stock market, others require logarithmic transformations to illuminate underlying trends. This highlights the need for a nuanced approach to reveal the multifaceted relationship between economic factors and stock indices. Inextricably linked to this conclusion is the concept of structural disruptions or market shifts. Such shifts represent profound changes in the underlying economic structure, which may be gradual or abrupt, and are influenced by a multitude of factors such as industrial transformation, technological innovation, and demographic change. For example, the rise of the Internet may catalyse the decline of specific traditional industries while pushing emerging technology industries to the forefront. These structural changes can introduce outliers in the data and alter established relationships and patterns among economic variables. In this study, it is important to recognise that the observed relationship between macroeconomic indicators and the NASDAQ may be affected by such structural breaks, adding an additional layer of complexity to the analysis. Based on the results of the study, the authors have developed a richer understanding of how macroeconomic forces shaped the stock market landscape over the course of the pivotal decade. The unique economic environment of the 2010-2020 period, characterised by a variety of global events and technological revolutions, provides the backdrop for the development of these relationships. When making an investing choice, the investor should analyse all relevant sources of information. As the global economy continues to move forward, stakeholders such as investors, market analysts, and policymakers will continue to need to pay close attention to historical data and emerging trends to ensure informed decision-making in a rapidly changing financial world.

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