EXAMINING THE PRESENCE OF FACTOR PREMIUMS IN SOUTH AFRICA'S LOCAL CURRENCY SOVEREIGN BOND MARKET

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Declaration

I hereby declare that this study is my own unaided work and that I have correctly acknowledged and referenced the work of others. It is submitted to fulfill the requirements for the degree of Master of Commerce in Investment Management at the University of the Witwatersrand, Johannesburg, South Africa.

I declare that this academic work has not been submitted for any other degree or examination at the University of the Witwatersrand or any other institution.

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Signed

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Abstract

While factor investing has gained prominence in recent decades – both in the academic literature and in its application to active, passive, and smart beta strategies in equity markets – it has a decidedly modest footprint in fixed income markets. This study contributes to the literature by examining the presence of factor premiums on the cross-section of South Africa's sovereign bond market, assesses their contribution to return variation, and assesses whether such factors are unique or subsumed by other market factors. Established measures of value, carry, momentum, and reversion from the literature are explored in this study across long-only, long-short, and combination portfolios. These portfolios are constructed from on-the-run, sovereign-issued local currency bonds.

This study finds statistically significant factor premiums for long-only value, carry, and reversion portfolios. Additionally, statistically significant factor premiums are identified across long-only and long-short combination portfolios. In many portfolio iterations, factor premiums are associated with improved risk efficiency and reduced return correlation relative to the sovereign bond benchmark. These findings lay further challenges to the EMH and the application of the CAPM in South Africa's sovereign bond market.

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1. Introduction

1.1. Background and overview

There is a wealth of established financial market literature on factor investing in international equity markets, where factor investing refers to the investment practice that targets specific drivers of return across financial instruments and asset classes. However, despite the size and significance of the fixed income asset class, there remains comparatively little research examining the merits of factor investing in international and domestic fixed income markets.

The academic literature on investment factors dates to the studies of Basu (1977) and Banz (1981), but Fama and French (1992) are credited for popularizing the literature. While Fama and French (1993) extend their research to include the sovereign and corporate bond market in the US, offering a bridge for an extension of the research that was gaining prominence in equity markets at the time, academic interest in fixed income factor investing has remained decidedly modest, as detailed by Bektić, Hachenberg and Schiereck (2021). This holds particularly true in an emerging market context, where researchers are often plagued by underdeveloped yield curves or related data constraints. The South African sovereign bond market breaks this mold, with a comparatively deep and liquid market relative to the size of the economy. South Africa has a well-developed local currency sovereign bond market, lending itself as a suitable environment to explore the presence of fixed income factors in an emerging market context.

This study intends to contribute to the literature by examining the presence of investment factors in the cross-section of South Africa's local currency sovereign bond market and further assessing whether such factors are unique or subsumed by other market factors.

1.2. Motivation of the study

Understanding the role that investment factors play in equity markets, and their adoption to improve risk-adjusted outcomes in a cost-efficient manner, has become a key component of equity portfolio construction in recent decades. However, this management framework has been slow to transfer to the fixed income portion of many investors' portfolios.

Ironically, the case for factor investing in a fixed income context is compelling given the various shortcomings of the market capitalization-weighted benchmark schemes often adopted by fixed income fund managers. These shortcomings include, but are not limited to, exposure concentration to often overly indebted counters, liquidity challenges, and limited price transparency across the asset class.

1.3. Knowledge gap

While equity-based factor investing has been prominent in the academic literature in recent decades, the understanding and appreciation of fixed income factors have lagged considerably. Data limitations are the primary constraint to the development of the factor investing literature in emerging markets, given the dearth of large and complete data sets in local currency fixed income markets relative to equity markets. These constraints are particularly binding in an emerging market context. However, South Africa's local currency sovereign bond market is characterized by its depth and liquidity – necessary preconditions for studying the transcension of the factor investing literature across asset classes. This chasm in the literature, despite the size and importance of the fixed income asset class in global financial markets, presents an apparent, yet surmountable, knowledge gap. To address this gap, this study draws on the established factor investing literature across equity and fixed income markets in developed economies and examines their presence and significance in South Africa's local currency sovereign bond market. This study not only extends the factor premium research to emerging market economies but may also offer market practitioners insights into alternative portfolio construction and risk management modalities.

1.4. Research objective

This study examines the presence of factor premiums in the domestic sovereign bond market. Specifically, the first research question posed is whether value, carry, momentum or reversion premiums exist in the cross-section of South Africa's local currency sovereign bond market. Drawing from Brooks, Palhares and Richardson (2018), the research question will extend to examine whether the premiums captured by value, carry, momentum, and/or reversion are unique and cannot be subsumed by other bond market factors. A logical extension of the analysis is to test for value, carry, momentum, and/or reversion premiums in a multivariate setting, where fixed income factor premiums are regressed on macroeconomic variables. Therefore, the research question evolves to whether macroeconomic variables explain value, carry, momentum, and/or reversion premiums in South Africa's local currency sovereign bond market. Lastly, if the various fixed income factor premiums are both present and independent, a further research question posed is what combination of value, carry, momentum, and/or reversion yields superior return outcomes in South Africa's local currency sovereign bond market?

1.5. Hypothesis

The hypotheses in this study stem from the research questions presented in Section 1.4. Roman numerals are used to label each hypothesis, with conventional numerals used to identify the null (0) and alternative (1) hypothesis.

1.5.1 Hypothesis I

HI,0: Value, carry, momentum, and/or reversion premiums do not exist in the cross-section of South Africa's local currency sovereign bond market, irrespective of the classification scheme and/or holding period.

HI,1: Value, carry, momentum, and/or reversion premiums do exist in the cross-section of South Africa's local currency sovereign bond market.

1.5.2 Hypothesis II

HII,0: The premiums captured by value, carry, momentum, and/or reversion are not unique and are instead subsumed by other bond market factors (principal components).

HII,1: The premiums captured by value, carry, momentum, and/or reversion are unique and are not subsumed by other bond market factors.

1.5.3 Hypothesis III

HIII,0: Macroeconomic variables fail to explain value, carry, momentum, and/or reversion premiums in South Africa's local currency sovereign bond market.

HIII,1: Macroeconomic variables can wholly or partly explain value, carry, momentum, and/or reversion premiums in South Africa's local currency sovereign bond market.

1.5.4 Hypothesis IV

HIV,0: No combination of value, carry, momentum, and/or reversion yields superior return outcomes in South Africa's local currency sovereign bond market.

HIV,1: Various combinations of value, carry, momentum, and/or reversion yield superior return outcomes in South Africa's local currency sovereign bond market.

1.6. Potential benefits of the study

Factor investing in fixed income securities has a decidedly modest footprint in the financial literature relative to the well-established research that covers international equity markets. Backed by decades of literature on the presence of systematic factors in equity markets, factor investing in the asset class has proliferated over that time, even spilling over into smart beta investment strategies. In stark contrast, despite the size of global fixed income markets and the prominent role that sovereign debt often plays in diversified investment portfolios, there exists a comparative dearth in the academic literature on fixed income factors both globally and domestically. Therefore, the foremost benefit of this study is the extension of the prevailing South African and emerging market factor investing literature to the domestic sovereign bond market.

Additionally, the management of fixed income portfolios in international financial markets is predominated by two primary risk channels: interest rate risk management and credit risk management. Therefore, the identification of independent fixed income factors may contribute to the generation of returns that break from the traditional risk management and alpha generation channels in fixed income markets.

Guided by the findings of Brooks and Moskowitz (2017) who find that the value premium in seven international bond markets remains significant when controlling for macroeconomic variables and principal components, another potential benefit of this study is the identification of fixed income factors in the South African sovereign bond market that subsume macroeconomic variables and therefore contribute to risk diversification in the management of domestic sovereign bond strategies. This diversification potential may contribute to enhancing the risk-adjusted return properties of the commonly adopted portfolio construction techniques in domestic sovereign bond portfolios.

2. Literature Review

The academic literature on investment factor premiums, also referred to as factor investing, dates from the studies of Basu (1977) and Banz (1981). However, the seminal study of Fama and French (1992) is specifically credited with popularizing the literature. They find that when used alone, three empirically determined variables, leverage, size, and book-to-market equity, reliably contribute to explaining the cross-section of average returns on the American Stock Exchange (Amex), the New York Stock Exchange (NYSE), and NASDAQ listed common equity between July 1963 - December 1991. When used in combination, the authors find that size and book-to-market equity subsume the explanatory power of leverage in explaining the cross-section of average US common equity returns.

Extending their analysis to the sovereign and corporate bond market in the US, Fama and French (1993) document that their portfolios intended to replicate two term-structure factors across the yield curve, default premium, and term premium, capture most of the variation in the returns of corporate and sovereign bond portfolios in their sample set. The explanatory power of these variables, which carry no significance in asset-pricing theory, diverges from the market beta from both the Sharpe (1964) and Lintner (1965) capital asset pricing models. While the insights from Fama and French (1992) were not novel; with the value premium in the financial economics literature per Basu (1977), the size effect per Banz (1981) and the liquidity premium per Amihud and Mendelson (1986), they are nonetheless credited for popularizing the pricing anomalies due to the large sample size and robust methodology employed in their study.

In a related strand of literature, Jegadeesh and Titman (1993) are credited for evidencing a momentum factor in the cross-section of US listed equity returns. The authors construct fictitious portfolios that invest in historical "winning" shares, while simultaneously selling "loser" shares over a medium-term investment horizon – between 3- and 12-month post portfolio formation. They apply this strategy to all US listed equity on the Center of Research in Share Price (CRSP) database between 1965 - 1989 over varying holding periods (3, 6, 9, 12 months) and portfolio formations, resulting in thirty-two test portfolios. They find that thirty-one of the portfolios generate statistically significant excess returns. Furthermore, highlighting evidence of short-term price reversals found in earlier literature, the authors observe that allowing a one-week gap between the formation of a portfolio and investment action yielded increased profits from their momentum-based investment strategy.

Before the seminal work of Jegadeesh and Titman (1993), momentum was hardly explored as an investment factor, but was instead preceded by the relative strength strategies that were popularized in the academic literature by De Bondt and Thaler (1985) who explored reversals and overactions in listed US equities between January 1926 - December 1982 and evidence reversals in total return outcomes of historical outperformers and underperformers over long holding periods, typically ranging between twelve and sixty months. Other contributors to the literature on relative strength strategies, Jegadeesh (1990) and Lehman (1990), document reversals in listed US equity returns over shorter investment horizons (daily, weekly, and monthly).

While style investing has gained prominence in recent decades – in the literature as well as its application to active, passive, and smart beta strategies in equity markets – it still has a modest footprint in fixed income markets, as detailed by Bektić, Hachenberg and Schiereck (2021). Despite the comparatively modest literature, compelling evidence of the presence of factor premiums in sovereign bond markets nonetheless exists. This includes Baltussen, Martens, and Penninga (2021), who study the presence of sovereign bond factor premiums across sixteen developed market jurisdictions, namely: Australia, Belgium, Canada, Denmark, Germany, France, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdon, United States, and New Zealand between December 1799 - 31 December 2020. The authors provide rich historical evidence of the persistence of value, momentum, and low-risk factor returns over time. Furthermore, Dekker, Houweling and Muskens (2021) find that value, momentum, low-risk, and size factors predict futures excess returns on the cross-section of emerging market hard currency corporate bonds. In a South African context, Hariparsad and Maré (2024) identify cross-sectional "non-parallel" curve risk premia that deliver persistent outperformance across regimes in the local sovereign bond market, extending factor attribution beyond duration and spread effects.

2.1. Value

The value premium, proxied using the book-to-market equity ratio by Fama and French (1992), explains the tendency of relatively cheap assets to outperform relatively expensive assets. Asness, Moskowitz and Pedersen (2013) explore the transcension of the value premium between various markets and asset classes. In addition to its presence in their sample set of US, Europe, and Japan common shares, they identify value premiums in their sample of government bonds, currency markets, and commodity futures.

For bonds, Asness, Moskowitz and Pedersen (2013) study sovereign bond returns across ten developed market jurisdictions, namely: Australia, Canada, Denmark, Germany, Japan, Norway, Sweden, Switzerland, the United Kingdom, and the United States between January 1982 - July 2011. Consistent with the approach adopted by DeBondt and Thaler (1985), the authors use the 5-year change in the yield of 10-year bonds as their value measure. They also explore alternative methods for defining value in sovereign bond markets, including real bond yields (10-year nominal yield relative to the 5-year consumer inflation forecast) and the term spread, which they identify as the differential between the sovereign 10-year nominal yield and what they term the "short rate".

Incorporating two of the value premium measures defined by Asness, Moskowitz and Pedersen (2013), specifically the real bond yield and the sovereign term premium, Mazzoleni and Kunz (2018) also identify the presence of a value premium in their study of nominal government bonds between March 1989 - October 2017 across twelve developed markets: Australia, Canada, France, Germany, Hong Kong, Italy, Japan, the Netherlands, Spain, Sweden, the United Kingdom, and the United States. They attribute the outperformance to the two primary fixed income return components; spot return and carry, using the carry definition of Koijen, Moskowitz, and Vrugt (2018). Their results attribute almost half of the excess return of the term spread portfolio to carry. They also find that the term spread is positively correlated to carry.

Brooks, Palhares and Richardson (2018) employ an implied real yield approach in their assessment of a value premium in nominal government bonds across thirteen developed markets: Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, the United Kingdom, and the United States between January 1997 - June 2017. They find a tendency for countries with relatively high real yields to outperform their counterparts. Additionally, the authors observe an improvement in the Sharpe ratio for the low tercile portfolios relative to the high tercile portfolios. In their monthly generated long-short portfolios which are comprised of an overweight allocation to high value bonds and an underweight allocation to low value (growth) bonds, the authors observe that value generates a statistically significant outperformance of 2.02% and a Sharpe ratio of 0.65.

Brooks and Moskowitz (2017) explore the relationship between the value premium and the commonly accepted bond market factors across seven developed market bond curves, namely: Australia, Canada, Germany, Japan, Sweden, the United Kingdom, and the United States. The authors employ an implied real yield as their measure of value, which they specify as the differential between the relevant nominal bond yield and the maturity-matched consumer price inflation (CPI) forecast. To understand the factors that drive sovereign bond returns across countries and over time, the authors construct three simple portfolios intended to span the common variations in the yield curve. They specify the first portfolio as a “level” portfolio that is comprised of the 10-year nominal bond from each country in their sample set. The second portfolio represents a duration neutral “slope” portfolio, comprised of a long holding in the 10-year maturity bond and a concurrent short holding in the 2-year maturity bond. The third portfolio represents a “curvature” portfolio that is long the 5-year maturity bond and short the 10- and 2-year bonds in each country on a risk neutral basis.

Brooks and Moskowitz (2017) use these simple portfolios to represent the first three principal components of the yield curve identified by Litterman and Scheinkman (1991), which capture almost all economically meaningful variation across the yield curve. They motivate the formation of these portfolios based on their constant portfolio weights and economic intuitions relative to the principal components, whose weights change over time and are prone to overfitting the yield curve across time periods.

The authors then regress the excess return of the level portfolio for each country to its respective value metrics and find economic significance in the relationship. The value factor increases in statistical significance when momentum and carry are included in the regression, and it remains statistically significant when the principal components are also included. Critically, Brooks and Moskowitz (2017) observe from their study that the first principal component, which represents the level of the yield curve becomes statistically insignificant in the presence of the value factor. Value also loads positively on the first principal component when risk-neutral long-short portfolios are examined. This evidence challenges the economic understanding of the drivers of excess returns across sovereign bonds by suggesting that value, when measured as a bond’s implied real yield, subsumes the “level” factor in a yield curve decomposition based on principal component analysis.

To further assess the power of value as an explanatory variable for government bond returns, Brooks and Moskowitz (2017) add macroeconomic variables (the annual rate of change in consumer price inflation and industrial production) for each country to their regression analysis for the level, slope, and curvature portfolios in their sample set. Although the macroeconomic factors are found not to capture any information in their slope and curvature portfolios, value is found to remain significant in the presence of macroeconomic variables and the principal components.

2.2. Carry

Carry as an investment concept had been studied almost exclusively in currency markets before the important contribution to the literature by Koijen, Moskowitz, and Vrugt (2018) who apply the concept to a variety of financial asset classes. They broadly define the carry of an asset "as its future return assuming that prices stay the same". Specific to bonds, they define carry as the return earned if the term structure of the yield does not change over a specified holding period (adjusted for the risk-free rate). Accordingly, carry in bond markets consists of two components: (1) a bond's yield spread relative to the risk-free rate, also referred to as the slope of the yield curve; and (2) the "roll down", which represents the price change in a bond owing to its movement along a downward sloping yield curve when the yield curve structure remains unchanged over a specified holding period. The carry calculation for bonds therefore assumes that the term structure of interest rates remains constant, and that bonds that roll down an upward sloping yield curve over time will enjoy a price appreciation approximated by the yield change multiplied by the instrument's modified duration.

The fixed income sample employed by Koijen, Moskowitz, and Vrugt (2018) consists of: (1) level (10-year maturity) and slope (10-year minus 2-year) portfolios across ten sovereign bond markets (Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, and Switzerland, the United Kingdom, and the United States) between November 1983 - September 2012, and (2) 1- to 10-year maturity US Treasury bond data between August 1971 - September 2012. The authors employ various approaches and weighting schemes to choose the exact weights for their carry-trade portfolio. The authors' findings, which are robust to various weighting schemes, indicate that the returns attributable to carry strategies in developed markets are not explained by other known return factors such as value and momentum – both within and across asset classes, including sovereign bond markets. While the relationship between carry and the other return factors varies across asset classes, exhibiting a positive relationship in some asset classes and a negative relationship in others, the strength of these relations is not large – with carry consistently producing positive alpha in the presence of those factors. Therefore, the authors find that carry as an investment factor in sovereign bond markets is not explained by the known return predictors. Instead, carry seems to subsume many of these return predictors, providing a consolidated framework of return predictability in sovereign bond markets. The authors conclude that carry represents a significantly different return predictor, both within and across financial markets, including global bonds and US Treasuries.

Brooks, Palhares and Richardson (2018) broadly define carry as "the tendency for higher yielding assets to outperform lower yielding assets". For bonds, they specify that "carry measures expected returns if nothing happens but for the passage of time". For their study of carry across the 13 bond markets in their sample dataset between January 1996 - June 2017, the authors test for carry across each country by examining both long and equal-duration weighted long-short portfolios – where the portfolio sorts are based on term-to-maturity terciles (1-5 year, 5-10 year and 10-30 year maturity buckets). The authors find a large and statistically significant excess return for carry portfolios across their sample set of government bonds (2.21%; t-stat = 2.11), but the carry premium attracts a fair degree of volatility and therefore results in a lower Sharpe ratio than the value factor across the same dataset.

Brooks, Palhares and Richardson (2018) also examine whether the return premium captured by carry constitutes is unique and not subsumed by other known bond market factors. The authors document only a modest relation to bond term premium in their regression analysis. Additionally, using quarterly economic growth, consumer price inflation, real yield, volatility, and liquidity data, the authors examine the sensitivity of their long-short sovereign bond portfolios to shocks in financial market and broader macroeconomic conditions. They find that the returns of their carry portfolios are generally resilient to economic and financial market fluctuations.

Brooks and Moskowitz (2017) present evidence that the returns attributable to carry across both their cross-sectional and time-varying level portfolios are positively correlated to the carry returns in global equity, currency, and sovereign bond markets. Koijen, Moskowitz, and Vrugt (2018) document that all carry strategies across asset classes have excess kurtosis, which results in fat-tailed return distributions and occasionally large relative profits and losses. Lastly, Brooks and Moskowitz (2017) and Hamdan, Pavlowsky, Roncalli, and Zheng (2016) identify that due to their excess kurtosis and their related higher probability of drawdowns, carry strategies are extremely risky during periods of market distress.

2.3. Momentum

Momentum investing, credited to Jegadeesh and Titman (1993), is an investment strategy premised on investing in financial assets based solely on their recent returns. The strategy relies on a short-term continuation of the prevailing return trajectory of a financial asset, which market participants may seek to exploit and systematically profit from.

Adopting simple and relatively standard measures for momentum, Asness, Moskowitz and Pedersen (2013) evidence the existence of a positive risk premia for momentum across all major asset classes, including sovereign bond returns across 10 developed market jurisdictions between January 1982 - July 2011. The authors caveat their findings by noting that some of their results are not statistically significant. Bonds are particularly found to exhibit weak evidence of momentum in returns across asset classes.

The authors employ a cumulative return for the past 12-months (excluding the most recent) as their measure of momentum, adopting it to maintain a uniform and consistent approach across asset classes – as well as minimizing the injurious effects of data snooping. Accordingly, their efforts to maintain simplicity and avoid data snooping may understate the true gross returns available to investors who employ alternative momentum measures. Brightman and Shepherd (2016), on the other hand, sampling 10-year sovereign bond data across eight developed market economies between January 1989 - June 2016, evidence statistically significant mean returns and Sharpe ratios on bond portfolios formed based on the 12-month trailing returns of its constituents. The momentum portfolios employed by the authors use a time series formation in which each counter's returns are compared to its own history. They employ a long-short investment strategy, investing in futures contracts with positive 12-month historic return momentum and short futures contracts on sovereign bonds with negative 12-month historic return momentum. Their portfolio formation process can result in net long or net short positions at any point, although these exposures broadly offset over the sample period.

In a novel approach, Brooks and Moskowitz (2017) study momentum for the level, slope, and curvature portfolios that they construct across seven countries: Australia, Germany, Canada, Japan, Sweden, the United Kingdom, and the United States. They find that momentum investing (on a duration-adjusted basis) is insignificant at predicting returns for their sample of sovereign bond portfolios. Contrasting to the evidence they find with value and carry, momentum is found to not capture any information from the principal components in their sample set. Momentum only becomes statistically significant when carry and the principal components are included in the regression analysis, but now with a negative coefficient. Principal components are found to only explain 25.5% of the cross-sectional variation and 40.7% of the time series variation of momentum in slope strategies. In their time series analysis, the authors find that the explanatory power of momentum remains significant for curvature strategies but is reduced for level strategies.

In addition to analyzing the zero-coupon yields of the seven countries, where they analyse synthetic returns, Brooks and Moskowitz (2017) also study a sample set of tradeable bonds that are included in the J.P. Morgan Government Bond Index (GBI). This sample set facilitates the study of live returns on a tradeable portfolio, offers a broader cross-section of bonds and addressed concerns related to the return mismeasurement. The J.P. Morgan GBI is formed from a wider cross-section of markets, but it is limited in its shorter time series relative to the authors' zero-coupon data. Specifically, the index is comprised of liquid, market capitalization weighted government bonds across thirteen developed market economies: Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, the United Kingdom, and the United States.

While slightly adapting the portfolio generating process used in the assessment of the value factor across the dataset for zero-coupon bonds, the authors generate level, slope, and curvature portfolios to represent the first three principal components and study the performance of fixed income factors using the on-the-run J.P. Morgan GBI data. Momentum is found to generate a 5.02% outperformance (t-stat = 2.46) in their level portfolio when the principal components are added to the regression analysis. They also find a negative correlation between momentum and both the first principal component and the value factor across their level, slope, and curvature portfolios. These findings support the notion that momentum represents a distinctive factor in level portfolios and its influence on returns is not subsumed by other known factors.

Brooks and Moskowitz (2017) also compare the returns of their level, slope, and curvature strategies to the factor returns from commodity, currency, and equity markets. They adopt the carry definition defined by Koijen, Moskowitz, Pedersen, and Vrugt (2016) for sovereign bonds and their definition of momentum and value for the other asset classes is consistent with Asness, Moskowitz, and Pedersen (2013). The authors find a positive correlation between momentum strategies that select yield level portfolios across countries and the momentum strategies that select commodity, currency, and equity market indices. These results evidence the strong linkage between momentum strategies across the major financial asset classes, supporting the findings of Asness, Moskowitz, and Pedersen (2013).

Finally, Asness, Moskowitz, and Pedersen (2013) evidence a negative relationship and consequent diversification benefit of value and momentum in their equal weight combination portfolios. They construct zero-cost portfolios to examine the efficacy of their various style portfolios, noting that the liquidity of their signal weighted portfolios remains unimpaired by the portfolio construction design relative to a market value-weighted alternative. They also observe a negative correlation between the first principal component and the liquidity risk factor loadings on value and momentum. They suggest that the negative relationship is due to the opposite sign loadings on liquidity risk – with momentum loading positively on liquidity and value loading negatively.

2.4. Reversion

Reversion, as referred to in this study, is rooted in the seminal work of De Bondt and Thaler (1985) who investigate the pricing efficiency of common equity on the NYSE between January 1926 - December 1982.

The authors construct "winner" and "loser" portfolios based on the 36-month cumulative excess return of the underlying common equity. These portfolios are held for nonoverlapping three-year periods before being reconstituted. The authors find evidence of behavioral biases in the market's reaction to news events – with extreme reversals in historical outperforming and underperforming equity over long holding periods, typically ranging between 12- and 60-months. On average, the empirical results found that historical loser portfolios outperformed the market by a cumulative 19.60% when measured 36-months after portfolio formation. Historical winner portfolios underperform the benchmark portfolio by 5.0% when measured 36-months after portfolio formation. Consequently, the cumulative average residual between the winner and loser portfolios was 24.6% over the sample period (t=stat = 2.20) when measured 36-months after portfolio formation. These persistent, long-term return reversals suggest a mean-reverting trend, inconsistent with the Efficient Market Hypothesis. The Overreaction Hypothesis is the authors' enduring contribution to the behavioral finance literature, which posits that investors habitually overreact to unexpected news flow, contributing to excessive movement in common equity valuation beyond intrinsic value.

Poterba and Summers (1988) study the mean reverting properties of common equity in the United States and seventeen other nations. The sample set spans both developed and emerging market economies, including equity price data from Columbia between 1959 - 1983; Germany between 1957 - 1986; South Africa between 1957 - 1986; the United Kingdom between 1939 - 1986; and the United States between 1871 - 1985.

The authors use variance ratio tests to analyze equity price data. These tests were central to their assessment of whether returns across markets followed a random walk or exhibited mean reverting properties. When following a random walk, common equity prices evolve such that future price returns are independent of past returns – reflected by a variance ratio of unity. Conversely, a variance ratio significantly different to unity suggests mean reverting properties in the relevant total return series. The authors find consistent evidence of serial correlation in equity price returns across jurisdictions over short-horizons, and negative autocorrelation over long investment horizons. The serial correlation in equity price returns over short-horizons is consistent with momentum effects, and the negative autocorrelation is consistent with mean-reverting properties in equity price returns in the long-term.

Daniel, Hirshleifer and Subrahmanyam (1998) contribute to the literature by proposing a theory of security market under- and overreactions based on two prominent psychological biases: investor overconfidence in the precision of private information; and biased self-attribution, which results in asymmetric changes in investor confidence as a function of their investment outcomes. The authors show that overconfidence contributes to negative long-term autocorrelation, excess volatility, and return predictability when the actions of investment managers are correlated with equity mispricing. Biased self-attribution, on the other hand, contributes to positive short-term autocorrelations, but negative correlation between realised future returns and historic long-term equity market performance. The concept of negative autocorrelations, which refers to the inverse relationship between historic asset price returns and future returns, is closely tied to long-term return reversals and mean reversion. The authors argue that this phenomenon, specifically in the context of long-term returns, is largely explained by behavioral factors like overreaction and investor overconfidence.

Chopra, Lakonishok and Ritter (1992) study the monthly returns from NYSE listed common equity between 1926 - 1986 for evidence of return overreaction and long-term return reversals. From the data set, all common equity that had been continuously listed for the prior five calendar years was ranked and assigned to one of twenty portfolios based on its buy-and-hold returns over the period. Accordingly, the first portfolio ranking period ends in December 1930 and the last one ends in December 1981, for a total of fifty-two ranking periods.

The authors find economically important long-term overreaction effects across their data set, where extreme prior losers outperform extreme prior winners by 5 - 10% per annum in the subsequent 5-year portfolio holding period. This abnormal return holds even when adjusting for size and beta effects. Shleifer and Vishny (1997) reason that these long-term return premiums are not arbitraged by active investors due to the opportunity cost of protracted market mispricing. According to the authors, the unpredictability of investor sentiment may contribute to the persistence of market mispricing in the short-term, with investors bearing the risk and potential cost of asset price deviation from fundamental fair value. This risk is pronounced when investors are risk averse, leveraged, or managers of third-party funds. For these reasons, they posit that active investors are likelier to exploit short-term return anomalies, with modest capital devoted to long-term arbitrage.

2.5. Combination portfolios

Having specified individual fixed income factors, this study moves on to determine whether implementing the various strategies in combination is more beneficial from a total return and risk utilization perspective than each in isolation. In this regard, Asness, Moskowitz and Pedersen (2013) evidence that value and momentum are negatively correlated, both within and across asset classes, including the fixed income markets in their sample set. The negative correlation between value and momentum strategies, in combination with the significantly positive expected returns across asset classes, implies that a combination of the two strategies results in improved risk-adjusted portfolios relative to those of the standalone strategies.

Brooks, Palhares and Richardson (2018) also construct a multifactor portfolio in their assessment of fixed income factors across sovereign bond markets and find that momentum is negatively correlated to value, carry, and quality for sovereign bonds (-0.32, -0.42, -0.22). They conclude that investors can derive significant diversification benefits from combining factor based sovereign bond portfolios (combination portfolio alpha of 2.8% and t-stat = 3.89) relative to single factor portfolios. Brightman and Shepherd (2016) also evidence a negative correlation of -0.18 between the value and momentum portfolios in their sovereign bond market study.

In addition to the compelling evidence of significant abnormal returns generated from the various style portfolios across sovereign bond markets, the evidence of significant abnormal returns due to the combination of value and momentum strategies only serves to present a further challenge for asset pricing theories to accommodate. Accordingly, the research that follows adds to the literature on pricing anomalies that challenge both the Capital Asset Pricing Model and the Efficient Market Hypothesis.

Hong, Harrison and Stein (1999) present a unified theoretic framework for underreaction, momentum, and overreaction in financial asset markets. The authors diverge from the assumption that asset prices are driven by the cognitive biases of a single economic agent adopted by Berberis, Shleifer, and Vishny (1998) and Daniel, Hirshleifer, and Subrahmanyam (1998). They instead emphasise the interaction between heterogenous economic agents. Specifically, their theoretical framework is centered on the interaction between “news watchers” and “momentum traders”. The authors assume that both groups are only boundedly rational and are consequently only able to process subsets of the publicly available information. News watchers act on valuation forecasts from privately observed fundamental analysis. In contrast, momentum traders condition on historic price changes. Additionally, the authors assume that private information gradually diffuses across the news watcher population. An implication of the slow rate of information diffusion in the model is an elevation in short-run return correlations. Hong, Harrison and Stein (1999) posit that this backdrop not only piques the interest of momentum traders but also contributes to pronounced return overreactions and larger long-run reversals. Consequently, the authors conclude that momentum prone financial assets are also likely to be reversal prone.

3. Data description and research methodology

3.1. Data description

The yield to maturity (YTM) of South African local currency, sovereign issued fixed-rate bonds forms the primary data set used for this study. The data is sourced from IRESS Expert. Supplemental bond data, including the issuance date, first coupon date, coupon frequency, and redemption date, is sourced for Bloomberg. The market and economic data sets used in the study are also sourced from Bloomberg. The study spans from 31 May 2007 - 31 October 2023 and includes both on-the-run and redeemed sovereign bonds, negating potential survivorship bias.

The YTM data and supplemental information are used to facilitate the calculation of the various pricing metrics for each bond. These include modified duration, rand per basis point (PV01), clean price, accrued interest, and all-in price. Bond returns can then be calculated from the monthly price data.

3.2. Theoretical framework

The theoretical frameworks used in this study are the capital asset pricing theory and the efficient market hypothesis.

The efficient market hypothesis (EMH) is credited to Fama (1970) and defines an efficient financial market as one where prices fully reflect relevant and available information. The capital asset pricing model (CAPM), accredited to Sharpe (1964), and Lintner (1965), describes the relationship between systematic risk and expected return for assets when markets are in equilibrium, market participants have homogenous expectations, and when all investors pursue a mean-variance optimizing objective. The CAPM builds on the model of portfolio choice developed by Harry Markowitz (1959), who posits that the expected return of a financial asset should be solely determined by its risk. While CAPM offers powerful and intuitive predictions on asset pricing and the relationship between risk and expected returns, its empirical record is rather poor – which calls into question its practical use. The primary challenge presented by the CAPM, identified by Roll (1977), is the theoretical and empirical elusiveness of the market portfolio which is central to the model.

The EMH is linked to the risk-return relationship popularized in the literature by Markowitz (1959) and the CAPM in that asset prices are presumed to immediately and fully price new and relevant information as it becomes available, with no subsequent benefit to trading on such information by market participants. Hereafter, the underlying risk of the asset should be the only driver of returns. However, the EMH and CAPM continue to be the subject of scrutiny and academic challenge, with two primary avenues of rebuttal: first, risk is multi-dimensional, and second, risk is disputed by many as a driver of return in favour of behavioral biases.

Fama and French (1992) are credited for consolidating pricing anomalies into a unified pricing model. They evidence that when incorporated within a single pricing model, size and value effects are responsible for most of the variation in United States equity market returns. This study follows a similar vein in assessing the presence of fixed income factors in South Africa's sovereign bond market, their independence, and whether they describe a significant portion of the cross-sectional variation in sovereign bond returns. Therefore, the findings in this study have potential implications for the

EMH and the application of the CAPM in South Africa's sovereign bond market, but the notion of whether fixed income factors are indeed risk factors is not directly considered.

3.3. Research methodology

This study examines the presence of style premiums in the domestic sovereign bond market and assesses their contribution to cross-sectional return variation.

Asness, Moskowitz and Pedersen (2013) document the transcension of the value, momentum, quality, and carry premiums across asset classes in developed financial markets, including sovereign bonds. Studying these dynamics in the domestic sovereign bond market first requires an appropriate measurement of these factors for the local context. Drawing from Brooks, Palhares and Richardson (2018), and overlaying the betting-against-beta framework of Frazzini and Pedersen (2014), this study employs simple and standard indicators for these style factors. Specifically, the "real bond yield" is used as the measure of value, which in this context refers to the nominal bond yield minus the maturity-matched consumer price inflation forecast. The implied real yield is then divided by the instrument's modified duration, which translates to a standardized measure of implied real yield per unit of interest rate risk. This measure seeks to capture the relative value of a bond by comparing its current value to a fundamental anchor, where relatively cheap sovereign bonds would be expected to outperform their relatively expensive counterparts.

For carry, this study uses the term spread on bonds relative to the 3-month Treasury Bill rate, consistent with the definition employed by Koijen, Moskowitz, Pedersen, and Vrugt (2016). The term spread is then divided by the instrument's modified duration, yielding a standardized measure of carry per unit of interest rate risk. This measure is intended to represent the coupon accretion element of bond returns. The 12-month trailing total return on sovereign bonds is used to measure momentum, which is considered a standard measure of this return factor in equity and other financial asset classes. Lastly, reversion as referred to in this study seeks to capture the pull to par effect, where the price of a bond converges to its redemption value with the passage of time. For the purposes of this study, this effect is specifically sought for oversold bonds, with the 18-month trailing total return used to measure the negative price momentum of South African, sovereign issued fixed-rate bonds. The reversion portfolio will be long exposure to oversold bonds on this basis, seeking to benefit from the pull to par effect.

For each investment style, interest rate (PV01) neutral portfolios are formed at the beginning of each month along the cross-section of the sovereign bond curve. Interest rate neutrality is achieved by scaling the returns of each on-the-run bond to the average cross-sectional PV01 for the prior month. This scaling is achieved by lending or borrowing at the bank rate (3-month JIBAR) as appropriate for each instrument to achieve PV01 neutrality. Instruments with a lower-than-average PV01 will therefore borrow at the prevailing bank rate, earning instrument-level returns on their outright exposure and borrowings, offset by the debt servicing cost. Instruments with higher-than-average PV01 will be net lenders, lending at the prevailing bank rate and earning the bank yield alongside the month's instrument-level return. This scaling of interest rate sensitivity on the yield curve results in duration-neutral (but rand imbalanced) exposures, allowing for a cross-sectional and time series comparison of bonds that are insensitive to the effects of parallel yield curve shifts.

Equally weighted tercile portfolios are then formed across investment styles at the beginning of each month, with T1 representing the most attractive tercile and T3 the least attractive on a relative basis. Cross-sectional duration neutrality eliminates the effects of parallel yield curve shifts as a return contributor, facilitating the comparison of returns within and across investment styles on a like-for-like basis.

The study adopts the approach used by Brooks, Palhares and Richardson (2018) for the formation of combination portfolios from the data set. The combination portfolios are equally weighted across the four style factors. PV01 neutrality across instruments and terciles eliminates the influence of interest rate risk as a possible return contributor across portfolios, ensuring their comparability from an interest rate risk perspective.

3.4. Limitations

This study adopts an empirical approach to assessing the presence, independence, and significance of fixed income factors in the domestic sovereign bond market. Therefore, the findings made are highly dependent on both the datasets and research methodologies that are relied upon. The historic data series for on-the-run bonds in South Africa is relatively short, and data availability therefore serves as a natural limitation relative to the international literature.

Additionally, two core assumptions underly the theoretical frameworks apply in this study. First, no pre-emptive judgement is made on whether CAPM holds true. Second, since this study seeks to determine whether fixed income style factors contribute to the cross-sectional variation in local currency sovereign bond returns in South Africa, the study is assumed to hold to the weak-form EMH and the arbitrage pricing theory (APT) model of Chen, Roll and Ross (1986). These frameworks specify that asset prices fully reflect relevant historical information and that only new information should impact expected returns. The APT framework in the asset pricing literature is not governed by the a priori definition of a theory, but rather depends on the empirical definition of the components that govern the data generating process of financial asset returns. Accordingly, this study adopts an empirical framework as it seeks to not only determine the presence of fixed income factors in South Africa's local currency sovereign bond market but also conclude on whether they suitably explain the cross-sectional variation in returns.

4. Data analysis and discussion

This chapter details the empirical results of the study. It begins with a summary of the sample data used and is followed by a presentation and discussion of the observations.

4.1. Sample data summary

The sample data used in this study represents the full subset of sovereign issued, South African local currency fixed-rate bonds between 31 May 2007 - 31 October 2023. Month-end data is used for the purposes of this study. The sample start date aligns with the availability of listed inflation swap data used for the calculation of the value premium. Sovereign bonds are the primary constituents of the Johannesburg Stock Exchange (JSE) All Bond Index (ALBI), an index comprised of the top twenty local currency, vanilla (fixed-rate, semi-annual coupon) bonds listed on the exchange – ranked dually by market capitalization and liquidity. Consistent with the ALBI exclusion criteria, the sample used in this study excludes bonds with a term to maturity of less than one year and bonds with embedded optionality. The periodicity and bond tenor range of the sample data used in this study are comparable to the sample used by Brooks, Palhares and Richardson (2018). The sample period also spans periods of significant financial market disruption, including the Global Financial Crisis (GFC) of 2008 - 2009, "Nenegate" in December 2015, and the Covid-19 pandemic in 2020.

The sample includes a combination of thirty on-the-run and matured sovereign bonds, accounting for potential survivorship bias in the data set. On average over the sample period; there are thirteen on-the-run sovereign fixed-rate bonds, ranging between a minimum of eleven bonds and a maximum of sixteen bonds; the historical average term to maturity of the index is 9.66 years, with a historical median of 7.55 years; the term to maturity ranges between a minimum of 1.00 year and a maximum of 35.69 years; the Price Value of a Basis Point (PV01), which measures the interest rate sensitivity of a bond's price to a basis-point change in yield, averages 462.23 and ranges between a minimum of 89.24 and a maximum of 1,433.06. The yield to maturity also captures an extreme range of variation across both the cross-section and time series, averaging 11.45% and ranging between a minimum of 4.76% and a maximum of 23.30%.

Table 1 exhibits the summary data used in this study. The sample data is transformed to form the value, carry, momentum, and reversion factor portfolios.

Table 1: Data summary

	Average	Median	Min	Max
Total instruments	13	12	11	16
Term	9.66	7.55	1.00	35.69
Modified duration	4.91	4.83	0.87	12.45
PV01	462.23	443.23	89.24	1,433.06
YTM	11.45%	10.98%	4.76%	23.30%

4.2. Normality and homogeneity of the variance tests

The Student's t-test and Welch's t-test both require that data be approximately normally distributed. As detailed by Ruxton (2006), the Student's t-test is ideal for assessing the statistical significance of datasets with homogenous variances while the Welch's t-test is used when the variance between datasets is unequal. The Mann-Whitney U-test is used in instances where the normality assumption is not met.

The Levene test, used to assess the homogeneity of variance between datasets, evidences that variances across the sovereign bond factor portfolios were not significantly different – validating the use of the Student's t-test for assessing the statistical significance of returns across the data set.

4.3. Performance of factor portfolios

4.3.1. Value portfolio

Value, as defined in this study, measures the implied real yield offered by South Africa's on-the-run, fixed rate, local currency sovereign bond market. The implied real yield is divided by the instrument's modified duration, which translates to a standardized measure of implied real yield per unit of interest rate risk.

While the tercile portfolios are constructed on an interest-rate neutral basis by lending or borrowing at the bank rate (3-month JIBAR) as appropriate for each instrument to achieve PV01 neutrality, ensuring their direct comparability, there remain noteworthy differences in risk and return metrics across terciles. These include term to maturity, mid yield to maturity (YTM), ex-ante implied real yields, and ex-ante carry.

The average term to maturity of the T1 value portfolio is 8.50 years, considerably shorter than the average term to maturity of 17.22 years for the T3 value portfolio. The average term to maturity of the equal weight on-the-run sovereign bond benchmark is 13.19 years. The average yield to maturity of the T1 Value portfolio is 8.38%, relative to the average yield to maturity of 9.02% for the T3 value portfolio and 8.86% for the benchmark. By design, the T1 value portfolio has the highest value factor across the factor portfolios in this study. The average monthly value factor of 0.68% on the T1 value portfolio is significantly different to the monthly average for the on-the-run benchmark of 0.45% and the value factors on all other portfolios in the sample set. It is noteworthy that the value premium for the T1 portfolio in this study dissipates when value is not normalized for interest rate risk. In this instance, when value is simply defined as the implied real yield on South African local currency sovereign bonds, the T1 value portfolio has an average ex-ante monthly real yield of 2.57% relative to the monthly average real yield of 2.63% for the on-the-run benchmark. The characteristics of Value Portfolios across terciles are summarised in Table 2.

The T1 value portfolio generates a mean monthly return of 0.77% and a standard deviation of 2.16%. These compare favourably to the mean monthly return of 0.65% and standard deviation of 2.36% for the equal weight on-the-run sovereign bond benchmark. Resultantly, the T1 value portfolio generates a mean monthly excess return of 0.13% relative to the benchmark over the sample period, which is statistically significant at the 5% level. The monthly average risk and return metrics for Value Portfolios are summarised in Table 3.

The mean monthly return and standard deviation of value portfolios exhibit a monotonic pattern across terciles. The mean monthly return declines from 0.77% for the T1 value portfolio to 0.55% for the T3 value portfolio, and the standard deviation of monthly returns increases from 2.16% for the T1 value portfolio to 2.41% for the T3 value portfolio. Interest rate neutrality across tercile portfolios facilitates their comparability on a like-for-like basis by eliminating the effects of parallel yield curve shifts as a return contributor. Consistent with the statistically significant excess return generated by the long-only T1 value portfolio, an interest rate neutral long-short strategy between the T1-T3 value portfolios generates a mean monthly total return of 0.22%, which is statistically significant at the 1% level. This return is generated with a standard deviation of 1.08% over the sample period.

4.3.2. Carry portfolio

Carry, as defined in this study, measures the term spread on local currency sovereign bonds relative to the 3-month Treasury Bill rate. The term spread is then divided by the instrument's modified duration, which yields a standardized measure of carry per unit of interest rate risk.

The average term to maturity of the T1 carry portfolio is 10.31 years, considerably shorter than the average term to maturity of 15.61 years for the T3 carry portfolio and 13.19 years for the equal weight on-the-run sovereign bond benchmark. The average yield to maturity of the T1 carry portfolio is 8.64%, which is lower than the average yield to maturity of 8.78% for the T3 carry portfolio and 8.86% for the equal weight on-the-run benchmark. As intended, the T1 carry portfolio yields the highest carry premium across the factor portfolios in this study. The carry premium of 0,46% per unit of interest rate risk on the T1 carry portfolio is significantly different to the on-the-run benchmark and all other factor portfolios in this study. The characteristics of Carry Portfolios across terciles are summarised in Table 2.

The T1 carry portfolio generates a mean monthly return of 0.74% and a standard deviation of 2.36%. These compare favourably to the mean monthly return of 0.65% and standard deviation of 2.36% for the equal weight on-the-run sovereign bond benchmark. Resultantly, the T1 carry portfolio generates a mean monthly excess return of 0.09% relative to the benchmark over the sample period, which is statistically significant at the 5% level. The monthly average risk and return metrics for Carry Portfolios are summarised in Table 3.

The mean monthly return and standard deviation of carry portfolios exhibit a monotonic pattern across terciles. The mean monthly return declines from 0.74% for the T1 carry portfolio to 0.61% for the T3 carry portfolio. In contrast to the monotonically decreasing mean return for the value portfolios, carry portfolios exhibit a monotonic decrease in their standard deviation of return, from 2.36% for the T1 portfolio to 2.23% for the T3 portfolio. An interest rate neutral long-short strategy between the T1-T3 carry portfolios yields a mean monthly return of 0.13% and a standard deviation of 1.01%. However, this relative return is only statistically significant at the 10% level.

4.3.3. Momentum portfolio

Momentum, as defined in this study, measures the 12-month trailing total return on sovereign bonds. Since Asness (1994), it has been standard in the literature to skip the most recent month's return when calculating momentum for listed equity. This is done to avoid the one-month reversal in equity returns which may be related to liquidity or microstructure effects. Asness, Ilmanen, Israel and Moskowitz (2015) outline that these macrostructure effects are less prevalent for all other asset classes, obviating the requirement to skip the most recent month in the momentum calculation for fixed income assets.

The average term to maturity of the T1 momentum portfolio is 11.98 years. While this is considerably longer than the 8.50 years term to maturity for the T1 value portfolio and 10.31 years for the T1 carry portfolio, it remains shorter than the 13.19 equal weight on the run benchmark and average term to maturity of 14.03 years for the T3 momentum portfolio. The average yield to maturity of the T1 momentum portfolio is 8.71%. This yield is higher than the average yield for T1 value and carry portfolios, but flat relative to the T3 momentum portfolio. As intended, the T1 momentum portfolio has the highest 12-month trailing total return, or momentum premium, across the factor portfolios in this study. The 12-month trailing total return of 10.53% on the T1 momentum portfolio is statistically significant relative to the on-the-run benchmark momentum of 8.13% as well as all other factor portfolios in the study. The characteristics of Momentum Portfolios across terciles are summarised in Table 2.

<u>Table 2: Factor portfolio risk and return characteristics</u>

T1 Factor Portfolios (Monthly Mean)	Term	MD	PV01	YTM	Value/MD	Carry/MD	Momentum	Reversion	Return	Std Dev
On the Run Benchmark	13.19	6.60	611.9	8.86%	0.45%	0.35%	8.13%	12.30%	0.65%	2.36%
Value	8.50	4.81	468.9	8.38%	0.68%	0.37%	8.41%	12.53%	0.77%	2.16%
Carry	10.31	5.66	546.7	8.64%	0.49%	0.46%	7.55%	11.48%	0.74%	2.36%
Momentum	11.98	6.14	581.8	8.71%	0.49%	0.34%	10.53%	14.14%	0.71%	2.26%
Reversion	15.12	6.73	620.6	8.90%	0.44%	0.38%	6.23%	9.10%	0.74%	2.28%
Combination	11.48	5.84	554.5	8.66%	0.52%	0.39%	8.18%	11.81%	0.74%	2.27%

T2 Factor Portfolios (Monthly Mean)	Term	MD	PV01	YTM	Value/MD	Carry/MD	Momentum	Reversion	Return	Std Dev
Value	13.25	6.90	664.73	9.11%	0.40%	0.35%	8.35%	12.48%	0.67%	2.26%
Carry	13.22	7.28	665.73	9.18%	0.42%	0.36%	8.18%	12.19%	0.65%	2.25%
Momentum	12.58	6.79	629.90	9.02%	0.44%	0.34%	8.39%	12.55%	0.66%	2.30%
Reversion	12.36	6.71	610.93	9.00%	0.41%	0.36%	7.88%	11.87%	0.66%	2.38%
Combination	12.85	6.92	642.8	9.08%	0.42%	0.35%	8.20%	12.27%	0.66%	2.30%

T3 Factor Portfolios (Monthly Mean)	Term	MD	PV01	YTM	Value/MD	Carry/MD	Momentum	Reversion	Return	Std Dev
Value	17.22	7.87	680.12	9.02%	0.28%	0.32%	7.72%	11.91%	0.55%	2.41%
Carry	15.61	6.97	606.40	8.78%	0.44%	0.23%	8.35%	12.69%	0.61%	2.23%
Momentum	14.03	6.52	585.63	8.71%	0.43%	0.36%	5.34%	10.08%	0.67%	2.32%
Reversion	10.90	6.01	565.04	8.61%	0.50%	0.33%	9.66%	14.97%	0.61%	2.33%
Combination	14.44	6.84	609.3	8.78%	0.41%	0.31%	7.77%	12.41%	0.61%	2.32%

Table 3: Mean monthly total return for 1-factor portfolios

		Value Portfolio (T1)	Value Portfolio (T2)	Value Portfolio (T3)	Value Portfolio (T1 - T3)
Value Portfolio	Mean Return	0.77%	0.67%	0.55%	0.22%
	Std Dev	2.16%	2.26%	2.41%	1.08%
	VaR	-2.52%	-2.49%	-2.82%	-1.62%
	Expected Shortfall (ES)	-4.26%	-4.32%	-4.81%	-2.02%
	Sharpe Ratio	0.06	0.01	-0.04	0.20
	Alpha	0.13%	0.03%	-0.09%	0.22%
	(t Stat)	2.40	1.16	-2.56	2.86

		Carry Portfolio (T1)	Carry Portfolio (T2)	Carry Portfolio (T3)	Carry Portfolio (T1 - T3)
Carry Portfolio	Mean Return	0.74%	0.65%	0.61%	0.13%
	Std Dev	2.36%	2.25%	2.23%	1.01%
	VaR	-2.68%	-2.41%	-2.58%	-1.54%
	Expected Shortfall (ES)	-4.72%	-4.31%	-4.40%	-2.30%
	Sharpe Ratio	0.04	0.00	-0.02	0.13
	Alpha	0.09%	0.01%	-0.04%	0.13%
	(t Stat)	2.32	0.29	-0.82	1.82

		Momentum Portfolio (T1)	Momentum Portfolio (T2)	Momentum Portfolio (T3)	Momentum Portfolio (T1 - T3)
Momentum Portfolio	Mean Return	0.71%	0.66%	0.67%	0.04%
	Std Dev	2.26%	2.30%	2.32%	1.03%
	VaR	-2.58%	-2.58%	-2.63%	-1.53%
	Expected Shortfall (ES)	-4.66%	-4.45%	-4.29%	-2.39%
	Sharpe Ratio	0.03	0.00	0.01	0.04
	Alpha	0.06%	0.01%	0.02%	0.04%
	(t Stat)	1.23	0.34	0.41	0.53

		Reversion Portfolio (T1)	Reversion Portfolio (T2)	Reversion Portfolio (T3)	Reversion Portfolio (T1 - T3)
Reversion Portfolio	Mean Return	0.74%	0.66%	0.61%	0.13%
	Std Dev	2.28%	2.38%	2.33%	1.01%
	VaR	-2.49%	-2.76%	-2.47%	-1.26%
	Expected Shortfall (ES)	-4.10%	-4.84%	-4.82%	-1.94%
	Sharpe Ratio	0.04	0.00	-0.02	0.13
	Alpha	0.09%	0.01%	-0.04%	0.13%
	(t Stat)	2.16	0.43	-0.84	1.82

The T1 momentum portfolio generates a mean monthly return of 0.71% and a standard deviation of 2.26%. These compare favourably to the mean monthly return of 0.65% and standard deviation of 2.36% for the equal weight on-the-run sovereign bond benchmark. Consequently, the T1 momentum portfolio generates a mean monthly excess return of 0.06% relative to the benchmark over the sample period. This return is not statistically significant. The monthly average risk and return metrics for Momentum Portfolios are summarised in Table 3.

In contrast to the monotonic relationship in the mean monthly return between tercile portfolios for value and carry, the mean monthly return decreased from 0.71% for the T1 momentum portfolio to 0.66% for the T2 portfolio before increasing to 0.67% for the T3 portfolio. The standard deviation for momentum portfolios exhibits a monotonic pattern across terciles, increasing from 2.26% for the T1 momentum portfolio to 2.30% for the T2 portfolio and 2.32% for the T3 portfolio. An interest rate neutral long-short strategy between the T1-T3 momentum portfolios yields a mean monthly return of 0.04% and a standard deviation of 1.03%. This excess return is not statistically significant.

4.3.4. Reversion portfolio

Reversion, as defined in this study, measures the 18-month trailing total return on sovereign bonds. Reversion seeks to capture the pull-to-par effect, where the price of a bond converges to its redemption value over the passage of time. The 18-month trailing return period is consistent with Cochrane & Piazzesi (2005), who evidence predictable time-variation, at short-horizons, in expected excess returns on the cross-section of US Treasuries between January 1963 – December 2003.

The average term to maturity of the T1 reversion portfolio is 15.12 years. This is considerably longer than the 13.19 equal weight on the run benchmark and all other factor portfolios. The average term to maturity of the T1 reversion portfolio is also meaningfully longer than the 10.90 years for the T3 reversion portfolio. The average yield to maturity of the T1 reversion portfolio is 8.90%. This yield is higher than the 8.86% yield of the equal weight on-the-run benchmark and 8.61% for the T3 reversion portfolio. By design, at 9.10%, the T1 reversion portfolio has the lowest trailing 18-month total return, considerably lower than the 18-month total return of 12.30% for the on-the-run benchmark and the other factor portfolios in the study. The characteristics of Reversion Portfolios across terciles are summarised in Table 2.

The T1 reversion portfolio generates a mean monthly return of 0.74% and a standard deviation of 2.28%. These compare favourably to the mean monthly return of 0.65% and standard deviation of 2.36% for the equal weight on-the-run sovereign bond benchmark. Consequently, the T1 reversion portfolio generates a mean monthly excess return of 0.09% relative to the benchmark over the sample period, which is statistically significant at the 5% level. The monthly average risk and return metrics for Reversion Portfolios are summarised in Table 3.

The mean monthly return of the reversion portfolios exhibits a monotonic pattern across terciles, declining from 0.74% for the T1 momentum portfolio to 0.61% for the T3 momentum portfolio. The standard deviation increases from 2.28% for the T1 reversion portfolio to 2.38% for the T2 portfolio before receding to 2.33% for the T3 portfolio. An interest rate neutral long-short strategy between the T1-T3 reversion portfolios yields a mean monthly return of 0.13% and a standard deviation of 1.01%. This relative return is only statistically significant at the 10% .

4.3.5. Combination portfolios

Having assessed the individual fixed income factor premiums, this study proceeds to explore the risk and return profiles of combination portfolios. Combination portfolios are constructed monthly as an equal weight blend of the underlying tercile portfolios.

The full spectrum of 33 long-only combination portfolios are examined, ranging from 2- to 4-factor combinations. Homogeneity is maintained across terciles for the long-only combination portfolios, with 11 resultant long-only combination portfolios across each tercile. The 33 long-only combination portfolios are comprised of 18 2-factor portfolios, 12 3-factor portfolios and 3 4-factor portfolios. Furthermore, 11 long-short combination portfolios are examined, ranging from 2- to 4-factor combinations. The long-short portfolios measure the performance and risk differential between the T1 and T3 combination portfolios. The 11 long-short combination portfolios are comprised of 6 2-factor portfolios, 4 3-factor portfolios and 1 4-factor portfolio. The interest rate neutrality of the underlying tercile portfolios relative to the equal weight on-the-run benchmark ensures the assessment of the risk and return dynamics of the combination portfolios on a like-for-like basis, eliminating the effects of interest rate risk variability as a potential relative return contributor.

Consistent with Brooks, Palhares and Richardson (2018), this study finds evidence of factor premiums across combinations of long-only and long-short, equal weight, interest rate neutral sovereign bond portfolios. Asness, Moskowitz and Pedersen (2013) also identify persistent factor premiums across their sample of long-only, interest rate neutral, fixed income combination portfolios. They emphasise the significance of the value and momentum combination portfolio – citing the high expected return and muted return variability relative to their standalone fixed income factor portfolios.

The mean monthly total return of 2-factor combination portfolios exhibits a monotonic pattern across terciles. Statistically significant factor premiums are identified across all 6 T1 2-factor combination portfolios explored in this study. The mean monthly return on these combination portfolios varies between 0.72% - 0.76%. This compares favourably to the mean monthly on-the-run benchmark return of 0.65%. Specifically, both the Momentum (T1) & Reversion (T1) combination portfolio and the Carry (T1) & Momentum (T1) combination portfolio generate a mean monthly total return of 0.72%, which is statistically significant at the 5% level and the represents the lowest return across T1 2-factor combination portfolios. Both the Value (T1) & Momentum (T1) combination portfolio and the Carry (T1) & Reversion (T1) combination portfolio generate a mean monthly total return of 0.74%, which is statistically significant at the 5% level. The large and statistically significant mean monthly return generated on the Value (T1) & Momentum (T1) combination portfolio relative to the on-the-run benchmark is consistent with Asness, Moskowitz and Pedersen (2013). Both the Value (T1) & Carry (T1) combination portfolio and the Value (T1) & Reversion (T1) combination portfolio generate a mean monthly total return of 0.76%, which is statistically significant at the 1% level and represents the highest return across T1 2-factor combination portfolios. The monthly average risk and return metrics for 2-factor combination portfolios are summarised in Table 4.

The 6 T2 2-factor combination portfolios generate modest mean monthly total returns relative to the on-the-run benchmark. The mean monthly return on these combination portfolios varies between 0.65% - 0.67%. These returns are not statistically different to the mean monthly on-the-run benchmark return of 0.65%. The mean monthly total return range on the 6 T3 2-factor combination portfolios varies between 0.58% - 0.64%. Specifically, both the Value (T3) & Carry (T3) combination portfolio and the Value (T3) & Reversion (T3) combination portfolio generate a mean monthly total return of 0.58%, which is statistically significant at the 5% level. The Momentum (T3) & Reversion (T3) combination portfolio generates a mean monthly total return of 0.64%, the highest of the T3 2-factor combination portfolios. The relative return on this combination portfolio is not statistically different to the mean monthly on-the-run benchmark return.

The mean monthly total return of 3-factor combination portfolios also exhibits a monotonic pattern across terciles. Statistically significant factor premiums are identified across all 4 T1 3-factor combination portfolios explored in this study. The mean monthly return on these combination portfolios varies between 0.73% - 0.75%. Specifically, the Value (T1) & Carry (T1) & Reversion (T1) combination portfolio generates a mean monthly total return of 0.75%, which is statistically significant at the 1% level and the highest across T1 3-factor combination portfolios. The Carry (T1)

& Momentum (T1) & Reversion (T1) combination portfolio generates a mean monthly total return of 0.73%, which is statistically significant at the 1% level and the lowest mean monthly return across the T1 3-factor combination portfolios. The monthly average risk and return metrics for 3-factor combination portfolios are summarised in Table 5.

Table 4: Mean monthly total returns for 2-factor combination portfolios

Combination Portfolios (2-factor)

	Value (T1) & Carry (T1)	Value (T1) & Momentum (T1)	Value (T1) & Reversion (T1)
Mean Return	0.76%	0.74%	0.76%
Std Dev	2.24%	2.19%	2.18%
VaR	-2.35%	-2.45%	-2.44%
Expected Shortfall (ES)	-4.31%	-4.30%	-4.07%
Sharpe Ratio	0.05	0.04	0.05
Alpha	0.11%	0.09%	0.11%
(t Stat)	2.78	2.13	2.95

	Carry (T1) & Momentum (T1)	Carry (T1) & Reversion (T1)	Momentum (T1) & Reversion (T1)
Mean Return	0.72%	0.74%	0.72%
Std Dev	2.28%	2.29%	2.23%
VaR	-2.52%	-2.57%	-2.43%
Expected Shortfall (ES)	-4.65%	-4.26%	-4.24%
Sharpe Ratio	0.03	0.04	0.03
Alpha	0.08%	0.09%	0.08%
(t Stat)	2.27	2.84	2.42

	Value (T2) & Carry (T2)	Value (T2) & Momentum (T2)	Value (T2) & Reversion (T2)
Mean Return	0.66%	0.66%	0.67%
Std Dev	2.25%	2.27%	2.31%
VaR	-2.50%	-2.55%	-2.56%
Expected Shortfall (ES)	-4.29%	-4.38%	-4.58%
Sharpe Ratio	0.01	0.01	0.01
Alpha	0.02%	0.02%	0.02%
(t Stat)	0.86	0.86	0.92

	Carry (T2) & Momentum (T2)	Carry (T2) & Reversion (T2)	Momentum (T2) & Reversion (T2)
Mean Return	0.65%	0.66%	0.66%
Std Dev	2.26%	2.31%	2.33%
VaR	-2.55%	-2.63%	-2.61%
Expected Shortfall (ES)	-4.37%	-4.55%	-4.64%
Sharpe Ratio	0.00	0.00	0.00
Alpha	0.01%	0.01%	0.01%
(t Stat)	0.41	0.45	0.48

	Value (T3) & Carry (T3)	Value (T3) & Momentum (T3)	Value (T3) & Reversion (T3)
Mean Return	0.58%	0.61%	0.58%
Std Dev	2.29%	2.34%	2.33%
VaR	-2.61%	-2.66%	-2.68%
Expected Shortfall (ES)	-4.46%	-4.51%	-4.75%
Sharpe Ratio	-0.03	-0.02	-0.03
Alpha	-0.07%	-0.04%	-0.07%
(t Stat)	-2.06	-1.13	-2.36

	Carry (T3) & Momentum (T3)	Carry (T3) & Reversion (T3)	Momentum (T3) & Reversion (T3)
Mean Return	0.64%	0.61%	0.64%
Std Dev	2.23%	2.25%	2.28%
VaR	-2.46%	-2.47%	-2.38%
Expected Shortfall (ES)	-4.28%	-4.46%	-4.51%
Sharpe Ratio	0.00	-0.02	0.00
Alpha	-0.01%	-0.04%	-0.01%
(t Stat)	-0.29	-1.03	-0.30

Table 5: Mean monthly total returns for 3-factor combination portfolios

Combination Portfolios (3-factor)	Value (T1) & Carry (T1) & Momentum (T1)	Carry (T1) & Momentum (T1) & Reversion (T1)	Value (T1) & Carry (T1) & Reversion (T1)	Value (T1) & Momentum (T1) & Reversion (T1)
Mean Return	0.74%	0.73%	0.75%	0.74%
Std Dev	2.22%	2.25%	2.23%	2.19%
VaR	-2.56%	-2.49%	-2.40%	-2.45%
Expected Shortfall (ES)	-4.40%	-4.38%	-4.14%	-4.14%
Sharpe Ratio	0.04	0.04	0.05	0.04
Alpha	0.09%	0.08%	0.10%	0.09%
(t Stat)	2.59	2.93	3.15	2.77
	Value (T2) & Carry (T2) & Momentum (T2)	**Carry (T2) & Momentum (T2) & Reversion (T2)**	**Value (T2) & Carry (T2) & Reversion (T2)**	**Value (T2) & Momentum (T2) & Reversion (T2)**
Mean Return	0.66%	0.66%	0.66%	0.66%
Std Dev	2.26%	2.30%	2.28%	2.30%
VaR	-2.55%	-2.61%	-2.53%	-2.52%
Expected Shortfall (ES)	-4.34%	-4.52%	-4.47%	-4.53%
Sharpe Ratio	0.01	0.00	0.01	0.01
Alpha	0.01%	0.01%	0.01%	0.01%
(t Stat)	0.78	0.49	0.81	0.82
	Value (T3) & Carry (T3) & Momentum (T3)	**Carry (T3) & Momentum (T3) & Reversion (T3)**	**Value (T3) & Carry (T3) & Reversion (T3)**	**Value (T3) & Momentum (T3) & Reversion (T3)**
Mean Return	0.61%	0.63%	0.59%	0.61%
Std Dev	2.28%	2.24%	2.28%	2.31%
VaR	-2.56%	-2.46%	-2.49%	-2.57%
Expected Shortfall (ES)	-4.37%	-4.36%	-4.50%	-4.56%
Sharpe Ratio	-0.02	-0.01	-0.02	-0.02
Alpha	-0.04%	-0.02%	-0.06%	-0.04%
(t Stat)	-1.33	-0.66	-2.01	-1.45

The 4 T2 3-factor combination portfolios generate a modest mean monthly total return of 0.66%. These returns are not statistically different to the mean monthly on-the-run benchmark return of 0.65%. The mean monthly total return range on the 4 T3 3-factor combination portfolios varies between 0.59% - 0.63%. The Value (T3) & Carry (T3) & Reversion (T3) combination portfolio generates a mean monthly total return of 0.59%, which is statistically significant at the 5% level and the lowest across T3 3-factor combination portfolios. The Carry (T3) & Momentum (T3) & Reversion (T3) combination portfolio generates a mean monthly total return of 0.63%, the highest across T3 3-factor combination portfolios. The relative return on this combination portfolio is not statistically different to the mean monthly on-the-run benchmark return.

Table 6: Mean monthly total returns for 4-factor combination portfolios

Combination Portfolios (4-factor)	On-the-run Combination Portfolio (T1)	On-the-run Combination Portfolio (T2)	On-the-run Combination Portfolio (T3)
Mean Return	0.74%	0.66%	0.61%
Std Dev	2.22%	2.28%	2.27%
VaR	-2.50%	-2.56%	-2.48%
Expected Shortfall (ES)	-4.26%	-4.47%	-4.42%
Sharpe Ratio	0.04	0.01	-0.02
Alpha	0.09%	0.01%	-0.04%
(t Stat)	3.03	0.76	-1.50

The pattern of monotonically declining mean monthly total returns across terciles is maintained for the 3 4-factor combination portfolios. The T1 4-factor combination portfolio generates a mean monthly total return of 0.74%, which is statistically significant at the 1% level. The mean monthly total return on the T2 and T3 4-factor combination portfolios declines to 0.66% and 0.61% respectively. These returns are not statistically different to the mean monthly on-the-run benchmark return. The monthly average risk and return metrics for 4-factor combination portfolios are summarised in Table 6.

Turning to the risk and return of long-short combination portfolios, statistically significant factor premiums are identified across 10 of the 11 portfolio combinations. The mean monthly return for the 6 2-factor T1 - T3 combination portfolios varies between 0.08% - 0.18%. Specifically, the Momentum (T1) & Reversion (T1) - Momentum (T3) & Reversion (T3) portfolio generates a mean monthly total return of 0.08%, which is statistically significant at the 5% level and the lowest of the 2-factor combination portfolios. The standard deviation on this long-short combination portfolio is 0.51%, with a resultant Sharpe Ratio of 0.17. Both the Value (T1) & Carry (T1) - Value (T3) & Carry (T3) and Value (T1) & Reversion (T1) - Value (T3) & Reversion (T3) portfolios generate a mean monthly total return of 0.18%, which is statistically significant at the 1% level and the highest of the 2-factor long-short combination portfolios. The standard deviation on these long-short combination portfolios is 0.78% and 0.66% respectively, with resultant Sharpe Ratios of 0.23 and 0.27. The monthly average risk and return metrics for the 2-factor long-short combination portfolios are summarised in Table 7.

Statistically significant factor premiums are also identified across all 4 3-factor long-short combination portfolios. The mean monthly return for the 3-factor T1 - T3 combination portfolios varies between 0.10% - 0.16%. Specifically, the Carry (T1) & Momentum (T1) & Reversion (T1) - Carry (T3) & Momentum (T3) & Reversion (T3) portfolio generates a mean monthly total return of 0.10%, which is statistically significant at the 1% level and the lowest of the 3-factor long-short combination portfolios. The standard deviation on this long-short combination portfolio is 0.42%, with a resultant Sharpe Ratio of 0.24. The Value (T1) & Carry (T1) & Reversion (T1) - Value (T3) & Carry (T3) & Reversion (T3) portfolio generates a mean monthly total return of 0.16%, which is statistically significant at the 1% level and the highest of the 3-factor combination portfolios. The standard deviation on this long-short combination portfolio is 0.58%, with a resultant Sharpe Ratio of 0.28. The monthly average risk and return metrics for the 3-factor long-short portfolios are summarised in Table 8.

Table 7: Mean monthly total returns for 2-factor long-short portfolios

Combination Portfolios T1 - T3 (2-factor)

	Value (T1) & Carry (T1) - Value (T3) & Carry (T3)	Value (T1) & Momentum (T1) - Value (T3) & Momentum (T3)	Value (T1) & Reversion (T1) - Value (T3) & Reversion (T3)
Mean Return	0.18%	0.13%	0.18%
Std Dev	0.78%	0.84%	0.66%
VaR	-0.86%	-1.07%	-0.69%
Expected Shortfall (ES)	-1.41%	-1.88%	-1.12%
Sharpe Ratio	0.23	0.15	0.27
Alpha	0.18%	0.13%	0.18%
(t Stat)	4.02	3.81	3.93

	Carry (T1) & Momentum (T1) - Carry (T3) & Momentum (T3)	Carry (T1) & Reversion (T1) - Carry (T3) & Reversion (T3)	Momentum (T1) & Reversion (T1) - Momentum (T3) & Reversion (T3)
Mean Return	0.09%	0.13%	0.08%
Std Dev	0.62%	0.73%	0.51%
VaR	-0.61%	-1.03%	-0.50%
Expected Shortfall (ES)	-1.34%	-1.37%	-0.91%
Sharpe Ratio	0.14	0.18	0.17
Alpha	0.09%	0.13%	0.08%
(t Stat)	1.94	2.53	2.33

Furthermore, a statistically significant factor premium is identified for the 4-factor long-short combination portfolio. The portfolio achieves a mean monthly return of 0.13%, which is statistically significant at the 1% level. The standard deviation on this long-short combination portfolio is 0.44%, with a resultant Sharpe Ratio of 0.30. The monthly average risk and return metrics for the 4-factor long-short portfolio are summarised in Table 9.

Beyond the statistical significance of the factor premiums identified in this study across T1 single-factor portfolios, T1 combination portfolios, and T1-T3 long-short portfolios, the factor premiums are also noteworthy for their economic significance. Economic significance, in this context, is inferred from the relative returns generated by the factor portfolios in the study, compared to the long-term active returns generated by domestic fund managers. Domestic fund manager returns are drawn from the October 2023 *Alexander Forbes S.A Bond Manager Watch*™ Survey. The mean monthly excess return of single-factor and T1 combination portfolios ranges between 0.06% - 0.13%, with the bottom end of the range matching the 50th percentile rank from the *S.A Bond Manager Watch*™ *Survey* for the 10 years ended October 2023. The top end of the range outperforms the 25th percentile rank over the same period. Additionally, the mean monthly return of T1-T3 long-short portfolios ranges between 0.04% - 0.22% across both single-factor and combination portfolios. While the bottom end of the range underperforms the 50th percentile rank from the *S.A Bond Manager Watch*™ *Survey,* the top end of the range outperforms all survey participants.

<u>Table 8: Mean monthly total returns for 3-factor long-short portfolios</u>

Combination Portfolios T1 - T3 (3-factor)	Value (T1) & Carry (T1) & Momentum (T1) - Value (T3) & Carry (T3) & Momentum (T3)	Carry (T1) & Momentum (T1) & Reversion (T1) - Carry (T3) & Momentum (T3) & Reversion (T3)	Value (T1) & Carry (T1) & Reversion (T1) - Value (T3) & Carry (T3) & Reversion (T3)	Value (T1) & Momentum (T1) & Reversion (T1) - Value (T3) & Momentum (T3) & Reversion (T3)
Mean Return	0.13%	0.10%	0.16%	0.13%
Std Dev	0.62%	0.42%	0.58%	0.51%
VaR	-0.75%	-0.52%	-0.62%	-0.61%
Expected Shortfall (ES)	-1.05%	-0.79%	-1.09%	-0.80%
Sharpe Ratio	0.21	0.24	0.28	0.25
Alpha	0.13%	0.10%	0.16%	0.13%
(t Stat)	3.76	3.94	3.64	3.72

<u>Table 9: Mean monthly total returns for 4-factor long-short portfolio</u>

Combination Portfolios T1 - T3 (3-factor)	Value (T1) & Carry (T1) & Momentum (T1) & Reversion (T1) - Value (T3) Carry (T3) & Momentum (T3) & Reversion (T3)
Mean Return	0.13%
Std Dev	0.44%
VaR	-0.58%
Expected Shortfall (ES)	-0.75%
Sharpe Ratio	0.30
Alpha	0.13%
(t Stat)	4.14

The return correlations across factor portfolios are also examined in this study. The sample data set exhibits a persistently large and positive return correlation across South Africa's local currency nominal bond returns. Naturally, this also holds for the return correlation of the factor portfolios examined in this study relative to the equal weight, on-the-run benchmark return. However, within this context, this study evidences the diversification benefit across factor portfolios. With a correlation coefficient of 0.9511, the T1 value portfolio provides the least correlated monthly return across factor portfolios relative to the on-the-run sovereign bond benchmark. Additionally, return outcomes for the T1 value portfolio are less variable than the on-the-run benchmark, evidenced by the 2.16% monthly standard deviation of return relative to 2.36% for the on-the-run benchmark. The monthly return correlations on the remaining single factor portfolios relative to the on-the-run benchmark are moderately stronger than the T1 value portfolio, ranging from 0.9610 for the momentum portfolio to 0.9709 for the carry portfolio.

Generally, relative to single factor portfolios, 2-factor portfolios evidence an increasing correlation of return to the on-the-run benchmark. While this observation is inconsistent with Asness, Moskowitz and Pedersen (2013), who find that value and momentum combination portfolios reduce return correlations relative to single factor portfolio formations across asset classes, it nonetheless remains noteworthy that the Value (T1) & Momentum (T1) combination portfolio produces the lowest correlation coefficient (0.9679) across the various multi-factor portfolio combinations.

Table 10: Factor portfolio return correlations

		Correlation coefficient	Rank vs Benchmark
Return Correlation	Value Portfolio (T1)	0.9511	1
	Carry Portfolio (T1)	0.9709	8
	Momentum Portfolio (T1)	0.9610	2
	Reversion Portfolio (T1)	0.9660	5
	Value (T1) & Carry (T1)	0.9724	9
	Value (T1) & Momentum (T1)	0.9679	7
	Value (T1) & Reversion (T1)	0.9766	10
	Carry (T1) & Momentum (T1)	0.9804	15
	Carry (T1) & Reversion (T1)	0.9805	16
	Momentum (T1) & Reversion (T1)	0.9835	21
	Value (T1) & Carry (T1) & Momentum (T1)	0.9779	13
	Carry (T1) & Momentum (T1) & Reversion (T1)	0.9867	27
	Value (T1) & Carry (T1) & Reversion (T1)	0.9812	17
	Value (T1) & Momentum (T1) & Reversion (T1)	0.9818	18
	Combination Portfolio (T1)	0.9844	23
	Value Portfolio (T3)	0.9769	11
	Carry Portfolio (T3)	0.9636	3
	Momentum Portfolio (T3)	0.9640	4
	Reversion Portfolio (T3)	0.9661	6
	Value (T3) & Carry (T3)	0.9821	19
	Value (T3) & Momentum (T3)	0.9801	14
	Value (T3) & Reversion (T3)	0.9864	25
	Carry (T3) & Momentum (T3)	0.9826	20
	Carry (T3) & Reversion (T3)	0.9776	12
	Momentum (T3) & Reversion (T3)	0.9838	22
	Value (T3) & Carry (T3) & Momentum (T3)	0.9860	24
	Carry (T3) & Momentum (T3) & Reversion (T3)	0.9871	28
	Value (T3) & Carry (T3) & Reversion (T3)	0.9866	26
	Value (T3) & Momentum (T3) & Reversion (T3)	0.9883	29
	Combination Portfolio (T3)	0.9895	30

4.4. Interaction with principal components

This section examines the interaction between the fixed income factors explored in this study and the first three principal components (PCs) of the yield curve, as motivated by affine term structure models, which implicitly assume that the factors that drive the cross-sectional variation in yields also drive the time series variation in excess return. Litterman and Scheinkman (1991) named these three principal components "level", "slope" and "curvature" – and they jointly describe nearly all (> 99.9%) of the variation in yields.

The explanatory power of the principal components on yields has been found to be stable across model specifications, estimation samples, types of interest rates, and countries. The evidence from the sample set employed in this study is no different, with the first three principal components of the yield curve explaining a cumulative 99.93% of the variation in the yield curve. Consistent with Litterman and Scheinkman (1991), with an explained variance ratio of 97.45% across the sample period, the first principal component captures the bulk of the yield curve variation across domestic sovereign, fixed rate nominal bonds. The second principal component has an explained variance ratio of 2.34% and the third principal component has a variance ratio of 0.14%. These findings are presented in Table 11.

Table 11: Principal Component variance ratios for South African Government Bonds

		Explained Variance Ratio	Cumulative Variance Ratio
Principal Components	PC1	0.97448	0.97448
	PC2	0.02338	0.99787
	PC3	0.00139	0.99925

The significant explanatory power of the first three principal components on yields serves as an intuitive starting point for exploring the primary contributors to returns in the domestic sovereign bond market. This study draws from Brooks and Moskowitz (2017), who examine the return premia associated with the level, slope, and curvature of yield curves through time and across seven developed market economies by borrowing the known pricing factors from other asset classes. In a similar vein, the excess return on an equal weight, constant maturity sovereign bond portfolio is assessed in this study relative to the principal components and fixed income factors to understand the key determinants of sovereign bond returns.

Specifically, in a panel regression setting, the 3-month excess return on a generic series of zero-coupon, South African sovereign bonds is regressed, jointly and separately, against the principal components and fixed income factor premiums identified in this study. The 3-month excess return is measured as the difference between the 3-month rolling cumulative return of equal weight, generic 1- to 29-year sovereign bonds, relative to the 3-month rolling cumulative return of the Short-Term Fixed Interest Call Deposit Index (STFCAD).

Table 12 reports results from panel regressions of the excess return of a generic series of zero-coupon, South African sovereign bonds. The dependent variable in the regressions is the 3-month rolling excess return on a generic series of zero-coupon, South African sovereign bonds. The independent variables, assessed both jointly and independently, include the first three principal components of the yield curve from the previous quarter, as well as the fixed income factors identified in this study: value, carry, momentum, and reversion.

The first column of Table 12 reports the relationship between the 3-month rolling excess return of the generic series of zero-coupon bonds and the first three principal components of the yield curve. The coefficient of -0.06 for the first principal component (PC1), which is statistically significant at the 1% level, evidences its negative relationship with the realised 3-month excess return of the generic series of zero-coupon sovereign bonds. This stands to reason, given the known inverse relationship between interest rates and the capital return of zero-coupon bonds – with bonds outperforming cash on a relative basis when yields decline, and underperforming when yields increase, *ceteris paribus*.

The coefficients of 0.20 and 0.05 for the second (PC2) and third (PC3) principal components respectively, which are both statistically significant at the 1% level, evidence their positive relationship with the realised 3-month excess return of the generic series of zero-coupon sovereign bonds. The first column of Table 12 reports an adjusted R-squared of 36.9%, which indicates how much of the 3-month excess return of the generic series of zero-coupon sovereign bonds is explained by measures of the first three principal components of the yield curve.

The second column of Table 12 reports the relationship between the 3-month rolling excess return of the generic series of zero-coupon bonds and the four fixed income factors explored in this study. The coefficient of -0.31 for the T1 value factor, which is statistically significant at the 1% level, evidences its negative relationship with the realised 3-month excess return of the generic series of zero-coupon sovereign bonds. Accordingly, a decrease (increase) in the value factor results in an increase (decrease) in the realised 3-month excess return. The carry and momentum factors are positively related to the 3-month excess return, with coefficients of 0.59 and 0.37, respectively. These coefficients are statistically significant at the 1% level. The reversion factor is negatively related to the 3-month excess return, with a coefficient of -0.12 which is statistically significant at the 1%. True to design, the coefficients of the momentum and reversion portfolios have opposite signs. This is explained by a momentum portfolio which seeks to benefit from the persistence in historic returns, relative to the reversion portfolio which seeks to benefit from historic return reversals. Also worth noting is the adjusted R-squared of 39.3% for the fixed income factors when jointly regressed against the 3-month excess return of the generic series of zero-coupon sovereign bonds. This marks a marginal improvement on the 36.9% for the first three principal components when regressed against the 3-month excess return, despite the first three principal components jointly describing nearly all the variation in yields.

The fourth to seventh column of Table 12 reports multivariate regression results of the principal components and each fixed income factor against the 3-month rolling excess return of the generic series of zero-coupon bonds. Contrasting the regression results from Brooks and Moskowitz (2017) who find that the fixed income factors explored in their study subsume the pricing information of the principal components, this study finds that the inclusion of the fixed income factors adds to the explanatory power of the principal components. Aside from column six, where PC3 is found to be statistically insignificant in the presence of the momentum factor, the coefficients of the principal components and other fixed income factors remain statistically significant when regressed against the 3-month excess return on bonds in a multivariate setting. Additionally, its noteworthy that in the presence of the principal components, the coefficient for the T1 value portfolio changes from negative to positive. The improvement in the explanatory power of the regression after adding individual fixed income factors is evidenced by the larger adjusted R-squared relative to the regression that only includes the principal components as explanatory variables.

Column twelve, which reports multivariate regression results of the principal component and all fixed income factors, highlights a considerable improvement in the adjusted R-squared relative to the regression specification that only includes the principal components. Specifically, the adjusted R-squared increases from 36.9% to 51.8%. Relative to column 1 of Table 12, where the principal components are assessed individually, PC1 retains its negative relationship with the realised 3-month excess return of the generic series of zero-coupon sovereign bonds, with a coefficient of -0.06 that is statistically significant at the 1% level. The positive coefficient of 0.13, which is statistically significant at the 1% level is also maintained for PC2. However, PC3 loses its statistical significance as an explanatory variable in this multivariate regression. Across the fixed income factors, the coefficient on the T1 value portfolio is marginally positive but loses its statistical significance. Consistent with prior model specifications in Table 12, the coefficients for the carry and momentum portfolios remain positive and statistically significant at the 1% level in column twelve. The coefficient of -0.12 on the reversion portfolio also maintains its sign and remains statistically significant at the % level.

As with Brooks and Moskowitz (2017), the fixed income factors identified in this study are found to better predict the excess return on a generic series of zero-coupon, South African sovereign bonds than the principal components which jointly explain 99.93% of the cross-sectional variation in the yield curve. This finding is at odds with the predictions of most affine term structure pricing models. However, while Brooks and Moskowitz (2017) find that the fixed income factors subsume pricing information from the principal components, this study finds that the fixed income factors add to the explanatory power of the predictive regressions of South African sovereign bond excess returns.

4.5. Interaction with macro variables

This section explores the relationship between macroeconomic variables that are not spanned by affine term structure models and the 3-month rolling excess return on the generic series of zero-coupon bonds. The fixed income literature finds evidence of a strong interaction between macroeconomic variables and developed market yield curves. Examples include the macro factors of Ludvigson and Ng (2010); the "hidden" or unspanned factor of Duffee (2011); and the inflation and industrial production growth factors of Joslin, Priebsch, and Singleton (2014); Cochrane (2015); Bauer and Hamilton (2015); and Brooks and Moskowitz (2017).

Panel C of Table 12 examines the relationship between the 3-month excess return of generic sovereign bonds, and unspanned macroeconomic factors in a panel regression setting. Drawing from the literature, the macroeconomic variables considered include the changes in monetary policy, inflation, fiscal policy, and industrial production. Specifically, the monetary policy rate considered is the South African Reserve Bank (SARB) nominal repurchase rate; the inflation rate considered is the year-on-year change in the headline consumer price index; the fiscal policy metric considered is the main budget balance measured relative to gross domestic product (GDP); and the aggregate economic growth metric considered is the year-on-year change in industrial production. The dependent variable in the regressions is the 3-month rolling excess return, and the independent variables, which are assessed jointly and independently, include the unspanned macroeconomic variables considered in this study.

The third column in Table 12 reports the influence of all unspanned macroeconomic variables on the 3-month rolling excess return. Industrial production is found to be statistically insignificant as an explanatory variable in this multivariate setting. The SARB nominal repurchase rate has a negative coefficient of -0.10, which is statistically significant at the 1% level, while the year-on-year change in the headline consumer price index has a positive coefficient of 0.05, which is statistically significant at the 1% level. The opposite signs of these variables are consistent with Taylor (1993). Furthermore, the influence of these variables is consistent with the literature, where among others, Bekaert, Cho, and Moreno (2010) find that monetary policy dynamics explain parallel shifts in the United States sovereign bond curve. The main budget balance has a negative coefficient of -0.19, which is statistically significant at the 1% level. Engen and Hubbard (2004) study the impact of sovereign debt on the term structure of interest rates and conclude that higher levels of government debt in the United States have contributed to higher long-term borrowing rates and a steeper yield curve. The unspanned macroeconomic variables have an adjusted R-squared of 32.6% when jointly regressed against the 3-month excess return of the generic series of zero-coupon sovereign bonds. This is lower than the 36.9% adjusted R-squared for the principal components when jointly regressed against the 3-month excess return, and the 39.3% for the fixed income factors when jointly regressed against the 3-month excess return.

The eighth to eleventh columns of Table 12 report multivariate regression results of the principal components and each unspanned macroeconomic variable against the 3-month excess return of the generic series of zero-coupon bonds. Contrasting the multivariate regression results from the third column, where the influence of all unspanned macroeconomic variables is considered jointly for their influence on the 3-month excess return, column eight evidences that industrial production bears a positive relation to the excess 3-month excess return when considered alongside the principal component. However, while statistically significant at the 1% level, the modest coefficient of 0.01 only marginally improves the adjusted R-squared to 37.6% relative to the 36.9% adjusted R-squared for the principal components when jointly regressed against the 3-month excess return. This improvement is attained without a meaningful decrease in the coefficients or statistical significance of the other variables in the multivariate regression.

Column eleven of Table 12 reports multivariate regression results of the principal components and South Africa’s main budget balance against the 3-month excess return of the generic series of zero-coupon bonds. The main budget balance is negatively related to the 3-month excess return in the presence of the principal components, with a coefficient of -0.14 that is statistically significant at the 1% level. This finding aligns with the literature's view that an increase in sovereign debt contributes to higher borrowing rates and, all else equal, results in a lower excess return on sovereign bonds relative to the domestic risk-free rate. Columns nine and ten indicate that when all the principal components are considered jointly in a multivariate regression setting with the addition of either of the monetary policy variables, the SARB repurchase rate or the year-on-year change in headline consumer prices, the principal components subsume these monetary policy variables. The analysis moves on to assess the relationship between the unspanned macroeconomic variables and the principal components.

Table 12 further reports multivariate regression results of the principal components and unspanned macroeconomic variables in column thirteen, and the fixed income factors and the unspanned macroeconomic variables in column fourteen. An adjusted R-squared of 40.6% is attained when jointly considering the unspanned macroeconomic variables and the principal components as explanatory variables in a regression setting. This marks an improvement from the adjusted R-squared of 36.9% when the principal components are regressed against the 3-month excess return. However, it is worth noting that the statistical significance of PC3 is lost in this regression iteration and the sign of the SARB nominal repurchase rate changes from negative to positive. The consequent positive relationship between the nominal repurchase rate and excess return on sovereign bonds not only diverges from other multivariate regression outcomes in the table but is also incongruent with the academic literature. Column fourteen reports an adjusted R-squared of 51.9% when jointly considering the fixed income factors and the unspanned macroeconomic variables as explanatory variables in a regression setting. All coefficients are statistically significant in this regression specification, and the signs on the coefficients are consistent with the hypothesized values except for industrial production and the carry factor. While the impact of the sign change for industrial production relative to previous regression iterations is mitigated by its modest coefficient, the change in the sign for the carry portfolio and its impact on the explanatory power of the regression is material. Despite the improved adjusted R-squared of this regression iteration, its reliability is thrown into question by the large negative coefficient assigned to the carry portfolio.

Lastly, column fifteen reports results of the principal component, the fixed income factors, and the unspanned macroeconomic variables jointly regressed against the 3-month excess return on zero-coupon sovereign bonds. Except for PC2 and industrial production, all coefficients maintain their hypothesised signs and retain their statistical significance. Despite maintaining a positive sign, the coefficient for PC2 reduces to 0.01 and loses its statistical significance. Industrial production maintains its negative sign in this regression iteration – but its impact is again mitigated by a coefficient of 0.00, when rounded to two decimal places. The adjusted R-squared for this regression materially improves to 55.6% and highlights the benefit of considering the fixed income factors alongside monetary and fiscal policy metrics as explanatory variables for excess sovereign bond returns.

Consistent with Duffee (2011), and Joslin, Priebsch, and Singleton (2014), this study finds evidence of meaningful interaction between unspanned macroeconomic variables and South African sovereign bonds. The fixed income factors considered in this study are found to maintain their statistical significance when considered alongside the unspanned macroeconomic variables and jointly regressed against the 3-month excess return of South African sovereign bonds. While Brooks and Moskowitz (2017) find that the fixed income factors subsume pricing information from the unspanned macroeconomic variables, including industrial production and inflation, this study finds that the fixed income factors add to the explanatory power of the predictive regressions of South African sovereign bond excess returns.

Table 12: Panel regression (3-month excess return vs fixed income factors vs unspanned factors)

3-month Excess Return

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A [3-month Excess Return vs Principal Components]															
PC1	-0.06			-0.07	-0.07	-0.06	-0.06	-0.06	-0.06	-0.07	-0.05	-0.06	-0.06		-0.05
(t-stat)	(-33.17)			(-33.96)	(-33.26)	(-33.53)	(-32.69)	(-33.42)	(-25.54)	(-31.49)	(-26.72)	(-29.82)	(-27.05)		(-18.99)
PC2	0.20			0.20	0.19	0.14	0.20	0.20	0.19	0.20	0.10	0.13	0.11		0.01
(t-stat)	(56.52)			(57.34)	(46.82)	(37.58)	(52.61)	(56.72)	(28.11)	(42.43)	(13.19)	(32.04)	(12.68)		(1.93)
PC3	0.05			0.05	0.05	0.01	0.06	0.07	0.05	0.05	0.03	0.02	0.00		-0.08
(t-stat)	(3.62)			(3.32)	(3.66)	(0.88)	(3.73)	(4.58)	(3.48)	(3.37)	(1.88)	(1.33)	(-0.22)		(-5.93)
Panel B [3-month Excess Return vs Fixed Income Factors]															
Value		-0.31		0.22								0.03		0.01	0.12
(t-stat)		(-11.55)		(7.8)								(1.12)		(0.41)	(4.62)
Carry		0.59			0.10							0.27		-0.30	0.14
(t-stat)		(18.47)			(2.48)							(7.79)		(-8.04)	(3.37)
Momentum		0.37				0.22						0.28		0.30	0.28
(t-stat)		(53.21)				(35.71)						(40.96)		(45.04)	(42.27)
Reversion		-0.12					-0.01					-0.12		-0.18	-0.11
(t-stat)		(-16.95)					(-2.1)					(-19.03)		(-26.98)	(-14.69)
Panel C [3-month Excess Return vs Unpanned Factors]															
RSA Manufacturing Production (YoY)			0.00					0.01					0.00	0.00	0.00
(t-stat)			(0.97)					(8.2)					(2.06)	(-3.13)	(-5.25)
RSA Repo Rate			-0.10						-0.02				0.04	-0.18	-0.04
(t-stat)			(-10.44)						(-1.91)				(3.56)	(-19.56)	(-3.83)
RSA Headline CPI (YoY)			0.05							0.01			0.08	0.07	0.12
(t-stat)			(7.08)							(1.71)			(9.78)	(10.57)	(16.62)
RSA Main Budget Balance			-0.19								-0.14		-0.22	-0.11	-0.22
(t-stat)			(-20.91)								(-14.27)		(-17.02)	(-13.64)	(-18.67)
Adjusted R^2	36.9%	39.3%	32.6%	37.5%	36.9%	48.4%	36.9%	37.6%	36.9%	36.9%	39.0%	51.8%	40.6%	51.9%	55.6%

4.6. Relation of fixed income factors with other asset classes

This section links the fixed income factors identified in this study to the factor premia from JSE listed equity. Following Asness, Moskowitz and Pedersen (2013), who find persistent value and momentum return premia across eight diverse financial markets in eight developed market countries, this study explores the common factor structure of returns in the domestic sovereign bonds and local equity market.

Factor portfolios formed to capture value, carry, momentum, and reversion premiums in the domestic equity market were used to facilitate this study. They include the FTSE/JSE Africa Value Index, a style index weighted towards companies with identifiable value characteristics based on the book-to-price ratio, sales-to-price ratio, and dividend yield. The FTSE/JSE Dividend+ Index represents a carry portfolio and is formed by selecting the top thirty listed shares domestically from a universe of the FTSE/JSE Top 40 Index and FTSE/JSE Mid Cap Index (excluding Real Estate Investment Trusts) based on their one-year forecast dividend yields.

Momentum returns for the domestic equity market are calculated from JSE listed equity data between May 2007 - October 2023 as the 12-month trailing total return on a liquid sub-set of the market. This is a standard measure of momentum in equity and other financial asset classes, as detailed by Jegadeesh and Titman (1993), and Asness, Moskowitz and Pedersen (2013). Liquidity, in this context, refers to the truncation of the investible universe of JSE listed equity to the top one hundred based on market capitalization – representative of a highly tradeable proxy of the market. The data is free of survivorship bias, with delisted shares included in the sample set. Returns are also adjusted for corporate actions. The equity momentum portfolio selects the top quartile from the subset of one hundred liquid shares based on the 12-month trailing return. The portfolio is weighted on a market capitalization basis and is held for a calendar month before it is reconstituted. Consistent with the definition of reversion employed for local currency sovereign bonds in this study, the reversion portfolio represents an underperforming subset of the market from a total return perspective. Specifically, employing the same subset of JSE data as the momentum portfolio, the reversion portfolio represents the worst performing quartile of the market based on the 18-month trailing return. As with the equity market momentum portfolio, the reversion portfolio is weighted on a market capitalization basis and is held for a calendar month before it is reconstituted. Mean monthly JSE factor returns and standard deviations over the sample period are presented in Table 13.

Table 13: JSE factor returns

		JSE ALSI	JSE Value Portfolio	JSE Dividend+ Portfolio	JSE Momentum Portfolio	JSE Reversion Portfolio
JSE Factor Portfolio Returns	Total Return (1m Avg.)	0.82%	0.70%	0.85%	1.06%	-0.84%
	Standard Deviation	4.45%	4.76%	4.75%	5.10%	6.64%

The FTSE/JSE Africa All Share Index generates a mean monthly total return of 0.82% and a standard deviation of 4.45%. The FTSE/JSE Value Index generates a mean monthly total return of 0.70% and a standard deviation of 4.76%. The mean monthly total return on the FTSE/JSE Value Index is not significantly different from the mean monthly total return on the FTSE/JSE Africa All Share Index. The FTSE/JSE Africa Dividend+ Index, which represents the carry factor in the domestic equity market, generates a mean monthly total return of 0.85% and a standard deviation of 4.75%. The mean monthly total return on the FTSE/JSE Africa Dividend+ Index is not significantly different from the mean monthly total return on the FTSE/JSE Africa All Share Index. The equity market momentum portfolio generates a mean monthly total return of 1.06% and a standard deviation of 5.10%. The mean monthly total return on the equity market momentum portfolio is not significantly different from the mean monthly total return on the FTSE/JSE Africa All Share Index. In contrast to the fixed income reversion portfolio, the equity market reversion portfolio generates a negative return premium. The equity market reversion portfolio generates a mean monthly total return of -0.84% with the highest standard deviation across factor portfolios at 6.64%. The mean monthly total return on the equity market reversion portfolio is significantly different from the mean monthly total return on the FTSE/JSE Africa All Share Index, which is statistically significant at the 1% level.

Table 14: Cross asset correlations – Fixed income factor returns vs JSE factor returns

		Correlation Coefficient
Cross Asset Correlations	Benchmarks	0.23
	1m Value	0.30
	1m Carry	0.50
	1m Momentum	0.25
	1m Reversion	0.35

Next, drawing from Asness, Moskowitz and Pedersen (2013), this study explores the potential transcension of factor returns between the domestic equity market and the domestic sovereign bond market. The returns from the fixed income factors are correlated to the corresponding returns from the equity market factors, suggesting the presence of common global risk factors across unrelated asset classes. A correlation of 0.23 between the total return of the on-the-run fixed income index and the FTSE/JSE Africa All Share Index serves as a benchmark for comparison of the cross-asset factor premiums. The return correlation for all factor portfolios increases relative to the passive, cross-asset benchmark. The return correlation for cross-asset momentum portfolios increases modestly to 0.25 relative to the cross-asset benchmarks. The correlation for the cross-asset value portfolios increases to 0.30 and increases further to 0.35 for the cross-asset reversion portfolio. At 0.50, the fixed income and equity market carry portfolios have the highest return correlation across asset classes.

The increase in correlation for cross-asset factor portfolios relative to the passive cross-asset benchmarks suggests the presence of common global risk factors. These correlation structures are not a prediction of existing behavioural models and are difficult to reconcile under rational asset pricing theories.

5. Conclusion

This study examines the presence of factor premiums in the cross-section and time series of South Africa's local currency sovereign bond market and assesses their influence on return variation and portfolio risk. While there is a wealth of established financial market literature on factor investing in international equity markets, the transcension of the literature to sovereign bond markets has laboured, despite the size and significance of the fixed income asset class. South Africa's deep and liquid local currency sovereign bond market presents a suitable environment to study the presence of fixed income factor premiums in an emerging market context.

The well-established factor premiums in the existing academic literature are adopted in this study. These include value, carry, momentum, and reversion. These style-based measures are underlined by sound economic intuition and represent a replicable and systematic approach to investing that has been found to generate unique long-term excess returns across markets and unrelated asset classes.

This study finds statistically significant factor premiums for T1, long-only value, carry, and reversion portfolios. While the T1 momentum portfolio also outperforms the on-the-run sovereign bond benchmark, this return premium is not statistically significant. The excess return on the long-only T1 factor portfolios is achieved with lower return variability relative to the benchmark. The PV01 neutral long-short value portfolio also generates a statistically significant excess return.

Additionally, consistent with Brooks, Palhares and Richardson (2018), this study finds evidence of factor premiums across long-only and long-short, equal weight, interest rate neutral combination portfolios. For the 2-factor combination portfolios, statistically significant factor premiums are identified for all long-only 2-factor combination portfolios and all long-short 2-factor portfolios. For the 3-factor combination portfolios, statistically significant factor premiums are identified for all T1 3-factor combination portfolios and all long-short 3-factor portfolios. The evidence of factor premiums in South Africa's sovereign bond market extends to 4-factor combination portfolios, with both the 4-factor T1 long only portfolio and the 4-factor long-short portfolios generating statistically significant factor premiums. Beyond the statistically significant factor premiums identified in this study across single-factor portfolios, combination portfolios, and long-short portfolios, the factor premiums are also noteworthy for their economic significance.

The return correlations across factor portfolios are also assessed in this study. The sample data set exhibits a persistently large and positive return correlation across South Africa's local currency nominal bond returns which naturally spills over to the factor portfolios. However, within this context, this study evidences the diversification benefit across factor portfolios, with the value portfolio providing the least correlated monthly return across all long-only portfolios. The Value (T1) & Momentum (T1) portfolio provides the least correlated monthly return across all combination portfolios.

The interaction between the fixed income factors and the principal components of the yield curve are also investigated. The explanatory power of the first three principal components on yields is an intuitive starting point for exploring the primary contributors to returns in the domestic sovereign bond market. As with Brooks and Moskowitz (2017), the fixed income factors identified in this study are found to better predict the excess return on a generic series of zero-coupon, South African sovereign bonds than the principal components, which jointly explain 99.93% of the cross-sectional variation in the yield curve. This finding is at odds with the predictions of most affine term structure pricing models. While Brooks and Moskowitz (2017) find that the fixed income factors subsume pricing information from the principal components, this study finds that the fixed income factors add to the explanatory power of the predictive regressions of South African sovereign bond excess returns.

Consistent with Duffee (2011), and Joslin, Priebsch, and Singleton (2014), this study also finds evidence of meaningful interaction between unspanned macroeconomic variables and South African sovereign bonds. The fixed income factors considered in this study are found to maintain their statistical significance when considered alongside the unspanned macroeconomic variables and jointly regressed against the 3-month excess return of South African sovereign bonds. While Brooks and Moskowitz (2017) find that the fixed income factors subsume pricing information from the unspanned macroeconomic variables, including industrial production and inflation, this study finds that the fixed income factors add to the explanatory power of the predictive regressions of South African sovereign bond excess returns.

This study extends the existing factor-based investing literature to South Africa's sovereign bond market, and not only evidences the existence of statistically significant factor premiums, but also evidences the improved risk efficiency and reduced return correlation of these strategies relative to the equal weight, on-the-run sovereign bond benchmark. These findings lay further challenges to the EMH and the application of the CAPM in South Africa's sovereign bond market.

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