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WHAT DRIVES THE CORRELATION BETWEEN STOCKS AND BONDS

AUTHORS: JEREMY HUDSON (HDSJER003)

SUPERVISOR: DR. AKIOS MAJONI

Abstract

This research paper investigates the correlation between stocks and bonds in South Africa between 2002 and 2020and further explores the macroeconomic variables which determine these stock bond correlations. South African stock returns are proxied by the FTSE/JSE All Share Total Return Index (JALSHTR Index) and the South African bond returns are proxied by FTSE/JSE ALBI Total Return Index (ALBITR Index). In addition, this paper includes the following indices in the analysis: JSE Industrial 25 Index Total Return Value (INDI25TR Index), FTSE/JSE South African Listed Property Total Return Index (JSAPYTR), JSE Financials 15 Index Total Return Value (FINI15TR Index).The correlations were calculated for each of the indices against the bond index over the sample period as well as rolling five year correlations. A regression analysis was conducted to investigate the regression to address the second research question The findings indicate a positive relationship between the bond index (ALBITR Index) and all the different types of equity indices (JALSHTR Index, INDI25TR Index, JSAPYTR, FINI15TR Index) over the sample period. The regression results reveal that long-term expected inflation was the only variable with a positive relationship to stock-bond correlations. All other variables (short term expected inflation, unexpected inflation, real interest rates, binary business cycles variable) exhibited a negative relationship with stock bond correlation. The results suggest that macroeconomic variables have limited influence, as none of them were statistically significant at the 10% significance level. The key contribution of this research is investigating the stock-bond relationship within the South African context over the past two decades

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Chapter 1: Introduction

1.1 Background of the study

For any investor entering the financial markets, it is essential to understand the relationship between the four primary markets: commodities, bonds, stocks and currencies. The bonds and stocks relationship is important to understand, as it provides insights into economic conditions, risk management and other key important economic indicators (Ciner, Gurdgiev, & Lucey, 2013). Policy makers rely on the stock bond correlation indicators to gauge investors' expectations regarding economic growth and inflation. By monitoring the correlation between stocks and bonds, policymakers can gain valuable insights into market dynamics and investor sentiment, enabling them to make informed decisions regarding monetary policy, economic stability, and overall financial market regulation (Andersson et al, 2008).

Prior research which was conducted on stock bond correlations yielded mixed findings. Some research papers found a positive relationship (Hong et al. 2009; Li et al. 2015 ; Shiller and Beltratti, 1992). Whilst other papers reported a negative relationship (Asgharian, Christiansen and Hou , 2016 ; Bekaert and Liu , 2002 ; Živkov et al. , 2019). Most studies focused on developed countries such as the United States (see Shiller and Beltratti , 1992 ; Li et al. , 2015.) and South Korea (see Hong, Lee, and Kim (2009). However, there has also been research conducted in developing countries, including Russia, Turkey, Romania (see Živkov et al. 2019).

Understanding the drivers of the stock bond correlation is crucial, as it enables investors and policy makers to make more accurate predictions of the future correlation, leading to better-informed - decision-making (Mishkin, 2016). This topic remains a subject of ongoing debate, primarily due to the conflicting findings within the literature, regarding the impact of macroeconomic factors on stock-bond correlations. Previous studies have highlighted the significance of inflation, the business cycle environment, and monetary policy (such as interest rates) (Ilmanen, 2003; Li, 2004 ; Yang et al., 2009).

Inflation was found to be an important variable which had a positive effect on the stock bond correlation (Andersson et al., 2008; Vähämaa, Krylova, & Andersson, 2008). Other researchers found that economic growth has a positive relationship on the stock bond correlation (Pradhan, et al., 2019) (Fink, Haiss, & Hristoforova, 2007). Real interest rates were found to have a significantly negative impact on the stock bond correlation in past research papers (Ohmi, 2015) , (Viceira, 2012). Prior studies focused primarily on developed economies such as the United States, United Kingdom and Germany (Andersson et al. 2008 ; Perego & Vermeulen, 2016), with limited research conducted in emerging markets (Dimic, et al , 2016). In shorter time frames, the correlation tended to change quickly. Whilst over longer horizons, the correlation generally remained positive. Monetary policy was found to be the most influential factor on stock-bond correlation (Timmer, 2018).

1.2 Problem statement

The limited research on the South African stock-bond correlation highlights a significant research gap, considering the unique economic and financial characteristics of the South African market. South Africa's economy combines elements of both developed and emerging market features, presenting distinctive challenges and opportunities (Andreasson, 2011 ; Adam et. al. , 2022). South Africa’s stock and bond markets are considered to be more advanced than other African countries (Radier, Majoni, Njanike, & Kwaramba, 2016) . South Africa occupies a distinctive position in the financial landscape, characterized by its emerging market status, abundant natural resources, and its pivotal role as a financial hub in Africa (Mhlanga, et al., 2021). The country has a diverse that spans crucial sectors such as mining, manufacturing, agriculture, and services, giving rise to intricate dynamics within its financial markets (Gelb, 2010). South Africa's financial markets are underpinned by robust regulatory frameworks, making them an attractive destination for foreign investors (Benassy-Quere et al., 2017). The nation's distinctive attributes, complemented by its global connections and demographic dynamics, render it a captivating focal point for financial research, offering valuable insights into both emerging markets and the broader global financial arena. What is not clear, within this unique context, is the relationship between stock and bond returns in South Africa, and the macroeconomic factors which drive this relationship.

A notable study by Pradhan et al. (2019) bridges this gap by examining the relationship between bond market development, stock market development, and economic growth across G-20 countries, including emerging economies such as Brazil, Russia, India, China, South Africa, Mexico, and Argentina. Their findings revealed that the development of bond markets plays a significant role in stabilizing financial systems, particularly in these emerging markets, where volatility is more pronounced. Stock-bond correlations in countries like Brazil, South Africa, and Argentina tend to fluctuate more widely due to the relatively immature financial markets, less robust regulatory frameworks, and higher exposure to external economic shocks (Pradhan et al., 2019). These insights underscore the need for more dynamic and tailored investment strategies in these economies compared to developed markets, where stock-bond correlations tend to be more stable (Davis & Zhu, 2004).

1.3 Research Aim

The aim of the research is to investigate the correlation between stocks and bond returns and the drivers of the correlation. The focus is on South African stocks and bonds listed on the Johannesburg Stock Exchange over the period 2002-2020.

1.4 Research Objectives

The research objectives for this paper are to:

- Investigate the correlation between stocks and bonds in South Africa.
- Investigate the drivers of the stock bond correlation in South Africa

1.5 Research questions

This paper aims to investigate two research questions.

- How did the correlation between South African stocks and bonds evolve during the period from 2002-2020.
- What are the drivers of the correlation between stocks and bond returns in South Africa.

1.6 Contribution of the study

This study makes a contribution to literature by focusing on the unique context of an emerging markets, specifically South Africa, which was largely ignored by prior studies (Dimic, et al

,2016 ; Živkov et al. , 2019). By analysing stock-bond correlation and its drivers, this study provides valuable insights for investors, policymakers, and scholars on how stock bond correlations have behaved over the past 20 years, and if macroeconomic variables have an influence on the stock bond correlations.

Chapter 2 Literature Review

The literature review is divided into 2 sections. The first section discusses the theoretical frameworks for the that explain the correlation between stocks and bonds followed by a discussion of the empirical findings

The second section focus on the second research question and it starts by presenting the theoretical framework around each macroeconomic determinant followed by a discussion of empirical findings on each macroeconomic determinant.

2.1 Theoretical Framework and empirical evidence on the correlation between stocks and bonds

Several theories aim to predict the correlation between stocks and bonds, including the : income/wealth effect, substation effect and the flight to quality effect.

Income/Wealth effect

Liberto (2021) describes the income/wealth effect theory as how changes in income and wealth levels can influence consumer spending patterns, thereby affecting investment decisions which in the context of the stock-bond correlation, the income/wealth effect predicts a positive relationship. When economic conditions are favourable, and individuals experience an increase in income or wealth, there is a tendency for higher spending and investment. Investors, with more disposable income, may allocate funds to both stocks and bonds, contributing to a positive correlation between these assets (Forlin, 2022).

Furthermore, during periods of economic expansion, the income/wealth effect suggests that both stocks and bonds may benefit. Stocks often thrive as corporate profits increase during economic upturns, while bonds may be sought after as individuals seek stable and income-generating assets. This positive correlation is reflective of the interconnectedness of economic prosperity, investor wealth, and the performance of both stocks and bonds in a thriving economy. The income/wealth effect, therefore, becomes a critical lens through which to analyse the intricate dynamics of financial markets, guiding investors in their asset allocation decisions (Hurley, 2022).

Numerous empirical studies in finance have found a positive relationship in support of the income/wealth effect (Hong, Lee and Kim , 2009 ; Kozak ,2022 ; McMillan, 2020 ; Shiller and Beltratti ,1992). All these studies focused on developed economies such as United States , United Kingdom and Japan. There is also empirical evidence which supports the income/wealth effect in developing countries (Ain & Siddiqui, 2019 ; Panchenko & Wu, 2009). All of the studies mentioned above the employed the Pearson correlation method to calculate the correlation between stocks and bonds using monthly data.). Hong, Lee, and Kim (2009) opted for a vector autoregressive (VAR) , instead of a Pearson correlation, model to examine the intricate connection between stock returns and bond returns. Their investigation revolved around monthly data obtained from both the Korean stock market and bond market. There were a variety of different bond returns used, some studies used real 10 year treasury bonds returns (Kozak, 2022) while other studies used nominal bond returns (Panchenko & Wu, 2009 ; McMillan, 2020.

Substitution Effect

The substitution effect refers to the tendency of investors to reallocate their portfolios based on the risk-return trade-off between stocks and bonds. This effect predicts a negative correlation between stocks and bonds (Markowicz, 2022). In periods of heightened market volatility or increased risk perception, investors may opt to shift their investments from stocks to bonds, or vice versa, depending on their assessment of the risk and return characteristics of each asset class. This behaviour stems from the idea that stocks and bonds are substitutes in an investor's portfolio, and as the perceived risk of one asset class increases, investors may substitute it with the other to achieve a more balanced and diversified portfolio (Brown, 2022).

There has been empircial evidence which supports the substitution effect. Andersson, et al. (2008) conducted investigations in the US, UK, and Germany, revealing prolonged phases of negative correlation between stocks and bonds, specifically, an increase in stock returns corresponded to a decrease in bond returns, and vice versa. Interestingly, the patterns of stock–bond correlations across these countries occurred at similar times. Bekaert and Liu (2002) found similar evidence in line with Andersson et al. (2008). Bekaert and Liu conducted an analysis of the relationship between stock and bond returns using data in the US. Their findings revealed a significant negative correlation between stock and bond returns. More recent research conducted by Markowicz (2022) found that bonds, proxied by 10 year US treasuries, and equities, proxied by US-large cap equities, have been negatively correlated over the past two decades in the US. However Markowicz did note that they had shown a postive relationship from 1970-1999.

<u>Flight to Quality Effect</u>

The flight to quality theory attempts to explain the shaping of the stock and bond correlations, during periods of financial distress or economic uncertainty. This theory is grounded in the idea that investors, seeking to protect their capital during turbulent times, shift their investments from riskier assets like stocks to safer and more stable assets such as bonds. The flight to quality effect, therefore, suggests a negative correlation between stocks and bonds during these stress periods (Papadamou, et al., 2021). In times of economic uncertainty or market downturns, investors often seek refuge in assets perceived as low-risk and high-quality, with bonds being a common choice. This flight to safer assets can be attributed to a desire to preserve capital and minimize exposure to the heightened volatility associated with equity markets. Consequently, as the demand for high-quality bonds increases, their prices rise, and yields decrease, leading to a negative correlation between stock returns and bond yields (Baele, et al., 2020). However there has been mixed evidence on the flight to quality theory, some support it whilst some contradict it.

There are several studies which support the flight to quality theory during financial crises or economic downturns which have shown a negative correlation between stocks and bonds as investors move to the perceived safety of bonds. Baur and Lucey (2009) examined the correlation between stocks and bonds duringt the 2008 Global Financial Crisis in developed economies such as the United States, United Kingdom, Germany and Japan and their findings supported the flight to quality phenomenon. Papadamou, et al. (2021) conducted research in the same countries as Baur and Lucey (2009), however they conducted their research during the Covid-19 pandemic and obtained consistent results. The correlation between stocks and bonds is dynamic and subject to continual shifts influenced by a myriad of economic factors. A negative correlation persisted in the early 2000's and turned positive around 2006 in South Africa (Weisberger, 2022)

However, there has been contradictory empirical evidence; this is seen in research conducted by Baig and Goldfajn (1999), who found there was a postive relationship between stocks and bonds in Thailand, Malaysia, Indonesia, South Kore and the Philippines during the Asian Financial Crisis. Bekaert, Harvey, and Lundblad (2007) conducted research into the flight to quality phenomenon and its impact on the correlation between stock and bond returns in emerging markets. Their empirical analysis provided compelling evidence affirming the existence of the flight to quality effect, where investors demonstrated a tendency to reallocate investments toward safer assets during turbulent periods. The research findings revealed a significant negative correlation between stock and bond returns during times of market distress.

2.2 Determinants of the correlation between stocks and bonds

. The correlation between stocks and bonds is affected by several macroeconomic including real interest rates/monetary policy, economic growth and inflation.

<u>Real interest rates/Monetary Policy</u>

During an expansionary monetary policy regime, central banks implement measures like lowering interest rates to stimulate economic growth. This has a dual impact on the relationship between stocks and bonds. Firstly, the reduction in interest rates makes existing bonds with higher yields more attractive, causing an increase in bond prices. Simultaneously, the lower interest rates influence the discount rates used to value future cash flows from stocks, making stocks more appealing to investors. The "search for yield" phenomenon emerges, as investors, in a quest for higher returns, shift from bonds to riskier assets such as stocks. This ultimately leads to a positive correlation between the two (Lysandrou & Shabani, 2018).

In contrast, during a contractionary monetary policy, central banks typically raise interest rates and implement measures to cool down an overheating economy and control inflation. This leads to a negative correlation between stocks and bonds. Higher interest rates increase the cost of borrowing and make bonds with fixed interest payments less attractive, causing bond prices to decrease. Concurrently, the higher discount rates applied to future cash flows from stocks can diminish their present values, making stocks less appealing to investors. This leads to a negative correlation between stocks and bonds. (Perego & Vermeulen, 2016).

Empirical research conducted by Chen, et al. (2006) into the influence of interest rates on the correlation between stock and bond returns in the United States. They discovered compelling evidence supporting the notion that interest rates play a pivotal role in shaping the correlation between stock and bond returns. Chen, et al. (2006) found that an increase in interest (contractionary monetary policy) rates leads to a negative relationship between stocks and bonds, whilst a decrease in interest rates (expansionary monetary policy) will therefore cause a positive correlation between stocks and bonds. Further empirical research supported these findings (Bansal et al., 2014; Marsh & Pfleiderer, 2010). Other studies such as Gulko (2002), invetsigated the correlation during a crisis period in the US and found a negative correlation They attributed this to the Federal Reserve's decision to raise interest rates (contractionary monetary policy) in order to curb inflation.

Inflation

Inflation can be broken up into two parts: expected inflation and unexpected inflation. Expected inflation refers to the predicted increase in prices based on available information, influencing economic decisions. Unexpected inflation occurs when actual inflation deviates from expectations, leading to financial market disruptions and uncertainty in planning (Brandt and Wang, 2003).

Expected inflation

When expected inflation is high, the real value of future bond cash flows diminishes. Investors demand higher bond yields to compensate for the anticipated loss of purchasing power. As bond yields increase, bond prices decrease, contributing to a negative impact on bond returns. Simultaneously, stocks may be perceived as more attractive because they have the potential to provide better returns in an inflationary environment. This leads to a positive correlation between stocks and bonds (Manley, 2022).

In an environment of low expected inflation, the dynamics of the stock-bond correlation undergoes subtle shifts. The income/wealth effect erodes the real value of bond cash flows and exerts less pressure on bond prices. Consequently, the traditional motivation for investors to favour stocks over bonds as a hedge against inflation is subdued. In this scenario, the stock-bond correlation tends to be more balanced, with investors not overwhelmingly favouring one asset class over the other. It underscores the nuanced interplay between inflation expectations and the intricate dynamics of the stock and bond markets in shaping their correlation (Nielson, 2022) .

Empirical studies such as Fama and Schwert (1977), found that expected inflation plays a role in shaping the correlation between stocks and bonds. When expected inflation levels are higher, there tends to be a positive correlation between stock returns and bond yields. Ilmanen (2003) used US data to examine the impact of inflation on the correlation between stock and bond returns and his findings were in line with those of Fama and Schwert (1977). In addition Ilmanen (2003) found that the impact of increasing inflation on stock prices is ambiguous, as both the expected future cash flows and the discount rates are likely to be affected and finds that during periods of high inflation, changes in the discount rates dominate the changes in cash flow expectations, thereby inducing a positive stock–bond return correlation.

However, there have been contradictory results. Research by Connolly, et al. (2021) looked at how the correlation between stock and bond returns in the United States, using quarterly data, is affected by expected inflation. Their findings showed that expected inflation places negative pressure on stock returns. They also found that investors tended to move away from stocks into bonds, which results in a negative correlation between stock and bond returns.

Unexpected Inflation

Unexpected inflation can be defined as the how inflation deviated from expectations (Fernando, 2022). Unexpected inflation tends to negatively impact the correlation between stocks and bonds. As unexpected inflation erodes the real returns of both stocks and bonds, it impacts the value of fixed interest payments and future cash flows. Central banks often respond to unexpected inflation by raising interest rates, affecting stocks and bond which leads to bond price declines and a decrease in the present value of future stock cash flows. The resulting uncertainty and market volatility tend to disproportionately affect stocks, prompting investors to seek the relative stability of bonds.

Empirical evidence conducted in the United States by Azar (2013) suggests that unexpected inflation can influence the correlation between stocks and bonds. When inflation unexpectedly increases, it leads to a negative correlation between stock returns and bond yields. There was a negative correlation found between stocks and bonds in emerging markets where there was unexpected inflation (Lee,1999,:Hu and Willett, (2000). Jung et al. (2007) conducted research in European markets and found that unexpected inflation only effected stock returns negatively and had a negligible effect on bond returns - which leads to a negative relationship between stocks and bonds. Conventionally, research papers gauge inflation uncertainty through a

GARCH process, specifically focusing on the conditional variance—a method uniformly adopted in the aforementioned research papers.

Economic Growth/Business Cycle

The correlation between stocks and bonds is influenced by the level of economic growth within a country. The strength of the correlation is dependent on the performance and trajectory of the economy. Economic growth can impact investor sentiment, market conditions, and the overall investment landscape.

During an economic boom, characterized by robust growth and optimism, a positive correlation between stocks and bonds typically emerges. The expanding economy contributes to increased corporate profits, making both stocks and bonds attractive to investors. In an economic boom there is a positive investor sentiment and heightened risk appetite which leads investors to allocate funds to both asset classes (Perego & Vermeulen, 2016).

In times of recession, a negative relationship between stocks and bonds often prevails. Economic downturns bring reduced consumer spending and declining corporate profits which negatively impact stocks. Concurrently, central banks implement expansionary monetary policies, lowering interest rates to stimulate the economy, thereby benefiting bonds. Investors, seeking safety, tend to favour bonds as a haven, causing bond prices to rise (Czasonis, et al., 2021).

Yang, et al. (2009) investigated the stock bond relationship in the United States and United Kingdom. They observed that when an economic cycle is at a peak, there is a positive correlation between stocks and bonds. However, when the business cycle is in its trough, they observed a negative correlation between stocks and bonds. Their findings are consistent with the those of Perego and Vermeulen (2016). Jammazi et al. (2015) conducted research on the impact of the business cycle on the stock bond correlation in developed European countries, utilizing a dynamic DCC-GARCH-copula model. Their findings reveal a significant evolution in the correlation between stock and government bond returns over time. During the 1990s, a positive relationship emerged, which was due to favorable economic prospects. In contrast, a negative stock–bond correlation became prevalent from the early 2000s in certain peripheral euro area countries such as Greece, Spain, Portugal and Ireland. This negative relationship was attributed to these countries experiencing poor economic prospects.

2.3 Conclusion

While research on the stock-bond correlation provides valuable insights, certain critiques warrant consideration. The time-varying nature of the correlation and potential global diversification effects are often not fully captured. Endogeneity challenges in establishing causality between macroeconomic variables and the stock-bond correlation. Behavioral factors, such as investor sentiment and market psychology, may not be adequately incorporated, and regime changes in financial markets could be overlooked.

The majority of the studies which looked at the correlation between stocks and bonds employed a Pearson correlation over a vector autoregressive model (VAR). The Pearson correlation is advantageous for straightforward assessment of the stock bond correlation, the simplicity and ease of interpretation makes it a valuable tool for quick insights into the strength and direction of these relationships. Another advantage of the Pearson correlation is that it is computationally less intensive compared to VAR models. However, its limitation lies in assuming linearity and sensitivity to outliers. In situations where the data exhibits complex or nonlinear relationship over time, or when examining temporal dependencies among multiple variables, a VAR model might be more appropriate.

Many of the studies used government bonds as a proxy for ‘bonds’ in their analysis of the stock bond correlation. Opting for a bond index rather than individual government bonds when assessing the correlation between stocks and bonds brings numerous advantages. Bond indices provide a diversified representation of the bond market, encompassing various issuers, maturities, and sectors, thereby mitigating idiosyncratic risks associated with individual bonds. These indices are designed to accurately reflect specific segments of the bond market and are regularly rebalanced, ensuring a dynamic composition that aligns with evolving market conditions.

Chapter 3: Data and Methodology

3.1 Data description and Sample Population

This research paper investigates the co-movement of stocks (equities) and the South African all bond index returns and the economic driving forces behind the stock-bond relationship.

The sample period spans from 2002-2020. 2002 was chosen for the starting year as this is the first year to have a complete data set, the data was not available pre 2002 as the FTSE/JSE All Share Total Return Index was started in June 2002. The data was collected at monthly intervals, as many economic variables (such as inflation) are reported on a monthly basis (Yang, et al., 2009). Research was conducted up until early 2020 to exclude or avoid the Covid-19 pandemic. The pandemic's unique disruptions could distort studied variables (Just & Echaust, 2020). Excluding the Covid-19 data allows the assessment of regular economic conditions' impact on stock-bond correlations, separate from the pandemic's exceptional effects (Liu, et al., 2022).

The bond returns are calculated from the FTSE/JSE ALBI Total Return Index (ALBITR Index). The ALBITR Index a proxy for the South African bond market. On average, it is comprised of 20 individual vanilla bonds The index covers the full range of South African bond maturities greater than one year (JSE, 2023).

The stock returns are calculated from the following indices:

- The FTSE/JSE All Share Total Return Index (JALSHTR Index) is a proxy for the South African equity market. On average it is comprised of more than 125 individual stocks covering at least 8 different sectors (JSE, 2023).
- The FTSE/JSE South African Listed Property Total Return Index (JSAPYTR Index) is a proxy for the South African property equity market. On average it is comprised of more than 15 individuals REIT stocks (JSE, 2023).
- The JSE Financials 15 Index Total Return Value (FINI15TR Index) is a proxy for the South African financial sector equity market. The FINI15 covers the South African banking sector as well as the South African insurance sector (JSE, 2023).
- The JSE Industrial 25 Index Total Return Value (INDI25TR Index) is a proxy for the South African industrial sector equity market (JSE, 2023).

All the data in this research paper was sourced from Bloomberg with the exception of South African inflation, GDP growth rates and long-term bond yields, which were sourced from Statistics South Africa and Federal Reserve Economic Data.

3.2 Measurement of variables

3.2.1 Stock and Bond Returns

Total return data encompasses both the price return and the income return. The returns were calculated using the total return formula. This is in line with Campbell and Ammer (1993) and (Rubbaniy, et al., 2021).

$$Total\ returns = \frac{Ending\ value - Beginning\ value + dividends}{Beginning\ value} \tag{1}$$

3.2.2 Inflation

Inflation is divided into two forms: expected inflation and unexpected inflation. Splitting inflation into two forms allows for measurement of investor sentiment around inflation (Hoesli, et al., 2008).

3.2.2.1 Expected inflation (EXPINF)

Expected inflation is the forecast of monthly inflation print. This study measures expected inflation in two ways: short term expected inflation (EXPINF_S) and long term expected inflation (EXPINF_L).

- Short term expected inflation **(EXPINF_S)**

Short term expected inflation is calculated by using a 100 month rolling window of data to forecast the inflation figure of the very next month. This forecast is produced by using a

Bayesian Vector Autoregression model. The model uses the following three variables as inputs: South African monthly inflation rate, the industrial production growth rate and the 12 month treasury bill rate of South Africa. These factors are employed, following the approach described by Hall et al. (2000), to predict near-term inflation.

- South African monthly inflation (INF)
  The South African monthly inflation is computed using the log difference of the monthly consumer price index (CPI) levels.
- Industrial production growth rate
  The industrial production growth rate was computed using the log difference of the monthly industrial production index.
- Treasury bill rates
  The 12-month South African treasury rate bill was used.

- Long term expected inflation **(EXPINF_L)**

This research paper uses equation 2 below to calculate long term expected inflation, this method is consistent with Bordo and Dewald (2001).

EXPINF_L = SALTB - SAGDP_GR (2)

Long term bonds are prone to unveil insights into projected forthcoming inflation due to the prevailing volatility of expected inflation outweighing that of the real interest rate over the long-term horizon (Fama, 1990).

Key

EXPINF_L – Long term expected inflation

SALTB - The long term bond yields for South Africa was proxied with the 10 year government bond yield. (Yardeni, et al., 2021)

SAGDP_GR – Gross Domestic Product (GDP) growth rates average over last 5years. The South African GDP growth rate was computed using the log difference of the quarterly South African GDP levels.

3.2.2.2 Unexpected inflation

Unexpected inflation is calculated as the residual error term from the Bayesian Autoregressive Model (BVar) mentioned above. (ie it is the difference between the actual inflation value less the forecasted value)

$$UNIF(t) = INF_{(t)} - EXPINF\_S_{(t)} \tag{3}$$

The $INF_{(t)}$ and $EXPINF\_S_{(t)}$ variables are explained above.

3.2.3 Real interest rate

$$RINT(t) = T\ Bill_{(t-1)} - EXPINF\_S_{(t)} \tag{4}$$

The ex-ante interest rate is equal to the difference between the 12- month treasury bill rate and short term expected inflation. This was chosen as the proxy for the real interest rate as it is in line with prior studies such as Laubach and Williams (2003) and Fama and French (1993).

The $T\ Bill_{(t-1)}$ and $EXPINF\_S_{(t)}$ variables are explained above.

3.2.4 Stock Unique Component

The stock unique component (STQ) shows how a stock's return is different from what investors expect based on general market trends and economic factors. It reveals the unique behaviour of a specific stock that is not influenced by overall market movements. This information is valuable for investors to understand what drives a stock's performance and make better portfolio decisions. This paper builds on the framework introduced by Li (2002) The STQ is calculated by regressing daily stock returns and daily bond returns for each month, and then calculating the standard deviation of the residuals as a monthly data point.

$$Si = \boldsymbol{\alpha} + \beta . Bi + \epsilon i$$
$$STQ\_t = \text{Standard deviation} (\epsilon) \quad (5)$$

Key
Si – daily stock returns
Bi –daily bond returns
ϵi – daily error term
STQ_t – monthly stock unique component

3.2.5 Business Cycles

The business cycles (BC) variable is a binary variable which allows the investigation of the impact of recessions (recession = 0) and "booms" (boom =1) on stock- bond correlations as done by Wen and Li (2020). This paper makes use of the South African Reserve Banks (SARB) definitions of a "boom" and "recession". The SARB defines a boom as: "A financial boom refers to a period of significant expansion and growth in financial markets, characterized by rising asset prices, increased investor optimism, and robust economic activity" and defines a recession as: "A financial recession is a significant decline in economic activity characterized by contraction in business activity, rising unemployment, and falling asset prices" (South African Reserve Bank, 2023).

This paper employs data from the South African Reserve Bank, which delineated periods of economic expansion, commonly referred to as "booms," as well as periods of economic contraction, known as "recessions," to investigate the dynamics of the South African economy (South African Reserve Bank, 2023).

- July 2002- July 2008: Boom
- August 2008- June 2009: Recession
- July 2009- November 2013: Boom
- December 2013- April 2017: Recession
- May 2017- June 2019: Boom

- July 2019- April 2020: Recession

3.2.6 Calculating uncertainty related to economic variables

The paper is based on the uncertainty rather than the level when studying macroeconomic variables, following the approach of Jurado et al. (2015). Examining uncertainty of macroeconomic variables, rather than just their levels, is important due to its significant implications for economic decision-making and market behaviour. For the following variables: expected inflation (short term and long term) ; unexpected inflation and real interest rates ,the study uses their level uncertainty as opposed to their levels. This section discusses how the uncertainty of each of the variable is determined. While the level of a variable indicates its current state, uncertainty reflects the unpredictability surrounding its future movements. High uncertainty can lead to cautious investor behaviour and reduced economic activity. Focusing on uncertainty allows for informed decision-making and shaping appropriate policy responses. It also aids in risk management and asset allocation strategies for investors. Understanding uncertainty provides insights into the dynamics of financial markets and economic behaviour, contributing to a more comprehensive understanding of the economic landscape (Jurado, et al., 2015).

3.2.6.1 Uncertainty of short term and long term expected inflation

This paper follows the approach set out by Orphanides and Williams (2002) which uses the level of expected inflation as a proxy for the uncertainty associated with it.

3.2.6.2 Uncertainty of unexpected inflation

This research paper follows Mumtaz and Zenetti's (2017) approach by employing a GARCH (1,1) model and uses the conditional volatility to approximate the level of uncertainty associated with unexpected inflation.

$$\sigma^2_t=\omega+\alpha_1\varepsilon^2_{t-1}+\beta_1\sigma^2_{t-1} \qquad (6)$$

3.2.6.3 Uncertainty of real interest rates

Similarly with the unexpected inflation, this paper followed Holston, et al. (2017) framework in estimating the uncertainty associated with real interest rates. Following their approach, this study employed a GARCH (1,1) model and used the conditional volatility to approximate the level of uncertainty associated with real interest rates.

$$\sigma^2_t=\omega+\alpha_1\varepsilon^2_{t-1}+\beta_1\sigma^2_{t-1} \quad (7)$$

3.3 Methodology

The methodology is divided into two distinct sections, each aimed at addressing two essential research questions: firstly, examining the correlation between stock and bond returns, and secondly, investigating the impact of macroeconomic variables on the relationship between stocks and bond returns.

3.3.1 Correlation between stock and bond returns

The Pearson's coefficient method was utilized in order to calculate the correlation of stocks and bonds.

$$Correlation = \frac{\sum(x_1 - \overline{x})\,(y_1 - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} \quad (8)$$

This paper will examine the correlation between the FTSE/JSE ALBI Total Return Index (ALBITR Index) with:

- FTSE/JSE All Share Total Return Index (JALSHTR Index)
- JSE Financials 15 Index Total Return Value (FINI15TR Index)
- JSE Industrial 25 Index Total Return Value (INDI25TR Index)

- FTSE/JSE South African Listed Property Total Return Index (JSAPYTR).

3.3.2 The impact of macroeconomic variables on the relationship between stocks and bond return

This paper uses a regression to investigate macroeconomic drivers of the correlation between stock and bond returns.This process is in line with the one employed by Jurado et al. (2015).

$$YCorr_t = \beta_0 + \beta_c \cdot YCorr_{t-1} + \beta_s \cdot STQ_{t-1} + \beta_{es} \cdot EXPINF\_S_t + \beta_{el} \cdot EXPINF\_L_t + \beta_r \cdot RINT_t + \beta_u \cdot UNINF_t + \beta_{bc} \cdot BC + \varepsilon_t \quad (9)$$

<u>Key</u>

Y*Corr* - Correlation between bond returns and stock returns

STQ – Stock Unique Component

EXPINF_S – Uncertainty of Short term expected inflation

EXPINF_L – Uncertainty of Long term expected inflation

RINT – Uncertainty of real interest rate

UNINF – Uncertainty of unexpected inflation

BC- Business Cycles

E – Error term

Determining the correlation between stocks and bonds using the equation (8), as the dependent variable has challenges such as being bounded (-1 to 1) and highly non-normal nature near the boundaries (Brixton, et al., 2020). To address this, the Fisher correlation transformation is applied which converts the correlation coefficient, shown in equation (8), into a standardized normal distribution. This transformation is commonly used in statistical analysis to enhance interpretability and facilitate comparisons of correlations (Brixton, et al., 2020).

Y*Corr* is the Fisher's transformation of the correlation coefficient shown in equation (9).

$$Y_{corr} = \left(\frac{1}{2}\right) * \ln \left(\frac{1 + corr}{1 - corr}\right) \tag{10}$$

This equation transforms the correlation coefficients range from [-1;1] to [- ∞; ∞].

Chapter 4: Results and Analysis

4.1 Summary Statistics of Stock and Bond Returns

Table 1 shows the sample statistic for stock and bonds returns at both monthly frequencies. The table also includes the average South African inflation rate over the period. The industrial index delivered the highest annualised average return over sample period at 16,3% per annum. Whilst the bond index delivered the lowest return at 9,03%. In terms of volatility the property index exhibited the highest standard deviation at 18,54% , whilst the bond index exhibited the lowest standard deviation of 7,26%.

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Table 1: The Sample Statistic For Stock And Bonds Returns

	Bond Index	Stock Index	Financials Index	Industrial Index	Property Index	SA Inflation
Mean(%)	9,03%	13,06%	12,06%	16,30%	14,58%	5,27%
Std Dev(%)	7,26%	16,03%	17,67%	15,16%	18,54%	2,53%
Median	0,79%	1,31%	1,18%	1,62%	1,79%	5,30%

4.2 Stock Bond Correlations

To address the first research question, this paper firstly runs a correlation matrix , presented in table 2, and secondly illustrates rolling 5 year correlations , shown in figure 1, of each of the pairwise indices in the correlation matrix

4.2.1 Correlation Matrix

The correlation matrix is calculated from equation (8). Table 2 is the correlation matrix between the Bond Index, FTSE/JSE , Stock Index, Financials Index, Industrial Index and Property Index.

The correlation between the stock index and the bond index was 0,13. The industrial index correlation with the bond index was very similar to the stock index at 0,16. The financial index and property index's correlations with the bond index was much higher than the stock index with a correlation of 0,51 and 0,61 respectively. This is most likely due to the fact that financial sector stocks and property stocks returns are more highly linked interest rate movements, whereas the all share index and industrial index are less sensitive to interest rate movements due to diversification.

Table 2: Correlation Matrix

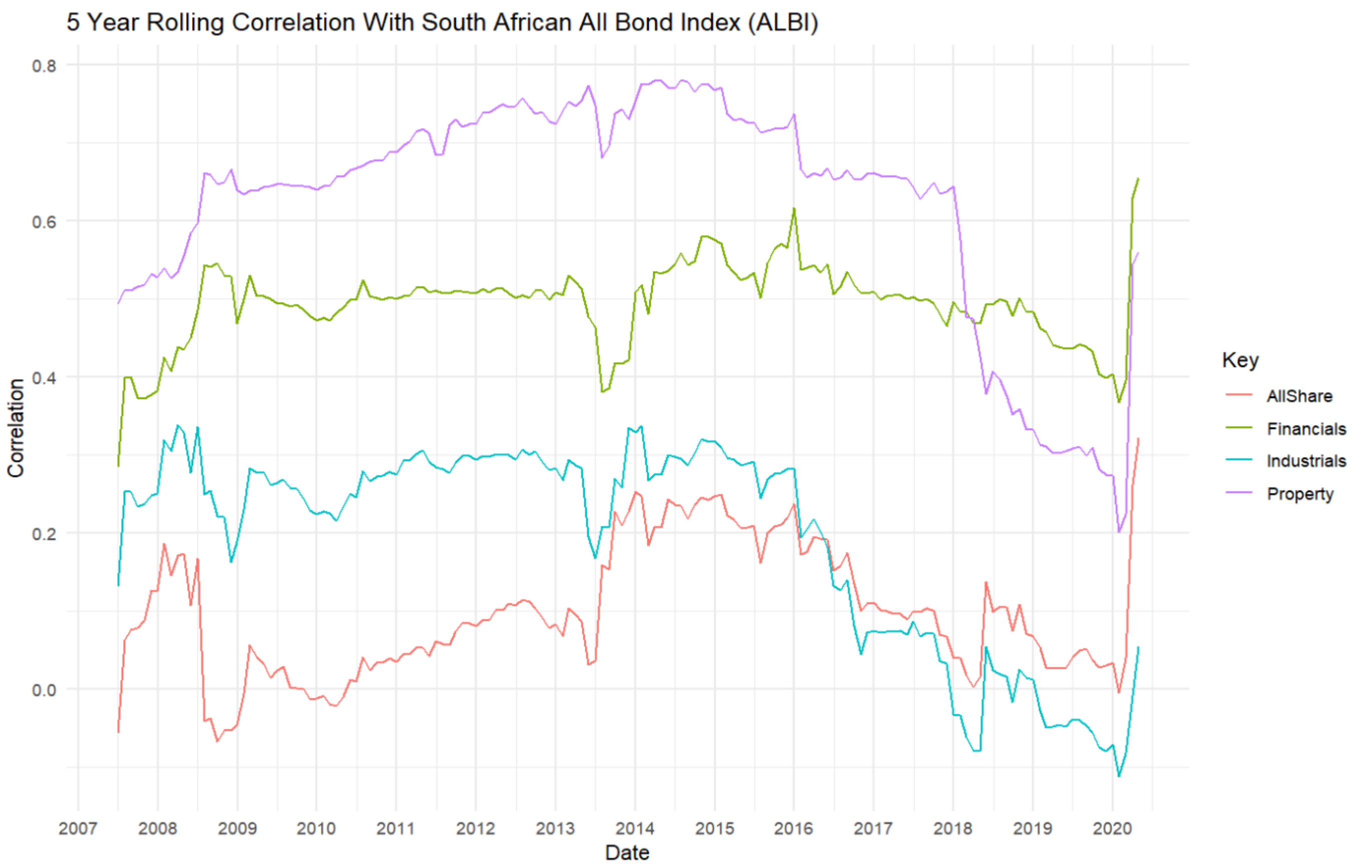
	Bond Index	Stock Index	Financials Index	Industrial Index	Property Index
Bond Index	1,00				
Stock Index	0,13	1,00			
Financials Index	0,51	0,71	1,00		
Industrial Index	0,16	0,85	0,69	1,00	
Property Index	0,61	0,38	0,71	0,39	1,00

The financials index and industrial index exhibit strong positive correlations with the stock index and between themselves. The property index correlation with the stock index is moderately positive. As expected the property index is less correlated with the stock index than the bond index (ALBI) . This is all depicted in figure 1.

4.2.2 5 Year Rolling Correlations

This shows the behaviour of this correlation of each of the indices: the graph with the bond index over 5 year rolling periods is shown visually. The 5 year rolling period correlation was calculated using equation (8) for consecutive 60 month return data. A 5 year rolling window allows for the observation of the behaviour of correlations between two indices over the sample period.

Figure 1: Rolling Stock Bond Correlations



FTSE/JSE All Share Total Return Index (JALSHTR Index)

The correlation with the bond index has remained within narrow bands around its average of 0,13 with a spike and dip between 2008 and 2009 . This was due to the global financial crisis. There was another peak between 2013 and 2014. There as another large spike in 2020 as a result of the Covid-19 Pandemic.

JSE Industrial 25 Index Total Return Value (INDI25TR Index)

The correlation with the bond index has remained within narrow bands from 2008 until 2016, hovering around 0,2. Since 2016 it has seen a large dip going into negative territory from 2018, with a few occasions of marginal positive correlation.

FTSE/JSE South African Listed Property Total Return Index (JSAPYTR)

Between periods 2008 to 2018, the property index has seen a steady incline in correlation with the bond index from 0,5 to 0,8. Since 2019 there has been a rapid decline all the way down to a correlation to 0,2. This is most likely due to a loss of investor confidence in South Africa. However, there was a large spike in the correlation between the property index and the bond index in 2020, once again due to the Covid-19 Pandemic.

JSE Financials 15 Index Total Return Value (FINI15TR Index)

The correlation with the bond index has remained within narrow bands around its average of 0,51. The financials index has the lowest volatility in its correlation with the bond index compared to the other indices. Although the volatility has been the lowest, it still experienced a spike due to the Covid-19 Pandemic.

These findings indicated a positive association between the bond index (ALBITR Index) and all other indices (JALSHTR Index, INDI25TR Index, JSAPYTR, FINI15TR Index) during the 2002-2020 period. Specifically, the correlation between stocks (JALSHTR Index) and bonds (ALBITR Index) generally exhibited a weak positive connection, except during the Global Financial Crisis. The results suggest that an increase in bond returns is associated with a slight increase in stock returns. This implies that incorporating both stocks and bonds in investment portfolios may yield significant diversification advantages. This positive relationship aligns with prior research (Rankin & Idil, 2014; Hong, Lee, and Kim, 2009) and is consistent with the income/wealth effect theory.

4.3 Results of the determinants on the stock bond correlation

To address the second research question, this paper runs the regression shown in equation (11).

$$YCorr_t = \beta_0 + \beta_c \cdot YCorr_{t-1} + \beta_s \cdot STQ_{t-1} + \beta_{es} \cdot EXPINF\_S_t + \beta_{el} \cdot EXPINF\_L_t + \beta_r \cdot RINT_t + \beta_u \cdot UNINF_t + \beta_{bc} \cdot BC + \varepsilon_t \tag{11}$$

This paper ran the regressions in order to show the effect of each individual macroeconomic factor. We then ran it with all the variables combined.

The lagged stock unique component (STQ)

The STQ is distinct from macroeconomic factors and serves as a control variable for stock return volatility, considering its unique influence on stock pricing factors.

Short term expected inflation (EXPINF_S)

EXPINF_S had a negative relationship with the South Africa stock bond correlation., Meaning that increases in expected inflation in the short term decreases the correlation between stocks and bonds and vice versa. When short term expected inflation is on the decline, investors are likely to enter the market and invest in a variety of assets, thus increasing stock bond correlations. However when short term expected inflation is on the rise, it may lead to a “frenzy in the market” resulting in a sell off of risky assets such as stocks and a move towards safer assets such as bonds, thus decreasing the correlation between these assets (Lin, Yang, Marsh, & Chen, 2018). These findings are consistent with those of Engsted and Tanggaard (2002), but are contradictory to Wu (2020). Overall, the results show that short term expected inflation was insignificant at the 10% level.

Long term expected inflation (EXPINF_L)

EXPINF_L had a positive relationship with the South Africa stock bond correlation, but was insignificant at the 10% level. This means that increases in expected inflation in the long term increases the correlation between stocks and bonds and vice versa. When long term expected inflation is on the rise, investors are likely to enter the market and invest in a variety of assets thus increasing stock bond correlations. However, when long term expected inflation is on the decline, investors may seek higher returning assets such as stocks over subdued bond yields thus decreasing the correlation between these assets (Ang, Bekaert, Wei,2009). These findings are consistent with those of Engsted and Tanggaard (2002). Overall, the results show that long term expected inflation was insignificant at the 10% level.

Real interest rates (RINT)

RINT had a negative relationship with the South Africa stock bond correlation, but was insignificant at the 10% level. These results suggest that increases in the uncertainty of real interest rates decreases stock bond correlations, as investors are likely to favour safer assets such as bonds over stocks during these periods. Decreases in the uncertainty of real interest rates, investors are likely to enter the market and invest in a variety of assets thus increasing stock bond correlations (Mahmudul & Salah, 2009). These results are in line with research conducted by Al-Naif (2014).

Unexpected inflation (UNINF)

UNINF had a positive relationship with the South Africa stock bond correlation, but was insignificant at the 10% level. Sudden increases in inflation (ie unexpected inflation) may lead central banks to raise interest rates in an effort to manage inflation. Elevated interest rates can have adverse effects on both stocks and bonds. For stocks, this can result in higher borrowing costs for companies, leading to reduced profitability and potentially lower stock prices. Similarly, for bonds, the rise in interest rates can contribute to a decline in bond prices. (Azar, 2010)

Business Cycle (BC)

The results indicate that business cycles do not have a significant impact on the stock-bond correlation in South Africa. Despite the expectation that different stages of the business cycle could influence the correlation (Koijen, Lustig, & Nieuwerburgh, 2017). The results are contradictory to prior studies (Odegaard, Skjeltorp, & Randi, 2011) who found that business cycles have a significant effect on the stock bond correlation.

The only variable significant at the 10% level in each of the regressions was the lagged STQ component, meaning the uncertainty of macroeconomic variables; long term expected inflation, short term expected inflation, real interest rate and unexpected inflation; have no effect on the South Africa stock bond correlation over the period investigated. This was confirmed by the adjusted r-squared of the models which was very low across the regressions at less than 0,05 , indicating that most of the high frequency fluctuations in the South African stock-bond correlation are explained by the first lag and stock unique component.

The findings suggest that the primary drivers of high-frequency fluctuations in the stock-bond correlation are the first lag and STQ variables. These factors account for the majority of the short-term variations observed. On the other hand, the impact of macroeconomic factors becomes more apparent when considering the broader trends in the stock-bond correlation. Macroeconomic factors play a role in shaping the major patterns and movements of the correlation over time. The lagged correlation estimate was positive in all regressions but highly insignificant.

Table 4: Regression of stock bond correlation

Model	Constant	Y-Corr $_{t-1}$	STQ	Expected inflation (LT)	Expected inflation (ST)	Real Interest Rate	Unexpected inflation	Business Cycle	R^2	F-Stat
1	-0,251 (-0,966)	0,092 (0,976)	12,300 ** (1,795)	3,666 (1,124)					0,030	2,151
2	0,082 (0,496)	0,101 (1,067)	12,716 ** (1,840)		-0,911 (-0,330)				0,020	1,748
3	0,163 (1,313)	0,085 (0,901)	15,704 *** (2,192)			-81,999 (-1,226)			0,032	2,235
4	-0,196 (-0,111)	0,102 (1,079)	12,922** (1,876)				67,468 (-0,129)		0,019	1,716
5	0,011 (0,151)	0,097 (1,023)	13,471 ** (1,955)					0,031 (0,633)	0,022	1,85
6	2,397 (0,814)	0,057 (0,586)	14,786 (2,039) ***	8,002 (1,412)	-1,626 (-0,522)	-814,697 (-0,845)	-89,416 (-1,118)	-0,004 (-0,067)	0,022	1,349

Significance Levels

**** 1% significance

*** 5% significance

** 10% significance

* 15% significance

The only variable of significance at the 10% level was the lagged STQ, none of the other variables were significant in any of the other models. Across the models the R^2 adjusted was between 1,9% and 3,2% indicating a very low percentage of variation in stock bond correlations accounted for by the model. Given the aforementioned poor R^2 adjusted values , all of models presented in table 4 have poor fitness.

4.4 Summary of Empirical Result

When examining the impact of various macroeconomic factors on stock-bond correlations in South Africa, it is notable that uncertainty about macroeconomic variables does not seem to play a significant role when employing an unconditional correlation regression. Instead, the analysis reveals that the stock unique component (STQ) emerges as the sole significant variable in these models. Furthermore, the study finds that business cycles do not account for any discernible variation in stock-bond correlations.

Chapter 5: Conclusion

This research paper examines the correlation between stocks and bonds in South Africa from 2002 to 2020, as well as the factors influencing this relationship. The bond returns are measured using the South African All-Bond-Index (ALBI) while the equity returns are based on variety of stock indices: JALSHTR Index, INDI25TR Index, JSAPYTR, FINI15TR Index.

The findings revealed a positive correlation between the bond index (ALBITR Index) and all other indices (JALSHTR Index, INDI25TR Index, JSAPYTR, FINI15TR Index) spanning the 2002-2020 period. Specifically, the correlation between stocks (JALSHTR Index) and bonds (ALBITR Index) generally demonstrated a weak positive connection, with an exception noted during the Global Financial Crisis. The results suggest that investors should not base stock bond diversification decisions in their investment portfolios based on uncertainty about macroeconomic variables as the models concluded that these do not have significant impact on stock bond correlations.

The model also examined the correlation between stocks and bonds, taking into account uncertainties related to macroeconomic factors such as expected inflation, real interest rates, and unexpected inflation, and revealed that these uncertainties do not influence the monthly fluctuations in stock-bond correlations. An interesting finding was the significance of the stock unique component (STQ) across various models. This paper found that the business cycles variable has no significant impact on stock bond correlations. These results imply that an uptick in bond returns is linked to a slight increase in stock returns, underscoring the potential diversification benefits for investors by incorporating both stocks and bonds in investment portfolios. Investors should be aware that stock-bond correlations can spike during periods of market strain, potentially leading to significant value destruction and undermining the benefits of diversification. This study also found that uncertainty about macroeconomic variables did not have a significant impact on explaining stock-bond correlations in South Africa. This lack of significance could potentially be attributed to these variables playing a larger role in explaining broader trends in stock-bond correlations, rather than focusing solely on monthly changes.

Furthermore, this research paper’s analysis was affected by certain limitations, including the loss of many observations due to the implementation of the Bayesian vector autoregression model to estimate uncertainty about short-term expected inflation. Additionally, the lack of detailed data on business cycles, which was thought to have a substantial influence on stock-bond correlations, posed another challenge. To enhance the analysis, it would be beneficial to increase the sample size and explore methods to mitigate observation loss when computing uncertainty about macroeconomic variables. Conducting regressions across different sector-specific stock indices, such as financials, industrials, and property, could also be beneficial. The rationale behind this approach is the likelihood of varying influences of uncertainty about macroeconomic factors on different industries. It's worth noting that due to the monthly frequency of economic variables, the analysis couldn't be performed on daily stock and bond returns, which might offer more granular insights and significant findings. Additionally, incorporating other economic variables, such as monetary policy shocks and credit spreads, could provide valuable inputs in comprehending the stock-bond correlation.

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Chapter 7: Appendix

BVAR: Short Term Expected Inflation Estimates

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2010											3,40%	3,62%
2011	3,45%	3,78%	3,72%	4,12%	4,21%	4,63%	5,04%	5,33%	5,35%	5,80%	6,03%	6,12%
2012	6,11%	6,30%	6,08%	6,01%	6,11%	5,74%	5,44%	4,87%	5,02%	5,48%	5,63%	5,63%
2013	5,63%	5,44%	5,90%	5,94%	5,88%	5,71%	5,44%	6,33%	6,44%	5,93%	5,54%	5,31%
2014	5,40%	5,86%	5,86%	5,97%	6,17%	6,59%	6,64%	6,24%	6,45%	5,96%	5,85%	5,78%
2015	5,35%	4,37%	3,85%	4,04%	4,41%	4,58%	4,70%	5,04%	4,59%	4,56%	4,67%	4,78%
2016	5,24%	6,12%	6,91%	6,14%	6,10%	6,15%	6,25%	6,05%	5,86%	6,01%	6,30%	6,58%
2017	6,74%	6,52%	6,24%	6,06%	5,68%	5,31%	5,04%	4,58%	4,77%	5,10%	4,85%	4,60%
2018	4,62%	4,35%	3,97%	3,82%	4,56%	4,45%	4,70%	5,10%	5,02%	5,07%	5,11%	5,16%
2019	4,49%	3,89%	4,08%	4,57%	4,42%	4,48%	4,42%	3,99%	4,42%	4,09%	3,68%	3,56%
2020	3,89%	4,59%										

GARCH: Real Interest Rates Conditional Volatility Estimates

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2010											0,21%	0,22%
2011	0,21%	0,20%	0,19%	0,18%	0,16%	0,15%	0,15%	0,14%	0,14%	0,14%	0,13%	0,13%
2012	0,13%	0,13%	0,13%	0,13%	0,13%	0,13%	0,13%	0,29%	0,26%	0,23%	0,21%	0,19%
2013	0,19%	0,18%	0,17%	0,16%	0,15%	0,15%	0,15%	0,15%	0,14%	0,14%	0,14%	0,14%
2014	0,14%	0,21%	0,20%	0,19%	0,19%	0,18%	0,23%	0,21%	0,19%	0,18%	0,19%	0,21%
2015	0,19%	0,21%	0,19%	0,18%	0,17%	0,17%	0,25%	0,23%	0,20%	0,19%	0,17%	0,22%
2016	0,25%	0,23%	0,21%	0,20%	0,18%	0,17%	0,16%	0,16%	0,15%	0,16%	0,18%	0,18%
2017	0,17%	0,21%	0,20%	0,19%	0,18%	0,17%	0,17%	0,22%	0,21%	0,19%	0,24%	0,21%
2018	0,20%	0,22%	0,20%	0,20%	0,20%	0,18%	0,17%	0,16%	0,16%	0,15%	0,17%	0,17%
2019	0,17%	0,21%	0,21%	0,20%	0,23%	0,23%	0,20%	0,20%	0,18%	0,19%	0,21%	0,20%
2020	0,18%	0,40%										

GARCH: Unexpected Inflation Conditional Volatility Estimates

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2010											0,33%	0,33%
2011	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%
2012	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%
2013	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,33%	0,34%	0,34%	0,34%	0,34%	0,34%
2014	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2015	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2016	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2017	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2018	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2019	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,35%	0,35%	0,35%
2020	0,35%	0,35%										