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Impact of Market Uncertainty on Stock-Bond Return Relation

Bachelor's thesis

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Declaration of Authorship

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Prague, August 1, 2023

Filip Rulíšek

Abstract

In this thesis, we investigate the relationship between stock and bond returns in the US market from January 2018 to May 2023, with a specific focus on the impact of market uncertainty on this relation. Employing the rolling window correlation method, we examine the dynamic correlation between these two assets, using the S&P 500 Index and the US 10-Year Treasury Price Index. The results show, on average, a negative correlation on both monthly and quarterly basis. On a monthly basis we also observed highly fluctuating patterns. Additionally, the findings presented herein demonstrate that both the level and changes in stock market uncertainty, measured by the CBOE Volatility Index, negatively affect the relationship between stock and bond returns. On average, during times of increasing market uncertainty, investors tend to shift their funds from risky stocks toward safer bonds, while periods of low market uncertainty are usually characterized by the opposite trend. We carried out the same analysis for 11 stock market sectors separately. Interestingly, this analysis revealed that the relationship between the returns of these sectors and government bond returns varies. While the majority of sectors exhibit the same negative correlation as the overall market, few sectors, such as Utilities and Real Estate, show a positive correlation. We have also found out that market uncertainty has a substantial negative impact on the returns of these sectors, with Technology and Energy sectors being the most significantly affected. In summary, the empirical evidence analyzed in this thesis clearly demonstrates that in recent years, the correlation between stock and bond returns was predominantly negative, with stock market uncertainty exerting a negative influence on this relationship. This suggests, that diversifying portfolios between these two assets might be very effective, especially during periods of high market uncertainty.

JEL Classification	C58, E44, , G11, G12, G14
Keywords	dynamic correlation, stock market, government bonds, market uncertainty

Title	Impact of Market Uncertainty on Stock-Bond Return Relation

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Abstrakt

V této práci zkoumáme vztah mezi výnosy akcií a dluhopisů na americkém trhu od ledna 2018 do května 2023, pří čemž se zaměřujeme zejména na vliv nejistoty na trhu na tento vztah. S využitím metody rolling window correlation zkoumáme dynamickou korelaci mezi těmito dvěma aktivy s využitím indexu S&P 500 a indexu amerického státního dluhopisu s desetiletou splatností. Výsledky ukazují v průměru zápornou korelaci na měsíční i čtvrtletní bázi. Na měsíční bázi jsme také pozorovali velmi kolísavé vzorce. Kromě toho zde prezentovaná zjištění ukazují, že úroveň i změny nejistoty na akciovém trhu měřené indexem volatility negativně ovlivňují vztah mezi výnosy akcií a dluhopisů. V průměru mají investoři v období rostoucí tržní nejistoty tendenci přesouvat svůj kapitál z rizikových akcií do bezpečnějších dluhopisů, zatímco období nízké tržní nejistoty se obvykle vyznačují opačným trendem. Stejnou analýzu jsme provedli samostatně pro 11 sektorů akciového trhu. Tato analýza odhalila, že vztah mezi výnosy těchto sektorů a výnosy státních dluhopisů se liší. Zatímco většina sektorů vykazuje stejnou zápornou korelaci jako v případě celkového, několik sektorů, jako například sektor veřejných služeb a nemovitostní sektor, vykazují korelaci kladnou. Zjistili jsme také, že nejistota na trhu má značný negativní dopad na výnosy těchto sektorů, přičemž nejvýznamněji jsou postiženy sektory technologií a energetiky. Souhrnně lze říci, že empirické důkazy analyzované v této práci jasně ukazují, že v posledních letech byla korelace mezi výnosy akcií a dluhopisů převážně negativní, přičemž nejistota na akciovém trhu měla na tento vztah negativní vliv. To naznačuje, že diverzifikace portfolia mezi tato dvě aktiva může být velmi účinná, zejména v obdobích vysoké tržní nejistoty.

Klasifikace JEL	C58, E44, , G11, G12, G14
Klíčová slova	dynamická korelace, akciový trh, státní dluhopisy, nejistota na trhu
Název práce	Vliv nejistoty na trhu na vztah mezi výnosy akcií a dluhopisů

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Contents

List of Tables

List of Figures

Acronyms

ADF Augmented-Dickey-Fuller

CBOE Chicago Board Options Exchange

DCC Dynamic Conditional Correlation

GARCH Generalized Autoregressive Conditional Heteroskedasticity

RWC Rolling Window Correlation Method

VIX CBOE Volatility Index

Chapter 1

Introduction

> *"Investors hold portfolios of assets in order to reduce the risk of a loss. If this risk reduction is not effective in times of financial crises then the benefits of diversification are reduced in times when they are needed most."*
>
> -Baur & Lucey (2009)

In recent years, the global economy has witnessed a series of historic and exceptional events, including the COVID-19 pandemic, periods of near-zero and exceptionally high interest rates, one of the most substantial bull markets in many years, unprecedented levels of inflation, or the recent war in Ukraine. These extraordinary events have greatly influenced the economic landscape of the United States and the world, leaving a significant impact on financial markets and investor sentiment. During this period of considerable instability, the relationship between two major assets, stocks and bonds, becomes increasingly crucial.

According to Andersson *et al.* (2008), understanding the stock-bond return relationship is crucial not only for investors when managing their portfolios and risks but also for governments. This understanding provides policymakers with valuable insights into market sentiments and economic prospects, helping guide their decisions. Chiang *et al.* (2014) explains in his study, that in times of positive economic prospects for a country, both bond and stock prices tend to rise. Optimistic prospects become dominant factors encouraging investors to hold both types of assets simultaneously, which results in a positive relationship between the returns of these two asset classes. On the other hand, during economic downturns, the relationship between stock and bond returns may turn negative. As investors become more risk-averse, they tend to shift their capital from risky stocks to safer bonds, leading to a negative correlation between the returns of these two assets.

Since the relation between stock and bond returns and the influence of market uncertainty on this relation might be somewhat unclear, the objective of this thesis is to investigate these important relationships in the recent period from January 2018 to May 2023. The initial part of the thesis will closely examine the dynamic correlation between the returns of these two assets, focusing on both monthly and quarterly windows. However, the main focus of the study is to analyze how the relationship between stock and bond returns varies both with the level of market uncertainty and with the changes in this variable. Moreover, this thesis will also focus on specific stock market sectors, as the nature of these relationships may vary among different sectors.

The thesis comprises the following chapters. Chapter 2 reviews the relevant literature and introduces our hypotheses. Chapter 3 describes the methodology and important assumptions for the time series analysis. In Chapter 4, we present the data used and conduct a preliminary analysis. Chapter 5 presents the empirical results of our analysis. Finally, Chapter 6 summarizes our findings.

Chapter 2

Literature Review and Hypotheses

Even with a significant amount of literature on the relationship between stocks and bonds, research findings often vary. These disparities can be attributed to differences in methodologies, studied periods, perspectives, the selection of explanatory variables, and other contributing factors.

In this section, we'll provide an overview of the existing studies in this field and explore how these different factors influenced the stock-bond return relation. We will begin by introducing studies that have examined the correlation between stocks and bonds, considering their findings across different countries and time periods. The next section will examine the factors that may influence this dynamic. Finally, the hypotheses proposed for this thesis will be presented.

2.1 Relationship Between Stock and Bond Returns

As already mentioned, numerous studies have investigated the relationship between stocks and bonds, with a significant portion of them employing correlation as a measure to assess this relationship. In this section, we will explain these studies and present the historical correlations between the two assets.

The examination of the stock-bond relationship was initiated by Shiller & Beltratti (1992) and Campbell & Ammer (1993). These studies presented evidence supporting a positive relationship between stock and bond markets. Campbell and Ammer's research, based on monthly return data from 1952 to 1987, revealed a modest positive correlation between stock and bond returns. Similarly, Shiller and Beltratti's analysis of annual data from the United States (1871-1989) and the United Kingdom (1918-1989) led them to a similar conclusion. One of the key arguments proposed by these studies is that variations in real interest rates contribute to a positive correlation. This is because the prices of both assets are inversely related to the discount rate, resulting in a positive relationship between stock and bond returns.

Subsequent studies by Baele *et al.* (2010), Bansal *et al.* (2014), and Chiang *et al.* (2014) have revealed significant shifts in the stock-bond relationship during the end of the 20th century. Specifically, the correlation has transitioned from predominantly positive to predominantly negative. This prevailing negative correlation persisted until the emergence of the COVID-19 pandemic, as highlighted by Hsu *et al.* (2020). According to these researchers, one contributing factor to this negative correlation is the phenomenon known as the "flight-to-quality," which will be explored in detail in the upcoming section.

Even though there has been a significant shift from a positive to a negative correlation on a long-term basis, several studies demonstrate that when examining the short-term correlation, it becomes more time-varying and not strictly positive or negative. For instance, Chiang & Li (2009) examined the correlation between US stock and bond returns from 1996 to 2008 using various time windows. Their findings indicated that as the window narrowed down to shorter time periods (such as monthly intervals), the correlation exhibited frequent shifts between positive and negative values. This varying relationship is further highlighted in the study conducted by Lin *et al.* (2018), who used continuous wavelet analysis to capture stock-bond return relations simultaneously on all time frequencies. Their findings during the period from 1988 to 2014 affirm the existence of a short-term fluctuating relationship. Furthermore, Ferrer *et al.* (2016), in line with previous authors, provided further confirmation of the presence of a short-term varying correlation between stock and bond returns. Additionally, their investigation focused on the top ten European countries and revealed substantial variations in the stock-bond relationship across these specific countries.

As one would expect, Ferrer *et al.* (2016) were not the only researchers investigating the correlation between stock and bond returns beyond the United States. Li (2002) conducted a study examining the correlation between stock and government bond returns in G7 countries spanning from 1958 to 2001. While there were variations observed among these countries, the overall trend mirrored the pattern discussed earlier in this section. Specifically, during the second half of the 20th century, the correlations exhibited a positive relationship. However, towards the end of the century, there was a notable shift in the correlation, with values approaching zero.

Lastly, Dimic *et al.* (2016) undertook a study investigating the relationship between stock and bond returns in ten emerging countries, including Argentina, Brazil, and Mexico, spanning from 2001 to 2013. Their findings not only revealed the rapid fluctuation of short-term correlations between stocks and bonds but also demonstrated that in the long term, the stock-bond correlation in emerging markets consistently remained positive throughout the entire sample period. This implies the presence of "equity-like" attributes in emerging market bonds over time due to country-specific risks.

2.2 Determinants of Stock and Bond Returns Relation

While it's important to understand how the correlation between stock and bond returns changes over time, an even more crucial question arises: Why does this correlation shift, and what factors influence this relationship? With countless studies exploring this question, this section will introduce a few of them and explain how and why these variables might impact the relationship between stock and bond returns.

In theory, inflation is considered a macroeconomic variable that may influence the correlation between stock and bond returns. However, the relationship between inflation and these asset classes is not straightforward. On one hand, an increase in expected inflation tends to raise discount rates, which can negatively impact stock and bond markets. On the other hand, an increase in expected inflation should also lead to higher expected future cash flows, which could potentially have a positive impact on the stock market. Consequently, the relationship between inflation and stock returns, as well as the overall correlation, becomes less clear.

To address this ambiguity, Ilmanen (2003) conducted a study using US data from 1926 to 2001 to explore the influence of inflation on the correlation between stock and bond returns. His findings suggest that during periods of high inflation, changes in discount rates have a more dominant effect than changes in cash flow expectations, resulting in a positive correlation between stock and bond returns. Yang *et al.* (2009) conducted a study in a comparable time period both in the US and the UK and arrived at similar conclusions: They found that higher stock-bond correlations tend to follow higher inflation rates in the previous period. Shen & Weisberger (2021) conducted a study on the impact of inflation in more recent years, extending their analysis until 2020. Their findings align with previous research as they also arrived at the same conclusion.

Another variable that might influence both stock and bond returns is economic growth. This factor was also examined by both Ilmanen (2003) and Yang *et al.* (2009). Ilmanen observed that economic growth tends to drive stock and bond prices in opposite directions. On the other hand, Yang *et al.* (2009) found that a lower correlation occurs during expansions only in the UK, while in the US, they discovered the opposite relationship.

Interestingly, Andersson *et al.* (2008) focused on both inflation and GDP, but they used the expected values instead of realized ones. They argued that this approach might be more suitable since stock and bond prices inherently reflect market participants' expectations of future inflation and economic growth, rather than reflecting only the historical data. In their study of the US, UK, and German markets from 1992 to 2006, they did not find any systematic relationship between economic growth expectations and stock-bond return correlations. However, what they did observe was that stock and bond prices tended to move in the same direction during periods of high inflation expectations. On the contrary, periods of negative stock-bond return correlations appeared to coincide with the lowest levels of inflation expectations.

Interest rates also play a significant role in influencing both stock and bond returns. When interest rates rise, bond prices tend to decrease as newly issued bonds offer higher yields, leading to a decline in the value of existing bonds. Additionally, higher interest rates can negatively impact stock prices, as increased borrowing costs for companies may adversely affect their stock performance.

The relationship between interest rates and the stock-bond correlation was investigated by Aslanidis & Christiansen (2012) and Shen & Weisberger (2021). Aslanidis and Christiansen's study, which covered the period from 1986 to 2009, revealed that high short-term interest rates are associated with a positive stock-bond correlation. Similarly, Shen & Weisberger (2021) arrived at the same conclusion in a broader time frame extending until 2020.

The last and most important part of this section will focus on a factor that might have a significant influence on the stock-bond relationship and is directly relevant to our study: market uncertainty. Theoretical and empirical evidence suggests that as market uncertainty increases, investors may adopt a more risk-averse approach, leading them to sell stocks and opt for bonds, which are considered safer. This phenomenon is commonly referred to in the literature as the "flight-to-quality" (Baur & Lucey 2009). The significance lies in the fact that during periods of crisis, if the co-movement of stocks and bonds becomes negative, investors who hold both assets may experience less pronounced losses since one asset class can offset the downturn by providing positive returns.

There are numerous studies that have explored the relationship between market uncertainty and the stock-bond return correlation. Firstly, in their study covering the period from 1986 to 2000, Connolly *et al.* (2005) observed a negative relationship between forward-looking measures of uncertainty (implied volatility and detrended stock turnover) and the future correlation between stocks and bonds. Moreover, they found that bond returns tended to be higher (lower) relative to stock returns on days when implied volatility increased (decreased) substantially and on days when stock turnover unexpectedly surged.

Furthermore, Baur & Lucey (2009) examined G8 countries, including the US, UK, Germany, and Japan, from 1994 to 2006, and their findings indicate the presence of flights-to-quality, which occur frequently during crisis periods. The study also reveals that flights tend to occur simultaneously in many countries, leading the researchers to suggest cross-country contagion as a potential explanation for this simultaneity. Additionally, Asgharian *et al.* (2015) used the macroeconomic uncertainty index as a measure of market uncertainty, which is based on the dispersion in survey forecasts for different macroeconomic variables. Their study focused on the US market spanning from 1986 to 2014, and their empirical findings similarly revealed the presence of flight-to-quality behavior.

Recent research conducted by Sakemoto (2018) and Skintzi (2019) revealed consistent findings in various countries. Sakemoto's study explored the impact of implied stock market volatility on stock-bond co-movement in 18 advanced and 13 emerging countries, including the Czech Republic, India, and the Philippines, from 2001 to 2014. On the other hand, Skintzi (2019) focused on 11 Eurozone countries such as Belgium or Finland. Despite these differences, both studies arrived at the same conclusion: higher market uncertainty corresponds to a lower stock-bond return correlation.

Interestingly, recent studies examining the influence of market uncertainty on the stock and bond return relationship, conducted by Kozak (2022) and Sarwar (2023), present somewhat conflicting findings. While Kozak (2022) analyzed the US market until 2020, using both implied and realized volatility, and found a negative impact on the stock-bond return correlation, Sarwar (2023) discovered that "rising stock market uncertainty raises stock-bond correlations during financial crises but lowers them during non-crisis periods," which contradicts previous research to some degree. These contrasting results suggest that the real impact of market uncertainty on the stock and bond relationship may not be as straightforward as it appears.

2.3 Hypotheses

Reflecting on the existing literature, the impact of market uncertainty on the stock-bond return relation has been extensively studied. However, certain aspects within this broad topic remain relatively scarce, leading us to formulate the following hypotheses.

Firstly, given the volatile market conditions in recent years, we aim to examine the changes in the monthly and quarterly correlation between stock and bond returns during this period. Based on insights from related studies (Section 2.1), we hypothesize that the relationship between stock and bond returns will be predominantly negative, as measured by the mean values of these two correlations. Additionally, we anticipate that the monthly correlation will exhibit significant fluctuations over time.

Secondly, in alignment with the current literature, we expect the influence of market uncertainty on the stock-bond return relation to be negative. Specifically, both higher levels of market uncertainty and greater changes in market uncertainty are anticipated to lead to a negative relationship between stocks and bonds.

Lastly, as literature focusing on specific stock market sectors is limited, deriving direct support from existing studies is challenging. Nevertheless, we anticipate potential differences between the overall stock market and individual stock market sectors. Despite this, we expect the relationship between stock and bond returns in specific sectors to follow a similar pattern to the overall market.

Chapter 3

Methodology

This chapter aims to provide a comprehensive theoretical background for the methodology used in this study. It begins with an explanation of crucial assumptions in financial time series analysis, such as stationarity, homoskedasticity, and autocorrelation. Subsequently, we explore the reasons for choosing a particular econometric method and outline its fundamental principles.

3.1 Assumptions of Time Series Analysis

3.1.1 Stationarity

Stationarity is an essential concept in time series analysis related to statistical properties of a time series, including mean and variance, that remain constant over a specific period. In contrast, a non-stationary time series can exhibit trends, seasonality, or other forms of non-random behaviour that may pose challenges in modeling and accurate prediction. Consequently, non-stationarity can yield spurious regression outcomes and misleading interpretations.

There are numerous techniques available to test for stationarity in a time series analysis. The Augmented Dickey-Fuller (ADF) test is a common statistical test used to determine whether a time series is stationary or not. This test aims to detect the presence of a unit root in a specific time series. The presence of a unit root indicates non-stationarity in the time series.

ADF test involves estimating the following regression equation:

$$r_t = \alpha_0 + \beta t + \alpha r_{t-1} + \sum_{i=1}^{p} \phi_i \Delta r_{t-i} + \varepsilon_t \tag{3.1}$$

Where α_0 is a constant, ε_t is an error term, Δr_{t-i} denotes the first difference of

r_t at lag i, and α and φ_i are the estimated coefficients capturing the relationship between the variables and the lagged differences.

The null hypothesis of the ADF test is that $\alpha = 1$, rejection of this hypothesis would indicate that the time series data are stationary.

3.1.2 Homoskedasticity and Autocorrelation

In order to maintain the validity of the OLS regression analysis that we will be using in our study, it is important to consider and address certain assumptions, particularly those related to heteroskedasticity and autocorrelation.

Heteroskedasticity refers to the situation where the variability of the residuals in a regression model is not constant across different levels of the independent variables. Autocorrelation, also known as serial correlation, is the correlation between the observations of a time series with their own lagged values, indicating the presence of a relationship or dependence between the current observation and past observations.

As in line with Hsu *et al.* (2020) and Connolly *et al.* (2005), we are going to calculate robust standard errors by Newey & West (1987) method, which controls for these two assumptions by adjusting the standard errors of coefficient estimates by incorporating lagged error terms.

3.2 Time-Varying Correlation

Given the extensive literature on the correlation between stock and bond returns, the analysis of this relationship has been approached through various methodologies. For example, Lin *et al.* (2018) employed wavelet analysis to effectively capture the time-varying dynamics of stock-bond relationships across different time frequencies. By examining the co-movements between stocks and bonds at various time scales, they offer valuable insights into the relationship between stock and bond returns, shedding further light on their dynamics.

Probably, the most commonly employed technique is the Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model introduced by Engle (2002). Dajcman *et al.* (2012) and Jones & Olson (2013) employed this model in their studies, enabling them to estimate both conditional variances and conditional correlations. This provided valuable insights into how the volatility of the variables under examination evolves over time and how they are interrelated.

However, in this study, we will employ the Rolling Window Correlation (RWC) method to examine the correlation between stock and bond returns. Despite its simplicity and certain drawbacks, such as slow adjustment to new information, the RWC method remains highly valuable and widely used in current studies, as demonstrated by its application in the research conducted by Hsu *et al.* (2020). Furthermore, Andersson *et al.* (2008)'s work highlights the strong similarities between the RWC method and the more advanced DCC-GARCH model over time. Considering these factors, we consider the RWC method to be the most suitable approach for calculating dynamic correlation in our thesis.

3.2.1 Rolling Window Correlation

This technique calculates the correlation between two variables over a sliding window of observations. It involves using a fixed window size for calculating the correlation coefficient and moving it step by step through the data, allowing for the examination of changing relationships over time.

Although the correlation typically stands for the well-defined Pearson product-moment formula, which is computed by dividing the covariance of the two variables by the product of their standard deviations:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{3.2}$$

In our analysis, the correlations will be computed based on the premise that the expected daily returns for both stocks and bonds are assumed to be zero, rather than using the sample mean of returns over each 22-trading-day and 66-trading-day interval, see Connolly *et al.* (2005).

Therefore, the equation applied to calculate the correlation for each time window is as follows:

$$\hat{\rho}_t = \frac{\sum_{i=1}^{k} r_{S,i} r_{B,i}}{\sqrt{\sum_{i=1}^{k} r_{S,i}^2 \sum_{i=1}^{k} r_{B,i}^2}} \tag{3.3}$$

$r_{S,i}$ denotes the daily return of a stock index at the time i,$r_{B,i}$ corresponds to the daily change of the government bond index. Additionally, the parameter k signifies the window length. In our specific case, the window size can be either 22 or 66.

Chapter 4

Data Description and Preliminary Analysis

This chapter will provide an overview of the data used in the research. It begins by introducing the US stock and bond market and reflecting on the various factors that potentially contributed to the market fluctuations observed during the analyzed period. Furthermore, an explanation of the independent variables used in the regression analysis in the next chapter will be presented. Finally, the last two chapters will be dedicated to data transformation, verifying the non-stationarity of our data and conducting fundamental descriptive statistics.

4.1 Standard & Poor's 500

For the purpose of this study, the S&P 500 index, downloaded at S&P Global website,[1] will be used as the proxy for the US stock market. However, it is relevant to mention that there are several other indexes available that can also serve as proxies, including well-known benchmarks such as the NASDAQ Composite or the Dow Jones Industrial Average, which has been used, for example, by Baur & Jung (2006).

The S&P 500 index is composed of 500 prominent companies listed on the U.S. stock market and covers approximately 80% of the total market capitalization available.[2] The S&P 500 index is calculated using a market-capitalization-weighted methodology, where the weight assigned to each individual company's stock within the index is determined by its market capitalization. Although

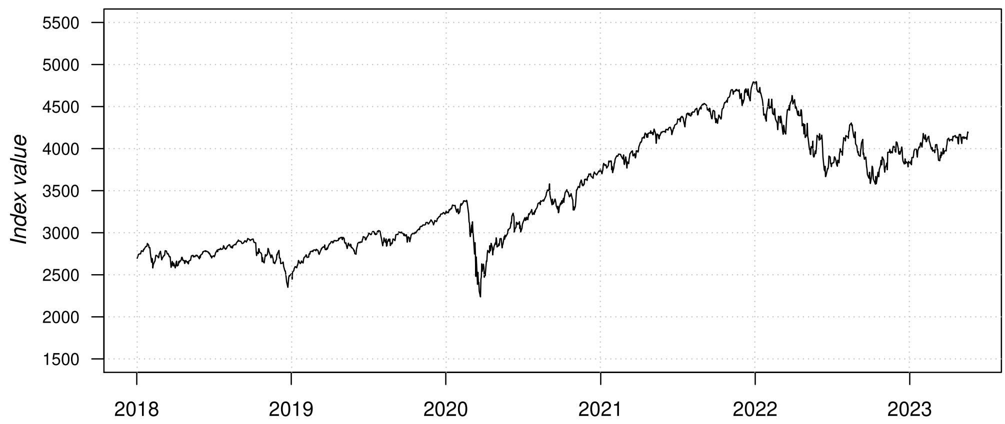
[1] https://www.spglobal.com/spdji/en/indices/equity/sp-500/#overview

[2] https://www.spglobal.com/spdji/en/indices/equity/sp-500/#data

the S&P 500 index is influenced to a great extent by the largest companies due to their substantial market capitalization, it is still widely recognized and extensively followed as a prominent benchmark for the whole US stock market.

During the studied period from January 2018 to May 2023, the S&P 500 index exhibited notable volatility, characterized by periods of heightened fluctuations. This can be observed in the graph below, which depicts the ups and downs of the index over this timeframe.

Figure 4.1: Time Series of the S&P 500 Index



As can be seen from the graph, before the onset of the COVID-19 pandemic, the S&P 500 index displayed a consistent upward trajectory. However, in March 2020, it experienced a substantial decline of over 30% as a result of the pandemic-induced economic disruptions and investor panic. To mitigate the impact, the Federal Reserve implemented proactive monetary policies, including interest rate cuts, which might played an important role in stabilizing the market and facilitating a swift recovery. Subsequently, the index not only recovered from the March downturn but also surpassed previous highs, reaching all-time records in late 2021 and early 2022.

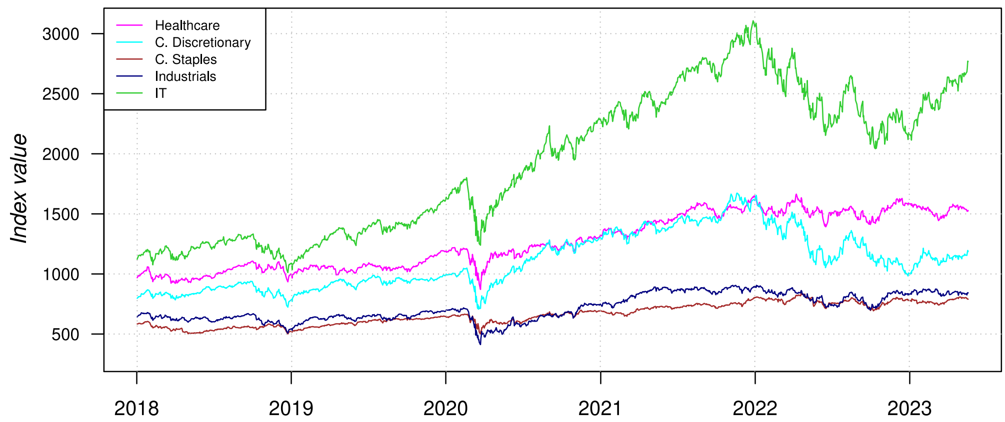
However, the market dynamics appeared to undergo a potential shift in early 2022, coinciding with the emergence of possible concerns regarding rising inflation. In response, the Federal Reserve made the decision to cautiously raise interest rates, which potentially influenced a shift in the market's trajectory. The market went through a year-long downward trend, with occasional ups and downs, as investors adapted to changing economic conditions.

4.1.1 US Stock Market Sectors

While the main focus of this study is on the relationship between the overall stock market, represented by S&P 500 index, and the US government bond market, a significant portion of our analysis will additionally focus on 11 US stock market sectors, as each has its own unique characteristics and performance drivers. Daily data of these sectors were obtained from MarketWatch website.[3]

Figure 4.2 and Figure 4.3 provide insights into the performance of these 11 sectors during the studied period.[4] For example, companies within the Healthcare sector played a crucial role during the pandemic. Additionally, the sector's defensive nature enabled it to outperform other sectors right after the economic downturn that occurred in March of 2020.

Figure 4.2: Time Series of US Stock Market Sectors, Top 5 Sectors



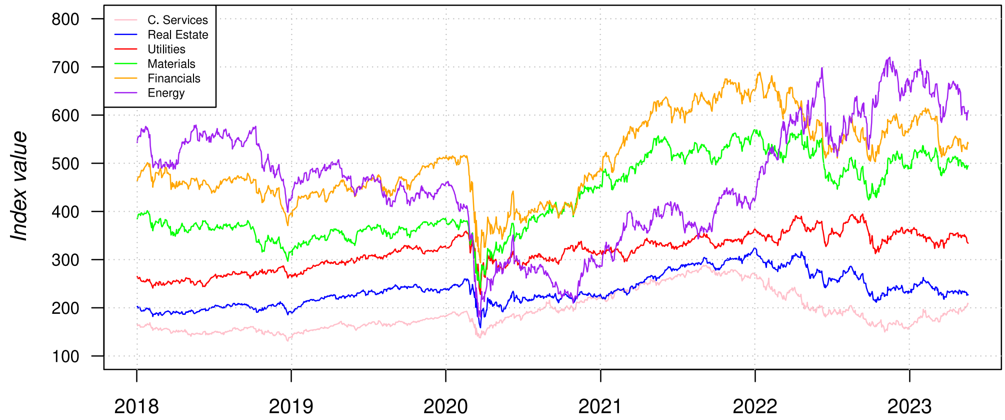
Another notable sector was the Energy sector. This sector, which includes companies involved in the production and distribution of oil and gas such as Exxon Mobil or Chevron, faced significant challenges during the pandemic. However, as the pandemic came to an end, conflict between Ukraine and Russia intensified, which caused oil prices to surge,[5] it was not unusual that these stocks recorded more than a two-digit growth during this period, which can be seen from the Figure 4.3.

[3] https://www.marketwatch.com/tools/markets/indexes/a-z

[4] We divided the 11 sectors into two graphs based on their average index values, as their wide range would have made a single graph less clear.

[5] https://oilprice.com/oil-price-charts/

Figure 4.3: Time Series of US Stock Market Sectors, Bottom 6 Sectors



Furthermore, Technology sector also played a critical role during the pandemic. The sector's growth potential and dominance in the digital economy helped it to outperform other sectors during the pandemic, as demand for online services surged, see Figure 4.2. But as most of these stocks might have been considered overvalued at the beginning of 2022, these companies were affected very significantly, when the economy and stock market shifted after the end of the pandemic.

In addition to the three major sectors previously discussed, the other sectors in the US stock market are Consumer Discretionary, Financials, Communication Services, Consumer Staples, Industrials, Materials, Real Estate, and Utilities. During this period, these sectors also experienced significant volatility, but to varying degrees.

4.2 US 10-Year Treasury Bond

US Treasury securities are debt instruments issued by the US Department of the Treasury to finance the government's operations and fund various programs. They are considered low-risk investments as they are backed by the full faith and credit of the US government, making them a popular choice for investors seeking stability and preservation of capital.

Although the US Treasury market, with a total value of $24.3 trillion (as of April 2023),[6] offers a wide range of securities with different maturities ranging from 1 month to 30 years, the use of the 10-Year Treasury bond has become

[6] https://www.sifma.org/resources/research/us-treasury-securities-statistics/

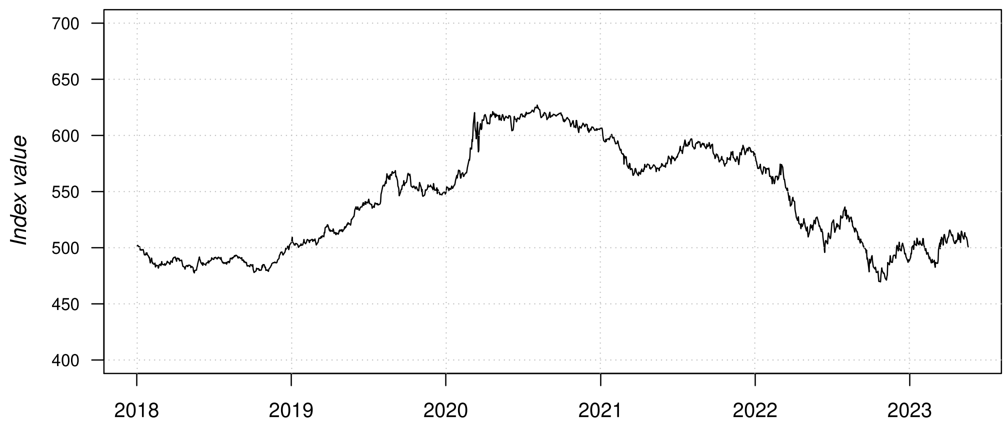
increasingly popular in the relevant literature due to the following reasons outlined in a study by Jammazi *et al.* (2015).

Firstly, the 10-year interest rates are a reliable indicator of market expectations and future economic prospects, playing a significant role in determining borrowing costs. Secondly, long-term government bonds are often seen as suitable substitutes for stocks, as they share similar maturity characteristics, potentially leading to stronger connections between these two assets. Lastly, shorter-term securities are more susceptible to the impact of monetary policy actions, making long-term interest rates a preferable choice over short-term rates.

While the yield might be the most important feature of any bond, for the purpose of this study, we use the U.S. 10-Year Treasury Bond Price Index, downloaded at S&P Global website,[7] due to its greater comparability with stock market prices. This approach aligns with other studies, such as that of Chiang *et al.* (2014).

The 10-Year Treasury Bond Index showed a different trend compared to the S&P 500 index during the studied period. This distinction is visually evident in the graph displayed below.

Figure 4.4: Time Series of the US 10-Year Treasury Bond Price Index



As can be observed from the Figure 4.4, in the first two years of the studied period, the index exhibited a slightly increasing pattern, similar to the movement observed in the stock market. However, when the COVID-19 pandemic

[7]https://www.spglobal.com/spdji/en/indices/fixed-income/sp-us-treasury-bond-current-10-year-index/#overview

emerged, the index experienced a significant surge, reaching high levels. This surge might be attributed to the implementation of quantitative easing measures by the Federal Reserve, which aimed to mitigate the economic impact of the pandemic.[8] This led to increased demand for US Treasuries, consequently driving up their prices. Following this peak, the index gradually started to decrease, indicating a decline in the bond market.

4.3 CBOE Volatility Index

For this study, we have chosen the Chicago Board Options Exchange Volatility (VIX) Index as a proxy for stock market uncertainty. However, it's worth noting that several other studies have utilized different variables as indicators. For instance, Dimic *et al.* (2016) employed the Merrill Lynch Option Volatility Estimate (MOVE) index as a suitable proxy for capturing treasury market uncertainty. Similarly, Lin *et al.* (2018) utilized the TED spread as an indicator of credit risk and market sentiment in the financial markets. Hsu *et al.* (2020) adopted the volatility connectedness index of US financial institutions, which not only reflects investor fear but also incorporates risk premia associated with systematic shocks in financial markets. Despite these alternatives, the VIX index stands out as the most commonly used representative of stock market uncertainty, making it a suitable choice for this study.

The VIX index, which is calculated and published by the Chicago Board Options Exchange, the source from which the data for this index was obtained,[9] uses options prices to estimate expected volatility in the S&P 500 Index over the next 30 days. It specifically considers exchange-traded options based on the S&P 500 Index with specific expirations and timeframes, providing a forward-looking measure of market sentiment and volatility expectations.[10] Evidently, the VIX Index experienced significant fluctuations throughout the analyzed period, as depicted in Figure 4.5.

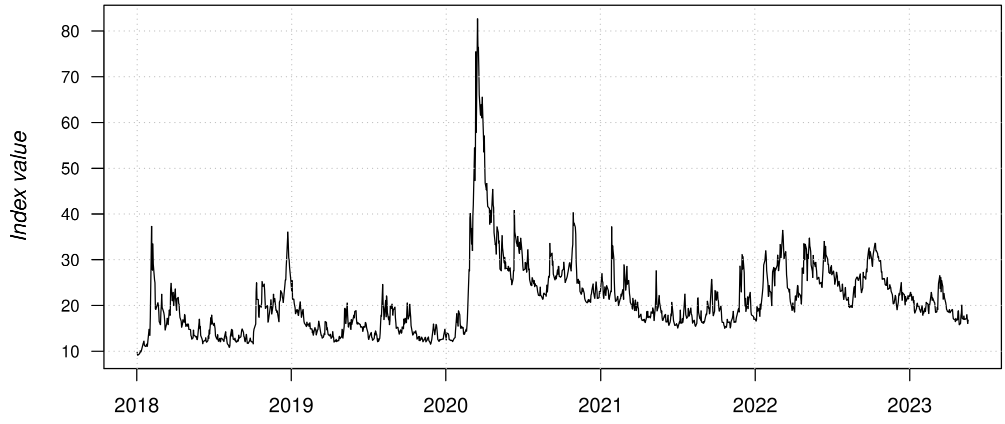
As evident from the graph, there were two notable spikes in the VIX Index before the COVID-19 pandemic, both coinciding with the turn of the year. The most significant spike occurred at the outset of the COVID pandemic, driving the index to reach a peak value of 80. Following this, the index stabilized

[8] https://www.federalreserve.gov/monetarypolicy/bst_recenttrends.htm

[9] https://www.cboe.com/tradable_products/vix/vix_historical_data/

[10] https://www.cboe.com/tradable_products/vix/faqs/

Figure 4.5: Time Series of the CBOE Volatility Index



within the range of 20 to 30 throughout the period until 2023, which represents relatively elevated values compared to the pre-pandemic levels.

4.4 Data Transformation

In this section, we will discuss the data transformations that are essential for our analysis. Firstly, the graphs of the stock and bond indices at the beginning of this chapter clearly show that this financial time series is very unlikely to be stationary. To address this issue, we will transform our time series into log returns series, which provides more convenient statistical properties for our analysis:

$$r_t = \ln\left(\frac{P_t}{P_{t-1}}\right) = \ln(P_t) - \ln(P_{t-1}) \tag{4.1}$$

The notation P_t represents the price of the stock or bond index at time t.

Additionally, considering that the VIX index is reported on an annual basis and in percentage units, and to align it with the units of stock and bond returns, we will apply the following formula also used by Čech & Baruník (2021) to convert it to a daily basis and scale it accordingly:

$$VIX_{daily} = \frac{VIX_{annual}}{\sqrt{250}}\frac{1}{100} \tag{4.2}$$

Where VIX_{annual} refers to the VIX index data discussed in the previous section.

4.5 Descriptive Statistics

Before jumping into the next chapter of empirical results, in this section, we will assess the non-stationarity of our data and provide descriptive statistics as an initial analysis. Table 4.1 presents the key statistical values of the three main variables used in this study.

Table 4.1: Descriptive Statistics of S&P 500 Index Returns, 10-Year Treasury Bond Index Returns and Daily VIX Index

	Mean	Min	Max	St.dev	ADF	P-value
S&P 500	0.033	-12.765	8.968	1.362	-10.12	<0.01
US Bond	0.000	-2.961	2.710	0.492	-10.30	<0.01
VIX Index	1.341	0.579	5.230	0.519	-4.50	<0.01

Note: Values of mean, minimum, maximum, and standard deviation are in daily percentage units. ADF refers to the Augmented-Dickey-Fuller test.

From Table 4.1, it is evident that the mean and median returns for the S&P 500 index were positive, indicating overall positive performance. Conversely, the 10-Year Treasury Bond Index exhibited negative average returns. The VIX index had an average value of 1.34 %. Furthermore, the S&P 500 index exhibited greater variability in returns compared to the Treasury Bond index. This is apparent from the significantly lower minimum value of -12.8% for the S&P 500 compared to the minimum value of -3% for the Treasury Bond index, as well as the substantially higher standard deviation of the S&P 500 returns, which was nearly three times larger than the standard deviation of the Treasury Bond index. Importantly, all three time series demonstrated stationarity, as evidenced by the p-values of the ADF test being significantly below 1%.

In addition, Table 4.2 provides an insightful breakdown of the same set of statistics, specifically focusing on each stock market sector. Firstly, it is worth noting that these sector-specific series also demonstrate stationarity, as evidenced by the ADF test's p-values falling below the 1% significance level. Secondly, a closer examination of the key statistical values reveals that the average returns for each sector throughout the studied period were positive, ranging from 0.008% to 0.067%. These positive average returns indicate a generally favorable performance of these sectors over the given time frame. Moreover, considering the substantial volatility witnessed during the analyzed period, it is

Table 4.2: Descriptive Statistics of US Stock Market Sectors Returns

	Mean	Min	Max	St.dev	ADF	p-value
Healthcare	0.034	-10.527	7.319	1.219	-11.189	<0.01
Materials	0.019	-12.147	11.003	1.539	-10.053	<0.01
Real Estate	0.008	-18.091	8.280	1.537	-10.248	<0.01
C. Staples	0.023	-9.690	8.075	1.092	-10.750	<0.01
C. Discretionary	0.030	-12.877	8.286	1.612	-9.940	<0.01
Utilities	0.017	-12.265	12.320	1.417	-10.717	<0.01
Energy	0.009	-22.417	15.111	2.290	-9.705	<0.01
Industrials	0.020	-12.155	12.001	1.500	-10.080	<0.01
C. Services	0.017	-11.030	8.802	1.575	-10.030	<0.01
Financials	0.012	-15.071	12.425	1.695	-10.023	<0.01
Technology	0.067	-14.983	11.300	1.769	-10.390	<0.01

Note: Values of mean, minimum, maximum, and standard deviation are in daily percentage units. ADF refers to the Augmented-Dickey-Fuller test.

particularly noteworthy that the minimum and maximum values of all sectors significantly deviated from zero. This observation underscores the dynamic and often unpredictable nature of the stock market, wherein the performance of individual sectors can experience considerable fluctuations. Lastly, the high standard deviation and range of both the Technology and Energy sectors highlight the distinct behavior and characteristics of these sectors, as previously discussed in Subsection 4.1.1.

Chapter 5

Empirical Results

In this chapter, we summarize the empirical findings discovered in our study. We will start with an examination of the correlation between stock and bond returns during the studied period. Then we will continue to analyze the dynamics of stock-bond returns, considering the influence of the level and changes of the stock market uncertainty.

5.1 Correlation Between Stock and Bond Returns

This section will present the results of the rolling window correlation between stock and bond returns on both a monthly and quarterly basis. Firstly, we will examine the returns of the overall stock market, represented by the S&P 500 index. Subsequently, we will proceed to present the correlation outcomes between bond returns and each specific stock market sector returns.

5.1.1 Overall Stock Market

In Table 5.1, we present the descriptive statistics of the rolling window correlation between the returns of the S&P 500 index and the 10-Year Treasury bond index in the period from January 2018 to May 2023.

Importantly, we found out that throughout this timeframe, the correlation exhibited an average negative trend, with a mean close to -0.23 for both monthly and quarterly measurements. This finding aligns with the negative trend discussed in the Section 2.1 (Literature Review). Furthermore, the inspection of Table 5.1 reveals that while the minimum correlation values in both cases are quite low, the maximum monthly correlation value (0.726) is significantly higher than its quarterly equivalent (0.465). This distinction aligns with

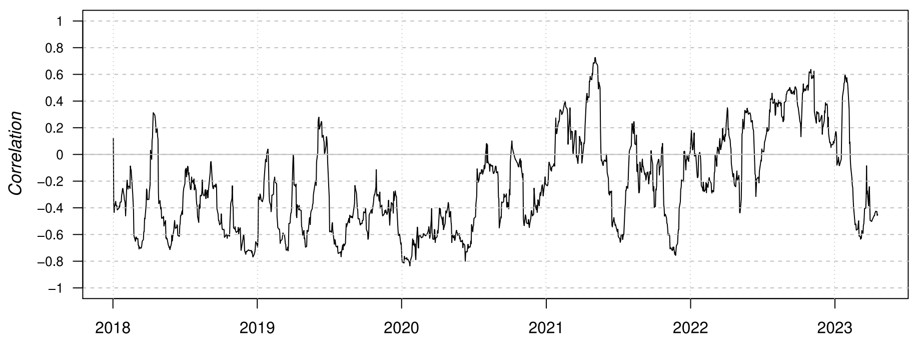
Table 5.1: Descriptive Statistics of Correlations Between Stock and Bond Returns

	Mean	Median	Min	Max	St.dev
Monthly	-0.227	-0.281	-0.835	0.726	0.359
Quarterly	-0.235	-0.304	-0.741	0.465	0.301

the higher standard deviation observed in the monthly correlation, as visually illustrated in Figure 5.1. Specifically, during the second quarter of 2021, monthly correlation values were remarkably high.

Moreover, an inspection of Figure 5.1 and Figure 5.2 (which depict the time series of stock and bond return correlations for monthly and quarterly intervals, respectively) reveals several other important findings.[11] Most notably, the monthly correlation between stock and bond returns changed substantially in very short periods of time. For instance, during the second quarter of both 2018 and 2019, the monthly correlation surged from approximately -0.7 to 0.3 within a few weeks before reverting back to previous levels.

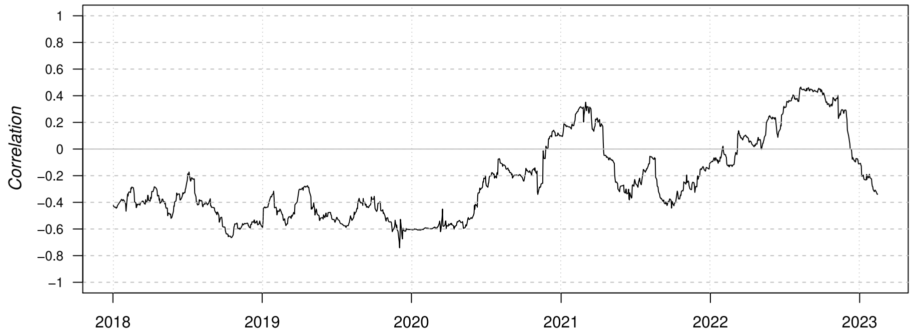
Figure 5.1: Monthly Stock-Bond Return Correlation



While the highly fluctuating monthly correlation depicted in the Figure 5.1 remains a key highlight of this graphical analysis, examination of Figure 5.2 reveals another important findings. Most importantly, with a larger window, a longer-term relationship between stock and bond returns becomes apparent.

[11] To enhance the validity of our findings, we calculated the rolling correlation using the 5-Year Treasury Bond index instead of the 10-Year equivalent, leading to nearly identical graphical results (see Figure A.1 and Figure A.2).

Figure 5.2: Quarterly Stock-Bond Return Correlation



Observing the first part of our studied period, from the beginning of 2018 to mid-2020, the correlation remained predominantly negative, fluctuating within the range of -0.6 to -0.2. However, in the middle of 2020, as the stock market rebounded from the COVID-19 pandemic-induced crash and entered a bull market, the correlation started to turn positive. This positive trend was short-lived, as it reverted back to negative values at the beginning of the next phase. Such behaviour occurred once again during the end of the studied period.

5.1.2 Stock Market Sectors

Proceeding to the analysis of the correlation between bond returns and each stock market sector returns, we make several interesting observations.[12] Surprisingly, as evident from Table 5.2 and Table 5.3, the mean values of monthly and quarterly correlation exhibit substantial variation, spanning from moderately negative to slightly positive values.

The Energy and Financials sectors belong to the negative side of this range, with their average monthly correlations as low as -0.326 and -0.405, respectively. Moreover, on a quarterly basis, their correlations with the Treasury bond were similarly low. Remarkably, when it comes to extreme values, the former sector's maximum monthly (0.459) and quarterly (0.216) correlations were significantly lower than the maximum values observed in other sectors. In contrast, the latter sector exhibited a one-time correlation as low as -0.890 on a monthly basis and -0.802 on a quarterly basis.

[12] As there are 11 stock market sectors, we have chosen to include only descriptive statistics of the monthly and quarterly correlation between the returns of the 10-Year Treasury Bond index and these sector indices. Graphical representations of these correlations can be found in Figure A.3 and Figure A.4

Table 5.2: Descriptive Statistics of the Monthly Correlation between Stock and Bond Returns, US Stock Market Sectors

	Mean	Median	Min	Max	St.dev
Healthcare	-0.141	-0.180	-0.818	0.665	0.343
Materials	-0.245	-0.312	-0.829	0.607	0.355
Real Estate	0.085	0.116	-0.798	0.716	0.348
C. Staples	-0.030	-0.034	-0.700	0.612	0.303
C. Discretionary	-0.164	-0.220	-0.808	0.721	0.360
Utilities	0.131	0.178	-0.678	0.797	0.318
Energy	-0.326	-0.347	-0.819	0.459	0.265
Industrials	-0.275	-0.342	-0.813	0.599	0.346
C. Services	-0.121	-0.089	-0.773	0.701	0.323
Financials	-0.405	-0.511	-0.890	0.591	0.348
Technology	-0.147	-0.196	-0.782	0.747	0.347

Table 5.3: Descriptive Statistics of the Quarterly Correlation between Stock and Bond Returns, US Stock Market Sectors

	Mean	Median	Min	Max	St.dev
Healthcare	-0.148	-0.141	-0.681	0.469	0.266
Materials	-0.261	-0.327	-0.727	0.510	0.289
Real Estate	0.059	0.100	-0.640	0.576	0.282
C. Staples	-0.059	-0.058	-0.665	0.446	0.234
C. Discretionary	0.102	0.151	-0.727	0.486	0.309
Utilities	0.166	0.238	-0.678	0.527	0.277
Energy	-0.336	0.067	-0.678	0.216	0.204
Industrials	-0.292	-0.367	-0.712	0.465	0.281
C. Services	-0.132	-0.099	-0.704	0.388	0.264
Financials	-0.421	-0.545	-0.802	0.484	0.304
Technology	-0.151	-0.202	-0.706	0.492	0.303

In contrast to these low correlations, the relationships between returns of the Real Estate and Utilities sectors with Treasury bonds were predominantly positive on both window lengths, with means close to 0.1. Moreover, the Consumer Discretionary sector also showed a positive average correlation, but only on a quarterly basis.

5.2 Market Uncertainty and the Stock-Bond Return Relation

Even though the correlation between stock and bond returns is crucial for investors in optimizing their portfolios, the primary focus of this thesis is the impact of market uncertainty on this correlation. This section will present two related, yet distinct findings. We will begin by exploring the influence of market uncertainty levels on the stock-bond correlation, and then shift our focus to investigate the impact of changes in market uncertainty on this relationship.

5.2.1 Impact of Level of Market Uncertainty

In this subsection, we investigate the relationship between stock returns and bond returns, specifically focusing on how this relationship varies with the level of the lagged VIX Index.

The regression equation used for this investigation is based on the work of Connolly *et al.* (2005), with some modifications made to suit the specific context of our research:

$$r_{B,t} = \beta_0 + (\beta_1 + \beta_2 VIX_{daily,t-1}) r_{S,t} + \epsilon_t \tag{5.1}$$

Where $r_{B,t}$ and $r_{S,t}$ refers to S&P 500 index and 10-Year Treasury Bond index daily returns at time t, respectively. $VIX_{daily,t-1}$ represents the previous day's level of the daily VIX index, while the betas are the coefficients that we aim to estimate.

Before we start with the interpretation of the results from the model described by Equation 5.1, it is important to clarify that, as both stock returns and bond returns are endogenous variables, the objective of this model is not to establish a direct causal relationship between these two variables, but rather capture the statistical relationship that exists between them.

Table 5.4 presents the outcomes obtained from estimating two variations of Equation 5.1. In the first scenario, our model is constrained by setting $\beta_2 = 0$, while in the second case, we utilize the full model.

By simplifying our model to include only one independent variable, we can estimate the relationship between the daily returns of stocks and bonds. From Table 5.4, it is evident that our estimate is negative and highly significant,

Table 5.4: Lagged VIX Index and the Stock-Bond Return Relation

	(1)	(2)
β_0	0.000	0.000
	(0.19)	(0.19)
β_1	-0.081**	-0.019
	(-3.29)	(-0.51)
β_2		-2.735*
		(-2.39)
R^2	0.049	0.056

Note: The regression is estimated using OLS, with t-statistics reported in parentheses. Standard errors and t-statistics are adjusted for autocorrelation and heteroskedasticity using the Newey-West method. The symbols *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively.

suggesting that the relation between stocks and bonds was negative during the studied period.

However, our main focus is on exploring how this relationship changes with the level of the lagged value of the VIX index, represented by the second coefficient β_2. In the second column (2) of our regression results, we observe that the interaction term between the lagged VIX index and S&P 500 return has become significant, whereas the influence of only the stock return is no longer significant. Moreover, the significance has shifted from β_1 to β_2, and the Adjusted R^2 has increased from 4.91% to 5.57%.

Nevertheless, the most crucial result of this model is the sign in front of the coefficient β_2. As this sign is negative, we may infer, that the stock-to-bond return relation is negatively influenced by the level of stock market uncertainty.

5.2.2 Impact of Daily Change of Market Uncertainty

However, the most interesting outcomes of this thesis are within this particular subsection. Here, we explore the influence of the daily changes in stock market uncertainty, as represented by the VIX index, on the daily returns of both stocks and bonds, as well as the correlation between these returns on that specific day.

To conduct this analysis, similarly to Connolly *et al.* (2005) we sorted the daily observations of stock and bond returns based on the daily change in VIX index. Subsequently, we calculated the sub-sample means for these various subsets and then we determined the correlation between the observations within each grouping. The results of this analysis are presented in Table 5.5.

Table 5.5: Change of the VIX Index and the Stock-Bond Return Relation

VIX Change	μ_S	μ_B	$\rho_{S,B}$
0 to 5th percentile	1.739	-0.219	-0.363
0 to 25th percentile	1.057	-0.067	-0.250
25th to 50th percentile	0.442	-0.057	-0.001
50th to 75th percentile	-0.108	-0.018	-0.056
75th to 100th percentile	-1.259	0.142	-0.203
95th to 100th percentile	-2.561	0.269	-0.327

Note: VIX Change refers to the percentile range representing the daily fluctuations in the VIX index, ranging from the most substantial decreases (0 to 5th percentile) to the largest increases (95th to 100th percentile).

The data in the first column in Table 5.5 provide important statistics showing how changes in market uncertainty affect stock returns. Notably, a clear negative relationship is observed between the changes in market uncertainty and stock market returns. For instance, when the change in VIX index was above the 95th percentile, the average stock return was -2.561%. On the other hand, when the VIX index decreased significantly (0 to 5th percentile), there was a substantial positive change in stock prices.

In contrast, bond returns demonstrated the opposite effect. As market uncertainty increased, bond returns experienced positive performance on average. Conversely, when the change in VIX index was below the 5th percentile, bond returns were, on average, -0.219%. These results highlight the different behavior of bond returns in response to changes in market uncertainty compared to stock returns.

Considering these two relationships, it is possible to infer that an increase in market uncertainty led to a "flight-to-quality" phenomenon, where investors shifted their funds from stocks to safer assets, government bonds. Conversely, when the financial market stabilized, investors might have reallocated their capital from bonds to stocks, which resulted in positive changes in stock prices and negative changes in bond prices. This trend is also known as "flight-from-quality" phenomenon.

The last column in Table 5.5 further supports these implications. Focusing on the correlations at both ends, i.e., during periods of significant changes, both positive and negative, in market uncertainty, we observe considerably negative values, unlike the periods of moderate VIX index changes. For instance, when the VIX index change was above the 95th percentile, the correlation between stock and bond returns in this sample was -0.327. Similarly, when the VIX change was below the 5th percentile, the correlation between stock and bond returns during those days was -0.363. These findings underscore the inverse relationship between market uncertainty and the relation between stock and bond returns.

Table 5.6: Change of the VIX Index and the Stock-Bond Return Relation, US Stock Market Sectors

VIX Change						
from (percentile) to (percentile)	0 5th	0 25th	25th 50th	50th 75th	75th 100th	95th 100th
Healthcare	1.453	0.810	0.341	-0.083	-0.932	-2.016
Materials	1.625	1.625	0.430	-0.326	-1.297	-2.549
Real Estate	1.128	1.128	0.259	-0.089	-0.682	-2.084
C. Staples	1.063	0.542	0.259	-0.031	-0.682	-1.615
C. Discretionary	1.705	1.436	0.534	-0.165	-0.932	-2.715
Utilities	1.417	1.417	0.288	-0.135	-1.358	-1.419
Energy	1.895	1.159	0.360	-0.031	-1.454	-2.771
Industrials	1.550	1.025	0.436	-0.048	-0.478	-2.623
C. Services	1.620	1.025	0.438	-0.150	-1.247	-2.614
Financials	1.869	1.053	0.390	-0.039	-1.358	-2.745
Technology	2.318	1.414	0.570	-0.166	-1.551	-3.089

Note: VIX Change refers to the percentile range representing the daily fluctuations in the VIX index, ranging from the most substantial decreases (0 to 5th percentile) to the largest increases (95th to 100th percentile).

Furthermore, Table 5.6 explores the same relationship between changes in stock market uncertainty and daily changes in stock returns, but with a focus on all stock market indices. At first glance, it becomes evident that, on average, similarly to the overall stock market, this negative relation holds true:

when market uncertainty increased, returns of these stock market indices were negative, and vice versa. However, there are a few interesting findings.

Firstly, Technology, Energy, and Financials sectors were the most significantly influenced by changes in market uncertainty. For instance, when the VIX index increased substantially (above the 95th percentile), the average daily returns of these market indices were -3.089%, -2.771%, and -2.745%, respectively. Conversely, when there was a decrease in market uncertainty, these sectors exhibited, compared to other stock market sectors, the highest returns on average. These findings are in line with the nature of these sectors, as all three are considered cyclical and, in theory, might be more responsive to such market conditions than other sectors.

On the other hand, the impact of market uncertainty on more defensive sectors, such as Consumer Staples, Utilities, and Healthcare, was less pronounced. For instance, when the VIX change was highly positive (above the 95th percentile) or highly negative (below the 5th percentile), the returns of the Consumer Staples sector were less than half compared to the Financials sector.

Chapter 6

Conclusion

In this study, we investigated how stock market uncertainty influences the relationship between stock and bond returns. By analyzing data from the US market spanning from January 2018 to May 2023, we reveal several empirical findings.

Firstly, we calculated the dynamic correlation between stock and bond returns on a monthly and quarterly basis, using the S&P 500 Index and the US 10-Year Treasury Price Index, respectively. Notably, we observed an average negative correlation between these two assets, with a mean value close to -0.23. Furthermore, while the quarterly correlation shifted from predominantly negative values in the first half of the study period to values closer to zero in the second half, the monthly correlation displayed high volatility and lacked any consistent patterns in this short-term relationship.

In addition, we found that both the level of market uncertainty, represented by the implied volatility index (VIX), and changes in this index had a negative influence on the stock-bond return relation. Moreover, during this period, we observed a trend known as the "flight-to-quality" phenomenon, where investors shifted their capital from stocks to bonds as market uncertainty increased. Conversely, we also observed a "flight-from-quality" effect, where in periods of negative changes in the VIX index, the average returns of stocks were positive, while bond prices declined. These two effects were further supported by a higher negative correlation between stocks and bonds during periods of high changes in market uncertainty.

Finally, a significant part of our research focused on all 11 stock market sectors. In these analyses, we found many interesting findings. Concerning the correlation between the returns of these sectors and government bond returns, we observed that while most sectors exhibited a negative correlation with bond returns, there were a few, such as Consumer Discretionary or Utilities sector, that displayed a positive relationship. Furthermore, in our examination of how changes in market uncertainty impacted stock market sector returns, we arrived at a similar conclusion as with the overall stock market: changes in market uncertainty had a negative influence on the returns of the stock market sectors. However, it is worth noting that certain sectors, such as Technology or Energy, were more significantly affected by this uncertainty compared to others.

In summary, this thesis provides empirical evidence that the correlation between stock and bond returns is primarily negative and highly dynamic in the short term. Moreover, it highlights the significantly negative impact of both the level and change of market uncertainty on the stock-bond return relationship. These findings might have a great value to investors, affirming the effectiveness of portfolio diversification, particularly in times of elevated market uncertainty.

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Appendix

Figure A.1: Monthly Correlation Between the Returns of the S&P 500 Index and the US 5-Year Treasury Bond Index

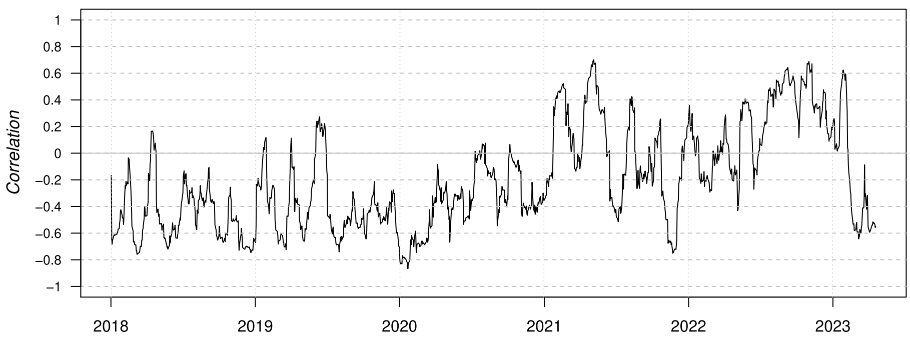


Figure A.2: Quarterly Correlation Between the Returns of the S&P 500 Index and the US 5-Year Treasury Bond Index

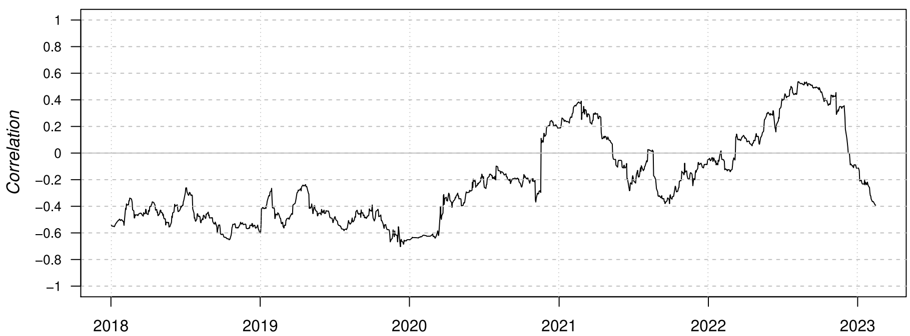
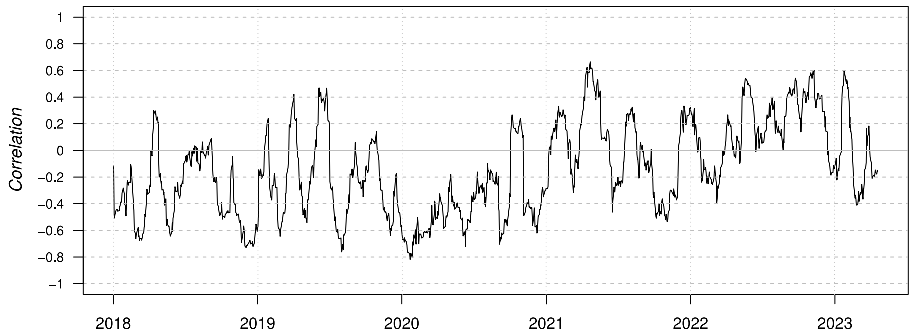
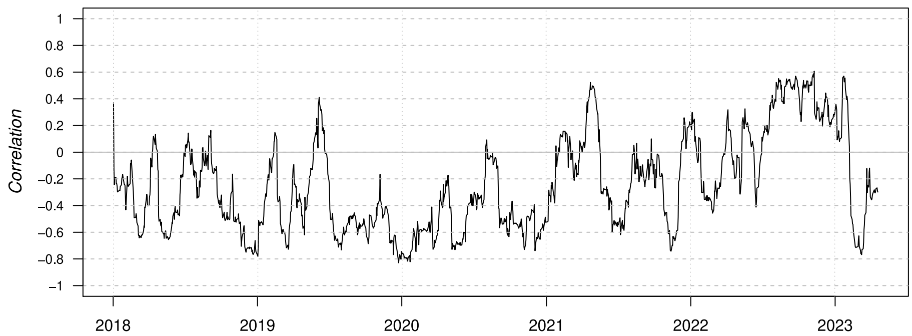


Figure A.3: Monthly Stock-Bond Return Correlation, US Stock Market Sectors

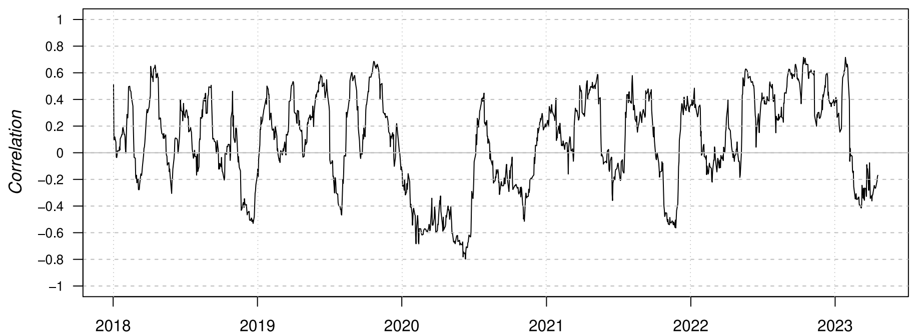
(a) Healthcare Sector



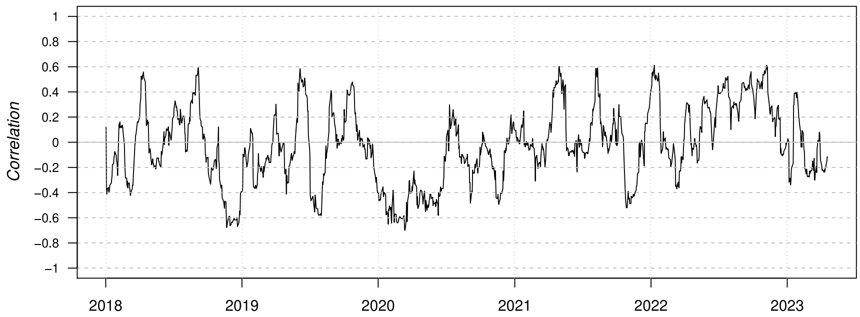
(b) Materials Sector



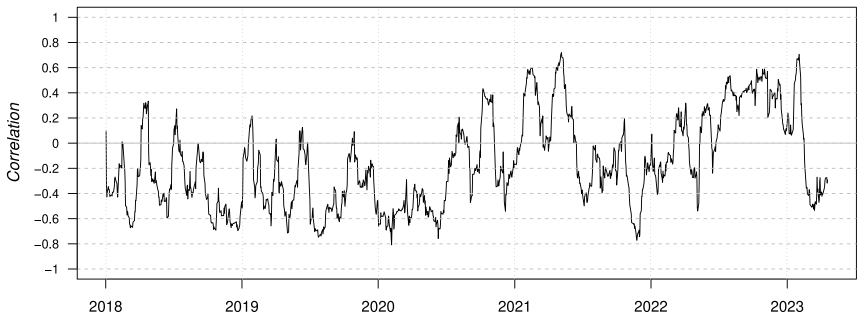
(c) Real Estate Sector



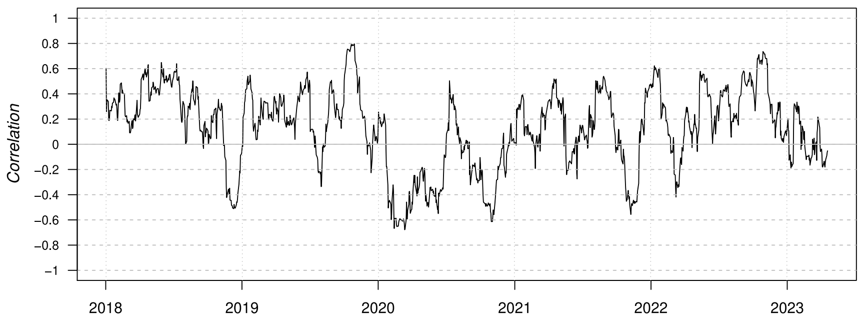
(d) Consumer Staples Sector



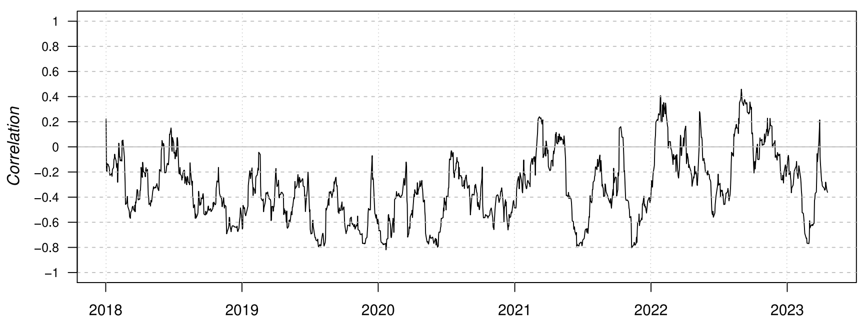
(e) Consumer Discretionary Sector



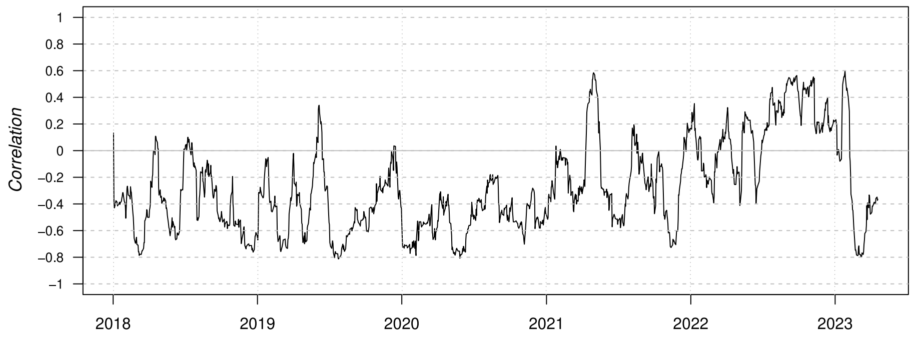
(f) Utilites Sector



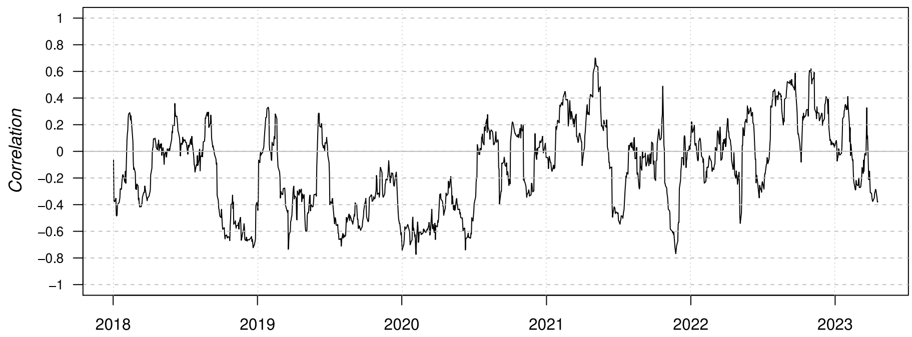
(g) Energy Sector



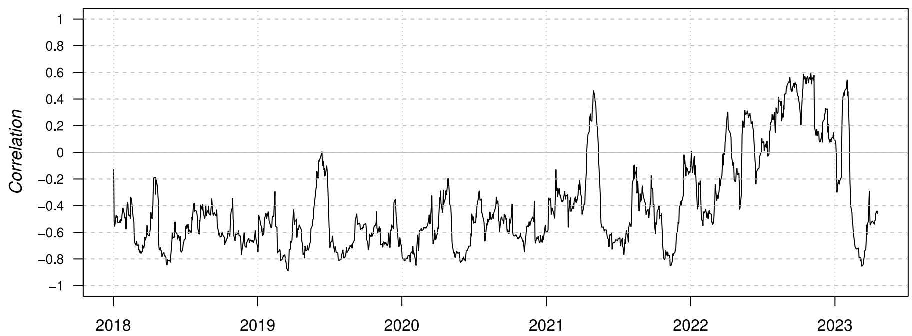
(h) Industrials Sector



(i) Communication Services Sector



(j) Financials Sector



(k) Technology Sector

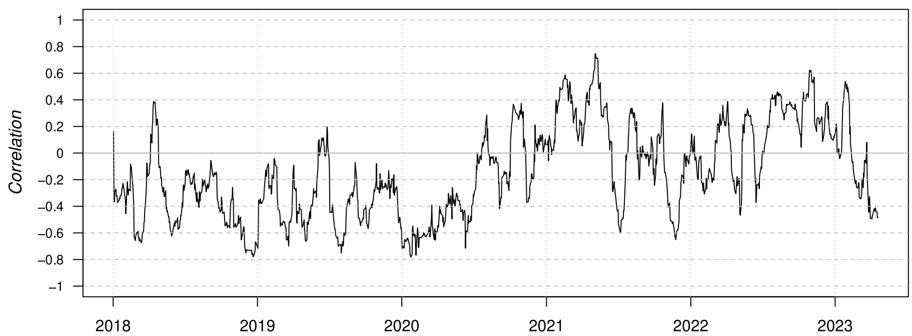
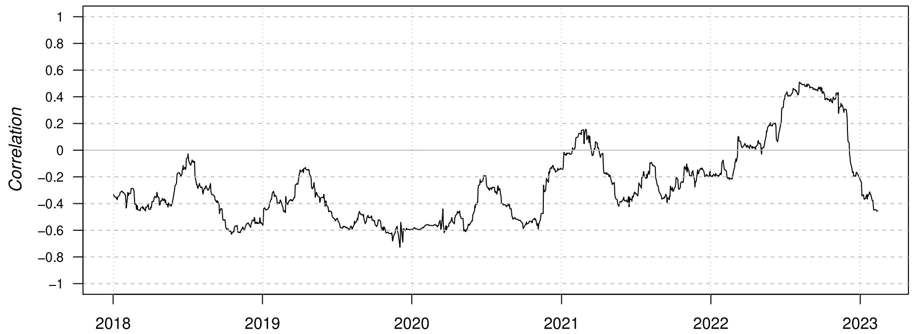


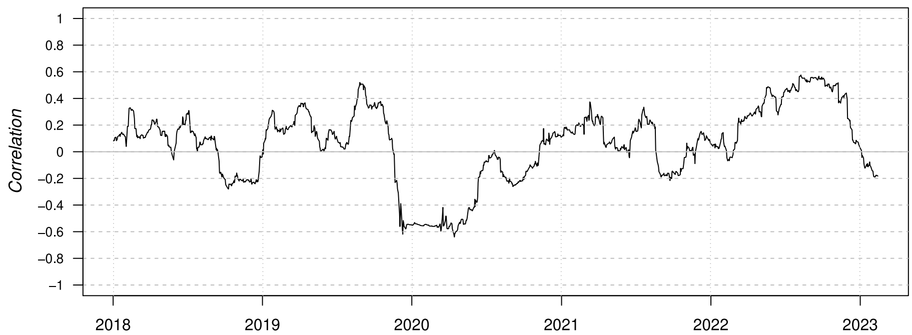
Figure A.4: Quarterly Stock-Bond Return Correlation, US Stock Market Sectors

(a) Healthcare Sector

(b) Materials Sector

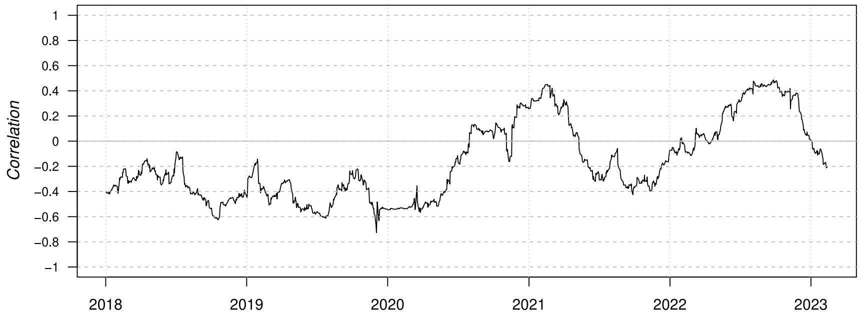


(c) Real Estate Sector

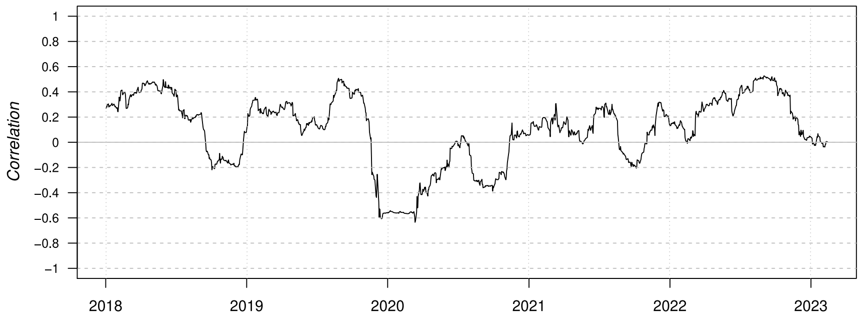


(d) Consumer Staples Sector

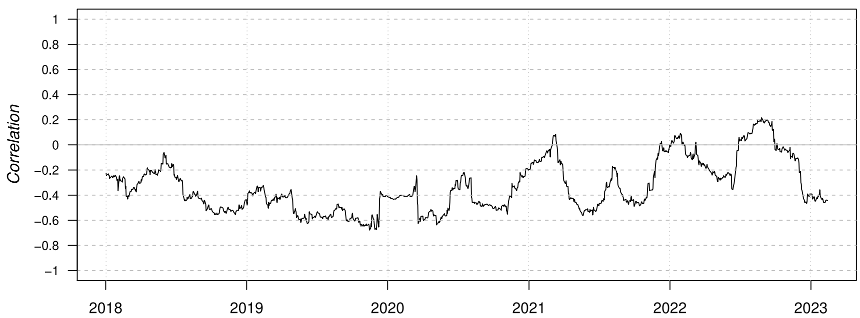
(e) Consumer Discretionary Sector



(f) Utilites Sector



(g) Energy Sector



(h) Industrials Sector

(i) Communication Services Sector

(j) Financials Sector

(k) Technology Sector