Performance determinants of foreign currency bonds issued by JSE-listed companies – an indexation approach

by

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Declaration

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Abstract

The number of Johannesburg Stock Exchange (JSE) listed companies that have issued foreign or hard currency denominated bonds has increased meaningfully since the global financial crisis in 2008. This broader hard currency opportunity set is primarily available to professional local investors but accessibility is largely constrained by a lack of reliable data and a representative index to assess performance. This thesis constructs hard-currency non-Rand denominated corporate bond indices using both traditional and fundamental indexation strategies to critically investigate the performance of the investable opportunity set. The constructed indices represent a first attempt to study the hard currency universe in South Africa and covers the 12-year period between 2008 and 2019. The main findings show that the constructed fundamental indices not only generate superior absolute nominal and excess returns versus a traditional market cap equivalent, but do so by taking less total, systematic and downside risk. The next substantive chapter considers the volatility of total bond returns generated by these indices. This is done using a GARCH-MIDAS framework that allows for the incorporation of data at different frequencies into the same model. The findings show that certain market and macroeconomic variables significantly affect the volatility of total returns generated by the constructed indices. Specifically, the JSE All-Share index is shown to account for approximately one third of corporate bond market volatility in the long run, which would suggest that monitoring performance at the aggregate equity index level could potentially improve the robustness of client portfolios holding corporate bond assets. The final substantive chapter builds on these conclusions by investigating the relative informational efficiency between the corporate bond and equity markets. This is done by using a VAR model to analyse the lead-lag relationship between bonds and equity issued by the same firms. The results are largely consistent with previous contributions to the literature showing that equity markets are relatively more informationally efficient and tend to lead corporate bond markets. This would suggest that equity returns are potentially predictive of future corporate bond returns and may allow professional investors to more appropriately manage risk in multi-asset portfolios.

Dedication

For Leigh, Belen and Isla.

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List of Acronyms and Abbreviations

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ALSI	All Share Index
APT	Arbitrage pricing theory
ARCH	Autoregression Conditional Heteroskedasticity
BIC	Bayesian Information Criterion
CAPM	Capital Asset Pricing Model
CDS	Credit default swap
CFO	Cash Flow from Operations
CPI	Consumer Price Index
EMH	Efficient Market Hypothesis
EM	Emerging Markets
EU	European Union
GARCH	Generalised AutoRegressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
HY	High Yield
HQ	Hannan-Quinn Information Criterion
IG	Investment Grade
JSE	Johannesburg Stock Exchange
Mtkcap	Market Capitalisation
MAR	Minimum Acceptable Return
MIDAS	Mixed Data Sampling
MENA	Middle East and North Africa
MPT	Modern Portfolio Theory
NASD	National Association of Securities Dealers
OLS	Ordinary Least Squares
OTC	Over the Counter

P/E	Price Earnings Ratio
RAFI	Research Affiliates Fundamental Indices
RV	Realised Volatility
SAInf	South African inflation
SAIP	South African Industrial Production
SIC	Schwarz Information Criterion
S&P	Standard and Poor's
UK	United Kingdom
US	United States
USIP	US Industrial production
USREER	US real effective exchange rate
USDZAR	US Dollar/Rand
VAR	Vector AutoRegressive
VIX	Volatility index

Chapter 1 | Introduction

1.1 Overview

The number of JSE-listed companies that have issued foreign currency has increased meaningfully over the last ten years. This broader hard currency corporate bond or credit opportunity set available to investors is not especially transparent with accessibility largely constrained by a lack of reliable data. Most of these bonds trade Over the Counter (OTC) with less transparency than their listed equity counterparts. This asset class is eligible for investment in vehicles including balanced funds, fixed income and bond funds, as well as specialised alternative, credit and hedge funds. The hard currency opportunity set is an important part of the investable listed universe and potentially has important risk management considerations for market practitioners managing both retail and institutional client savings. The market cap of the investable opportunity set across both primary and secondary listings amounts to approximately $230m as at the end of December 2019. This is approximately 67% of South Africa's nominal GDP at the same date (South African Reserve Bank, 2023).

South Africa has a large and established fund management industry which is expected to practice strong stewardship over savings pools they manage on behalf of both retail and institutional clients. According to Pillay and Fedderke (2022) the South African private retirement industry manages total assets amounting to approximately 50% of GDP. Despite the size of the industry, the country has one of the lowest discretionary savings rates in the world with household savings averaging approximately 2% of GDP (National Treasury, 2021). Contractual savings through unit trusts, retirement annuities and pension funds are relatively large compared to both the size of the domestic economy as well as relative to emerging market peers (Stanlib, 2020). A study by Orthofer, Du Plessis, and Reid (2019) also found that life insurance and pension funds make up 36% of household private wealth, which is competitive with most developed market economies.

Fund managers invest across well-developed domestic capital markets. Assessing the footprint of the Johannesburg Stock Exchange (JSE) by the measuring of market capitalisation as a percentage of GDP shows that South Africa is a relative outlier compared to global peers. The world average for stock market capitalisation to GDP amounts to 98.6%. By comparison, the South African average is around 156% with the current 2020 number coming in at 312%. The SA ratio is among the highest in the world. (TheGlobalEconomy.com, 2020). Given the savings pool linked to that capital as well as potential spill-over effects into the real economy from a sizeable financial market, industry regulation has been relatively stringent. Pension funds own approximately 40% of the assets on the JSE and are regulated by the Pension Funds Act (PFA) (IFC, 2013).

The growth in the market capitalisation of the JSE has been partly supported by the secondary listings of large multinational companies with primary listings on foreign stock exchanges. These include consumer staples companies, Anheuser-Busch InBev SA/NV (AB InBev) and British American Tobacco Plc, as well as basic materials and diversified mining companies Anglo American Plc, BHP Group Plc and Glencore Plc. Companies often pursue secondary equity listings to increase access to a more diversified pool of investor capital as well as diversify funding sources.

These firms also have listed hard currency debt programmes that allow them to raise capital in global bond markets. Siegfried, Simeonova and Vespro (2007) find that the issuance of foreign currency bonds by non-financial companies is motivated by trying to widen the base of potential investors, hedge currency risk, reduce costs and more efficiently manage regulatory hurdles that constrain the operational capacity of the firm. The ability to tap into a broader investor base of foreign investors allows issuers to mitigate idiosyncratic risks that may arise in specific markets, regions or geographies. It also allows issuers to diversify funding sources to fund the operations of the business (Black and Munro, 2010).

By including the bonds of JSE secondary listed companies as part of the investable hard currency opportunity set, South African investors would also be able to consider the bond debt by these firms for inclusion in client portfolios. Fund managers with fixed income, credit, balanced and flexible fund mandates could all potentially utilise the constructed indices to widen their investment universe and consider the eligibility of the constituent bonds to meet portfolio performance, risk management or diversification objectives.

These are entities that are well known to domestic fund managers given the size of the equity footprint on the JSE. The ability to invest higher up the capital structure in hard currency debt issued by these companies potentially introduces another opportunity to enhance portfolio returns and improve diversification. The academic evidence is supportive of local investors having a relative advantage over foreign investors in home markets. Bae, Stulz and Tan (2008) found that local analysts have higher success rates in forecasting earnings even after controlling for individual analyst or firm-specific characteristics.

The evidence presented in this thesis is timely given recent regulatory changes. Under Regulation 28 (Reg 28) of the PFA, South African fund managers are now able to allocate up to a maximum of 45% of fund Net Asset Value (NAV) in foreign non-Rand denominated assets. The new limit was increased from 30% in February 2022. The higher offshore allocation is especially useful for investors able to combine the diversification benefits of both foreign currency equities and bonds in multi-asset portfolios. However, managing currency risk is relatively more challenging with the increase in offshore limits. Various authors have emphasised the impact of global factors including commodity prices, market volatility and global shocks on the volatility of the rand (Fedderke and Flamand (2005), Hassan (2015), Maveé, Perrelli and Schimmelpfennig (2016)). By understanding the effect of currency on both the level and volatility of corporate bond returns, investors managing capital in constrained Reg 28 compliant portfolios can potentially maintain their foreign currency strategic asset allocation towards equities while diversifying corporate bond exposure between local and hard currency bonds to improve portfolio robustness. Furthermore, by better understanding the variables that provide predictive or explanatory power for the level and variance of corporate bond returns, they can more appropriately manage the trade-off between risk and return in client portfolios. The substantive chapters of this thesis will seek to examine these variables in more detail.

1.2 Aims and Objectives

The intention of this thesis is to construct a JSE foreign currency corporate bond index and identify the determinants of both the level and variance of returns at the aggregate index level. The purpose is to improve the transparency of the hard currency opportunity set available for inclusion in professionally managed investment portfolios and to quantify the effects of the real economy and financial variables that are most likely to impact on risk-adjusted returns.

This thesis is constructed with three substantive chapters, each delineated with specific aims and objectives, to investigate and provide evidence to support the statement of intent shown above.

The first substantive chapter aims to construct a hard currency corporate bond index using both a traditional market capitalisation as well as a fundamental approach. The objective is to both identify the full investment opportunity set available to professional fund managers and, furthermore, to analyse and attribute the risk-adjusted performance of the constructed indices at the aggregate and constituent sector levels. The methodological approach is largely consistent with the seminal contributions to the indexation literature by Arnott, Hsu and Moore (2005) in equity markets and Arnott et al. (2010) on fixed income. The main findings are that the constructed fundamental indices deliver superior mean variance performance and deliver statistically significant excess returns over the market cap benchmark. Sector performance attribution shows that these excess returns are relatively more attributable to selection instead of allocation effects, with only the fundamental sales index showing positive attribution from asset allocation over the sample period between January 2008 and December 2019.

The second substantive chapter aims to examine the determinants of the volatility of long-term corporate bond returns. The objective is to use a Mixed Data Sampling (MIDAS) methodology within a GARCH setting to explain long-run corporate bond returns using low-frequency macroeconomic and financial variables. The GARCH-MIDAS methodology allows for the disentanglement of the long-term component of volatility from short-run dynamics. Three specifications, namely a realised variance (RV), level and volatility, and variance ratio analysis, are used to estimate the predictive power of the macroeconomic and financial variables to explain long-term volatility of hard currency corporate bond returns at the aggregate index level. The methodological framework is consistent with Engle, Ghysels and Sohn (2013). The main findings show that South African industrial production, default and the JSE All Share Return variables significantly affect bond market return volatility, the most significant of which is that equity market returns account for almost one-third of corporate bond market return volatility at the aggregate index level. On the other hand, domestic inflation has a limited impact on foreign-currency bond market return volatility. For foreign currency denominated corporate bonds, long-term volatility is shown to be negatively related to the volatility of US industrial production. The US Real Effective Exchange rate is shown to have low explanatory power for hard currency returns at the aggregate corporate bond index level.

The third substantive chapter aims to examine the informational efficiency between hard currency non-Rand denominated corporate bond market and equities issued by the same companies. The objective is to analyse the co-movement of these assets at the aggregate index level through a Vector Autoregression (VAR) methodology and interrogate for lead-lag effects using a Granger Causality test. In addition, the analysis is stratified by equity listing type (primary or secondary), sector, issuer type, duration exposure and issuer rating. The methodological approach is consistent with Downing, Underwood, and Xing (2009) and also a more recent contribution by Tolikas (2018). The main findings show evidence for a lead-lag relationship between corporate bond and equity returns at the aggregate level. Empirical analysis at a stratified level reveals varying patterns depending on the type of stratification investigated. Equity returns lead bond returns for investment-grade bonds, but the same relationship does not hold for high-yield bonds where the relationship is found to be bi-directional. With respect to listing, both primary and secondary listings are shown to be strongly bi-directional. The findings also show that equity returns lead bond returns for low duration bonds. The rand dollar exchange rate is also shown to be statistically significant at the 1% level of significance in terms of negatively affecting hard currency corporate bond returns.

1.3 Limitations

Limitations are included in this introductory chapter to frame the discussion around specific constraints that are relatively unique to developing and emerging markets versus developed market counterparts. The most prominent limitations of this study relative to previous contributions to the literature on corporate bonds are indicated below.

The most notable constraint is the lack of credit rating data availability from the main third-party rating agencies, Moody's, S&P or Fitch. This is especially pronounced at the individual bond level, where credit rating data is not widely available across the 12-year sample period between January 2008 and December 2019. Long-term foreign currency ratings are not consistently available for approximately 50% of underlying constituent bonds. This limits the granularity of analysis at the individual bond-specific level that is relatively widely used across the developed market literature on bond and fixed income asset pricing. This thesis attempts to mitigate this constraint by modelling credit ratings at the firm-specific level and applying the issuer's long-term foreign currency rating across the individual bonds that specific issuers have outstanding. While this does allow for relatively meaningful observation and testing at the broader investment grade and high yield issuer types, it does not necessarily capture the underlying credit, default and liquidity risk in the underlying individual bonds. Put differently, the approach is useful for aggregating general credit quality at the issuer level but may not capture the investment risk of the bonds that a specific issuer has outstanding. This limitation is not expected to significantly detract from the stated intention and associated aims and objectives of this thesis. Given the relatively smaller sample size and emerging nature of the hard currency corporate bond universe, segmenting bond exposures too narrowly may potentially detract from the robustness of findings. From a more practical perspective, professional fund managers in South Africa are expected to perform their own credit ratings and not rely on external rating agencies to construct portfolios. The equity of the sample companies trades on the JSE, which imposes stringent requirements on companies to maintain their equity listings. Fundamental company data is readily available to investors, allowing both professional and institutional investors to perform their own credit analysis and form a view of issuer creditworthiness.

Another constraint is that data has been sourced at lower frequency, given that mark-to-market (MtM) pricing is not consistently available at higher frequency intra-day or daily as used in some developed market studies. These limitations are entirely an outcome of missing or unavailable data points for the metrics indicated above, as opposed to an explicit exclusion of these variables. It should be noted that the indices presented in this study are constructed on the full population of fixed rate corporate bonds in issue across the sample period from January 2008 to December 2019. There have been specific exclusions made for different reasons explained in Chapter 3 but, in aggregate, because the investable universe has relatively lower breadth than developed market peers, the company and underlying bond constituents are considered to be fully representative of the investment universe available to investors. This does somewhat mitigate the lack of liquidity, rating and higher frequency pricing data available to the extent that these limitations and constraints are endemic of the relatively narrower investment universe compared to developed market peers.

The length of time series for the corporate bond indices used in this chapter is relatively short, covering the 12-year period from January 2008 to December 2019. This is an outcome of the hard currency listed corporate bond universe being especially narrow prior to the 2008 financial crisis. Because no comparative index exists and indices need to be constructed, the December 2019 cut-off was to facilitate adequate time for data collection, cleaning, interpretation, and deduction.

Lack of appropriate benchmark. No current benchmark exists for the SA corporate bond market, either in local or foreign currency. The South African primary listings are also too small to be included in a global EM corporate bond index weighted either by traditional market cap or fundamental weighting methodology. This is predominantly because the primary listed, South Africa-domiciled issuers have a smaller operational footprint and a relatively higher funding mismatch due to earning a significant percentage of revenue in Rands while bond coupon and capital repayment are likely to be in stronger, less volatile developed market currencies.

Another constraint is that the majority of bonds in the sample do not report and disseminate data in accordance with TRACE requirements, so trading volumes and liquidity data are not available for approximately 50% of the sample.

1.4 Contributions

This study aims to contribute to the literature on asset pricing with a specific focus on the level and volatility of aggregate corporate bond returns from a country (South Africa) and regional (EM) perspective.

To the best of the author's knowledge, this is the first contribution to the literature on both traditional and alternative indexation for foreign currency bonds issued by JSE-listed entities. In addition, it also adds to the literature on capital market pricing on emerging market corporate bonds with specific regard to hard currency debt and is the first to consider this from both an African and South African perspective. This thesis also focuses on total returns, so it is directly comparable to equities. Many of the previous contributions consider credit spreads, which contribute to total returns, but do not necessarily explain the total returns generated by corporate bonds.

To the best of the author's knowledge, this is the first paper to investigate the volatility of corporate bond returns in an emerging market context using a GARCH-MIDAS framework that attempts to understand the long-run component of corporate bond returns volatility. There have been EM contributions examining the level of returns, specifically with regards to credit spreads, but this is a first contribution investigating volatility at the aggregate index level.

To the best of the author's knowledge, this thesis is also the first contribution to the global EM literature, which attempts to examine the co-movement of listed EM corporate bonds and equities in a lead-lag framework.

1.5 Motivation

An important motivation for this thesis is contributing towards improving the transparency on an asset class that has a sizeable economic footprint but trades with limited information.

There have been numerous contributions to the literature that support the premise of increased visibility and transparency contributing to better client outcomes in financial markets. Pagano and Roell (1996) argue that, in aggregate, increased transparency results in lower transaction costs for traders irrespective of nominal trade sizes. Goldstein, Hotchkiss and Sirri (2006) and Bessembinder, Maxwell and Venkataraman (2006) make similar assertions by examining the effect of increased transparency on bid-offer spreads, finding evidence of lower trading costs for actively traded bonds. Asquith, Covert and Pathak (2013) later show that improved market transparency reduces the price dispersion for both investment grade and high yield bonds. There are, however, still opposing views on whether investors actually benefit from increased transparency in corporate bond markets. Naik, Neuberger and Viswanathan (1999) provide a dissenting opinion, suggesting that higher transparency could actually introduce frictional costs through intermediary rents which could potentially increase trading costs for investors. There are arguments, especially in emerging or developing markets like South Africa, where market structure may be a constraint. Holmstrom (2015) argues that bond markets are less informationally efficient, and that increased transparency may not necessarily result in improved investor outcomes. In aggregate, however, the literature is supportive of markets benefitting from improved trading visibility and overall market transparency.

Radier et al. (2016) asserts that the South African corporate bond market is similar to other emerging markets and is constrained from a size, composition and liquidity perspective. There is general agreement from regulators that policy initiatives are required to the improve the liquidity and transparency of primary and secondary market corporate bond markets in South Africa. The most prominent include enhancing liquidity and price discovery through the implementation of an electronic corporate bond trading platform, improving price transparency for OTC trades, and supporting market integrity by implementing the Global Financial Markets Association (GFMA) Guiding Principles for Market Transparency Requirements (National Treasury, 2018). It's potentially instructive to consider lessons from other countries where corporate bond markets have also experienced friction. Battellino and Chambers (2005) assert that the Australian corporate bond market was catalysed by numerous initiatives supporting its growth. The construction of bond indices for benchmarking purposes, direct experience in offshore corporate bond markets and more sophistication of the investor base were all meaningful contributors to a more robust market structure.

The rest of this thesis will be structured as follows. Chapter 2 presents the theoretical premise. Chapter 3 presents the data and summary statistics. Chapters 4, 5 and 6 present the three main substantive contributions. Chapter 7 concludes.

Chapter 2 | Theoretical Premise

2.1 Introduction

This chapter introduces the literature supporting the traditional capital market theory. The aim is to provide an overview of the seminal asset pricing and indexation contributions to the literature that frame the research presented in this thesis. The theoretical premise supporting the mean-variance framework, the capital asset pricing model (CAPM), and the efficient market hypothesis (EMH) is presented to contextualise the use of more traditional market cap-weighted indexation relative to valuation indifferent fundamental alternatives. These models are contrasted against the primary theoretical, empirical and behavioural critiques that suggest that other factors potentially contribute to the market portfolio being less efficient than the traditional model proposes. These market pricing anomalies include arguments relating to the size and value effect as standalone factors and as part of the Fama and French 3-factor model that expands on the CAPM.

To better understand the substance of traditional market cap-weighted indexation relative to valuation indifferent alternatives like fundamental indexation, it is important to consider the theoretical premise underpinning the debate. The theory that supports market equilibrium and market efficiency is discussed through a review of the following seminal contributions to the literature: the modern portfolio theory (MPT) and mean-variance framework proposed by Markowitz (1952), the CAPM presented by Sharpe (1964), and the EMH specified by Fama (1970).

It is important to note that a full analysis of the seminal literature is outside the scope of this thesis. The purpose was not to independently appraise the arguments for and against their academic or market significance but to objectively consider the evidence that facilitated the evolution of investment strategies from advocates of these theories to those suggesting their specification is inconsistent with implementation.

2.2 Capital Market Theories

2.2.1 Modern Portfolio Theory

Markowitz (1952) presents an approach for how rational investors with different individual risk profiles could potentially maximise risk-adjusted returns when faced with probability distributions of uncertain outcomes. He specifies variance as a proxy for risk and constructs different combinations of mean-variance portfolios to demonstrate the opportunity set of efficient portfolios available to individual investors with different risk profiles. These combinations are located on a so-called efficient frontier, and the most optimal mean-variance portfolio is also found on this theoretical line. Portfolio diversification is indicated as necessary because investors face uncertain outcomes and investing in a diversified basket of securities improves the expected risk-adjusted return profile of the investment. Diversification is effectively shown to be a necessary but not sufficient condition to reduce risk. Markowitz (1952) asserts that investors can mitigate against less favourable outcomes and lower risk through diversification strategies but cannot completely eliminate volatility or risk from the total portfolio. By allocating capital to a diversified group of securities, investors reduce exposure to single security risk and select the most efficient mean-variance portfolio to maximise their expected risk-adjusted returns in accordance with their individual risk tolerance levels. Diversification can be seen as a relatively low-cost strategy to reduce the probability of poor outcomes given the relatively unknown risks embedded in assets at the individual security level.

Markowitz (1959) builds on the mean-variance approach to establish MPT as a framework to find the most optimal portfolio in which market participants can invest. An important construct is presenting the optimal portfolio as an outcome of investors allocating capital to a basket of securities that represents both the highest expected return and lowest implied risk. Markowitz (1959) uses the framework of this separation theory to establish the capital allocation line (CAL), which represents combinations of risky and risk-free assets. He shows that the optimal mean-variance portfolio where the combination of risky and risk-free assets lies tangent to the Markowitz (1952) efficient frontier. This tangency point shows the market portfolio that is expected to deliver the highest returns by assuming the lowest levels of risk.

2.2.2 Capital Asset Pricing Model

Sharpe (1964) leverages off the premise of MPT as presented by Markowitz (1959) and considers investors' preference under the simplifying assumptions of homogenous expectations and utility maximisation. Investors are further assumed to be risk-averse and disposed to choose the portfolio that offers the highest expected return with the lowest possible risk. He deconstructs risk into systematic or beta risk, which represents the covariance of an asset with its market risk, and unsystematic risk, which is unique to a specific asset, sector, or industry. Diversification is indicated as a strategy for mitigating and reducing unsystematic risk while investors taking on higher levels of systematic risk must be compensated with higher expected returns. Under these conditions, the rational investor can be expected to allocate capital to the most optimal mean-variance efficient portfolio. Sharpe (1964) presents this option as the market portfolio and indicates the market moves to equilibrium as market participants invest in this combined basket of assets.

The CAPM was established using the theories of Sharpe (1964). The model is presented as a reliable approach to determine the price for listed equities when markets are in equilibrium. While there are shortcomings in the underlying assumptions, the simplicity of the framework is useful for analysing the implied risk and return trade-offs available to the average investors allocating capital to the market portfolio. Investors are only compensated for exposure to risks that cannot be mitigated, reduced, or eliminated through diversification.

The implications of the CAPM are that active management strategies are unlikely to deliver superior performance on a risk-adjusted basis. Market risk is unavoidable, but active investors choosing to not hold the market portfolio choose to take on incremental levels of avoidable residual risk. The CAPM assumes that expected residual returns are zero. This suggests that active investors choosing to not invest in the market portfolio should only be rewarded for residual returns with positive residual deviation away from the predicted zero values indicative of superior performance over the market. If residual returns are expected to be zero, as predicted by the CAPM, then there is no incentive for investors to deviate from the market portfolio by pursuing active management strategies. Passive investing represents the most optimal capital allocation strategy for investors under these conditions.

2.2.3 Efficient Market Hypothesis

Fama (1970) asserts that listed asset markets are characterised by random returns that provide no consistent arbitrage opportunities. The author presents three forms of market efficiency that negate attempts by investors to generate superior returns over the market on a sustainable basis. He introduces the EMH that classifies markets as weak, semi-strong or strong form. The weak form suggests that investors are unable to outperform the market using only historical information; the semi-strong form indicates that investors are unable to outperform the market using only publicly available information as historical prices fully reflect security fundamentals; and the strong form states that investors can never outperform the market as the market prices of securities contain all relevant past and expected future information. The theoretical premise of the EMH expands on the hypothesis of Samuelson (1965), who indicated that the market is perfectly efficient under the assumptions of all participants having access to a frictionless market where homogenous information is immediately incorporated into security prices in an unbiased manner. The premise of an efficient market is that security prices immediately adjust or normalise in a manner that completely offsets any short-term mispricing or valuation anomalies.

2.3 Critique of Capital Market Theory

2.3.1 Arbitrage Pricing Theory

The arbitrage pricing theory (APT) emerged a few years after Sharpe's (1964) publication as the criticism of the CAPM intensified. Ross (1976) asserts that the expected return of a financial asset is affected by several risk factors. Underpinning the APT is the law of one price, which asserts that the same asset may not be sold for different prices. In addition, the APT is specified in the form of a multi-factor model where a key assumption of the model is that asset returns are sensitive to changes in factors (Sharpe, Alexander & Bailey, 1999). An important part of the underlying assumptions of the APT is that risk factors should have an effect on returns, and that risk factors should affect expected returns. Furthermore, Jones (2007) suggests that risk factors cannot be fully predicted as they may contain information that is unexpected to the market.

2.3.2 Roll's Critique

Roll (1977) argues that the market portfolio as presented in the CAPM is not empirically observable and disputes the robustness of a market proxy being used as approximation of the true market portfolio. His contribution suggests that it is plausible that the proxy market portfolio may be mean-variance efficient while the unobservable true market portfolio may not be. Sharpe (1964) indicates that the true market portfolio comprises global multi-asset securities. The implication under Roll (1977) is that constructing such a portfolio is not practically feasible, which further supports his criticism of the unobservable nature of the CAPM.

Roll (1978) further suggests that using proxy for the unobservable true market portfolio impairs the reliability of quantifying beta or systematic risk. Mis-specifying both the market portfolio and beta coefficient through the CAPM would adversely affect the reliability of the risk-adjusted return profile of the market portfolio.

2.3.3 Behavioural Finance

The premise of the behavioural economics contribution to asset pricing literature is the hypothesis that individuals do not necessarily behave in a rational manner. Kahneman and Tversky (1977) found that rational decision-making is inherently conflicted by systematic thinking errors and biases that contradict the theoretical behavioural assumptions embedded in the CAPM and EMH. Kahneman and Tversky (1977) indicate that the manner in which market participants can be expected to assimilate information differs from the unbiased assumption presented under the EMH. They assert that individuals have a propensity to overweigh more current information relative to the past, which introduces a recency bias inconsistent with the theories presented by Fama (1970). This suggests that current market prices may not necessarily incorporate all the information required to rationally and efficiently price assets. The discrepancies in how different individual investors make decisions add additional complexity to the manner in which new information is initially processed and ultimately priced into assets.

The concept of recency bias is supported by De Bondt and Thaler (1985) in their investor overreaction hypothesis. The premise of this hypothesis is based on the idea of mean reversion in asset prices. The authors consider the manner in which a security is undervalued in the short term and re-rated positively when the securities future outlook is expected to be especially prosperous. They consider the manner in which investors process company earnings by valuing a company below fair value because of historically weak company earnings and then adjust expectations as the projected future earnings of the company improves. Similarly, expensive companies priced above fair value negatively de-rates as expectations of the company's future outlook diminish. In both cases, the overreaction of security price in one particular direction is normalised as expectation of future prospects become less uncertain. The implication is that the size of the subsequent normalisation of the security price moving closer to fair market value is effectively determined by the size of the initial mispricing. This suggests that the dispersion of price fluctuations around the theoretical fair value is greater for securities that are significantly over- or undervalued by investors before adjusting expectations for updated forecasts. De Bondt and Thaler (1985) assert that systematic security mispricing is corrected over time as security prices converge to their mean reverting fair values.

2.3.4 Fama and French Factors

Fama and French (1993) concede that pricing and valuation anomalies could be attributed to other risk factors not explicitly specified in either the CAPM or their three-factor model using beta, size, and value coefficients. Fama and French (1993) contribute further to the asset pricing literature by developing a three-factor model to investigate average risk-adjusted returns in listed equity markets. They suggest that the investors' overreaction hypothesis presented by De Bondt and Thaler (1987) is a useful framework to understand the tendency for both smaller and value style companies to deliver returns above the expectations priced into the traditional CAPM model. The Fama and French (1993) model specification includes the traditional beta coefficient presented under the CAPM, and importantly, includes approximations for the value and size factors identified - as potential contributors to companies' earning excess market returns. The authors identify their size factor as small minus big (SMB) to consider the premium of small capitalisation over larger cap companies, and the value factor is calibrated as high minus low (HML) to consider the premium of so-called value over growth companies. The model is essentially an expansion of the CAPM as both SMB and HML are explicitly specified in the model to better understand the risk factors not captured by the CAPM beta coefficient. Fama and French (1993) concede that value and size factors modelled under their three-factor methodology produce excess market returns but do not cite explicit reasons for the relative outperformance. However, they suggest that the investors' overreaction theory as hypothesised by De Bondt and Thaler (1985) constitutes a plausible explanation for the observed anomalies.

There have been other notable contributions to examine market pricing anomalies not addressed by traditional asset pricing models. Early contributions to the literature on the relative inefficiency of listed security markets examines the observable accounting fundamental measures of company earnings and book values to investigate asset pricing. Basu (1977) and Rosenberg, Reid and Lanstein (1985) combine fundamental and market measures to test the assumption of market efficiently underpinning the CAPM.

Basu (1977) investigated the capital market theory through a framework of analysing price earnings (P/E) ratios. He found evidence to dispute the robustness of systematic or beta risk in the CAPM, and specifically argues against the CAPM's contributing to efficiently priced asset valuation and the model accounting for expected returns. Basu (1977) shows that the assets that generated superior risk-adjusted returns were not predicted by the CAPM. He found that companies with low P/E ratios are priced below their true intrinsic or fair values and that the excess return is an outcome of the convergence of that undervalued share price towards fair value. Low P/E shares therefore outperform the market as investors typically undervalue these shares when current and short-term expectation of earnings growth are relatively less prosperous. Basu (1977) further demonstrates that the use of fundamental accounting information can potentially improve security valuations, which will help investors generate excess returns. These findings further suggest that valuation anomalies are indicative of a less efficient market than modelled under the CAPM.

Rosenberg, Reid and Lanstein (1985) produced the seminal work on extending the contributions of Basu (1977) by examining market efficiency through a book value framework. They use book-to-market ratio to test the assumptions of market efficiency embedded in the CAPM. Their findings indicate that companies with high book-to-market values generate higher risk-adjusted returns than predicted by the CAPM and companies with lower book-to-market values produce lower risk-adjusted returns than implied by the model. The authors assert that these conclusions provide further evidence against the assumed efficiency of the unobservable market portfolio indicated under the CAPM.

Fama and French (1993) assert that beta underestimates systematic risk and that the risk implied in asset valuations should include additional factors. Their work corroborates the findings of Rosenberg, Reid and Lanstein (1985) that companies' book-to-market value contributes towards explaining risk-adjusted returns that deviate from that estimated by the CAPM.

Banz (1981) studied the size effect using a similar approach as Roll (1978) where the misspecification of the CAPM presented by Sharpe (1964) has contributed to additional risk factors not explicitly incorporated in systematic or beta risk. Banz (1981) found that smaller stocks or companies with lower market capitalisations generated higher average returns compared to stocks with higher market capitalisations. The outperformance of listed smaller cap companies over larger cap companies is primarily attributed to the analysis of company risk profiles being adversely affected by relatively incomplete or weaker information. Price discovery is also less transparent because of small cap shares trading in lower volumes and with substantially less liquidity than larger cap peers. Both these factors affect the ability of market participants and investors to reliably estimate systematic risk factors over time.

2.3.5 Smart Beta

Despite being an investment approach that has attracted relatively recent attention, the smart beta methodology has its origins in the seminal asset pricing contribution presented by Fama and French (1992). The strategy uses a systematic investment approach to construct portfolios that select securities based on observable market factors as opposed the relatively more traditional market cap-weighted approach. In addition to size and value factors, smart beta also uses momentum and volatility as explicit factors to model portfolios. Jegadeesh and Titman (1993) made early contributions to the momentum factor, which is a strategy of buying securities that have delivered recent outperformance and selling underperforming securities. Their work focuses on an investment strategy of buying winners and selling losers and found significantly positive returns were generated following that momentum approach. The volatility factor, which was examined by Ang et al. (2006), suggests that low volatility securities can be expected to deliver higher return relative to higher volatility securities. More specifically, they found that stocks with high sensitivity to changes in aggregate volatility experience relatively lower average returns. The factors used as part of a smart beta approach can be considered additional risk premia over the CAPM market risk factor or beta, the use of which could potentially improve the persistence of risk-adjusted returns.

2.4 Fundamental Indexation

Indexation strategies have also contributed to the broader asset pricing literature on market efficiency. The debate is predominantly based on the merits of valuation dependant versus valuation indifferent indexation strategies, and the previously identified market pricing anomalies of value and size still remain the main points of contention.

Arnott, Hsu and Moore (2005) support the earlier seminal contributions of Graham and Dodd (1934) that state that assets can at times trade below their fair or intrinsic value in listed markets. Valuation indifferent indexation strategies can be expected to benefit from the lack of market pricing and market participant perception of value, influencing the weighting of index constituents. Market cap-weighted indexation strategies are overrepresented by expensive companies and under-represented by cheap companies. Using valuation agnostic measures to construct a fundamental index mitigates this bias and is more likely to result in investing in an index portfolio priced to deliver superior risk-adjusted returns. De Bondt and Thaler (1987) also found that the superior performance of fundamental indexation is that the underlying portfolios are underweight, cheaper traditional value securities with more price upside relative to expensive growth securities.

2.4.1 Active versus Passive Investing

A related strand of literature related to the rise of lower cost indexation as direct investment strategy is the debate between the merits of active versus passive management.

2.4.2 Passive Approach

Indexation can be considered a passive investment strategy to the extent that investors are not taking active bets and are effectively investing in a portfolio of companies that should be representative of the broader market or the underlying sectors, industries, and asset classes that constitute that market. Allocating capital to the market portfolio as presented by Sharpe (1964) can be considered a passive investment strategy as investors are theoretically diversified across an optimal multi-asset, multi-geography investment universe.

Malkiel (2003) concludes that the argument supporting the superiority of passive over active investment strategies is agnostic of market efficiency. Passive strategies are expected to deliver excess returns over active strategies in markets considered to be both efficient and inefficient. In efficient markets where asset prices fully reflect all known available past information and future prospects, the absence of market pricing anomalies renders active investment strategies futile. Malkiel (2003) suggests that in inefficient markets, pricing anomalies could potentially provide opportunities for active investment strategies to generate superior returns, but this is dependent on fund manager skill. Furthermore, even with the existence of pricing anomalies, the costs of trading and mean reverting correction of asset mispricing would negate any sustainable benefits of the active strategies on a long-term basis.

2.4.3 Active Approach

Treynor and Black (1973) contend that investors could potentially benefit from deviating from the market portfolio by applying superior judgement and discretion than the average market participant. Investors allocating capital under a long-term risk and reward approach could potentially arbitrage from short-term price fluctuations and earn excess returns over the market portfolio. The implication is that investors without access to unique information, unable to exercise superior judgement, and unable or unwilling to adopt a long-term investment philosophy may be better off pursuing passive investment strategies and holding the market portfolio.

The research on active management in both equity and fixed income strategies is not especially supportive of outperformance persisting over time. Marcus (1990) found that only the best funds exhibit evidence of market outperformance and asserts that active management can be a feasible investment strategy. Fund costs have also been cited as a meaningful detractor from outperformance by actively managed strategies. Ippolito (1993) indicates that on a risk-adjusted basis, the average fund delivers returns approximately equal to the index with no evidence of statistical outperformance over time. Early contributions from Jensen (1968) on mutual funds, Kritzman (1983) on fixed income funds, and Dunn and Theisen (1983) on institutional funds support the hypothesis that the average fund generally does not consistently outperform the market. Other studies, however, found mixed results with persistence of returns over certain periods being negated in subsequent periods. Malkiel (1995) presents some evidence of persistence for US Equity Mutual Funds in the 1970s that were later shown to disappear over the next decade. Carhart (1997), on the other hand, investigates equity mutual funds from 1962 to 1993 and identifies significant evidence of strong underperformance persisting in the bottom quartile of mutual funds.

Arnott, Hsu and Moore (2005) suggest using fundamental firm-specific accounting information as an alternative to using company market capitalisations as an approximation of size. They indicate that book value, sales, dividends, and cash flow are robust measures that are inherently related to the financial strength of the company and fairly represent the company size. There should also be a positive relationship between the financial strength of the firms and size of the firms as indicated by its observable market capitalisation. They assert that fundamental accounting data is highly correlated with the observable market capitalisation of listed companies, which should mitigate the risk of a fundamentally constructed index deviating significantly from a market cap-weighted alternative. This suggests that fundamental indexation could still be an appropriate strategy for passive investors to pursue. Arnott, Hsu and Moore (2005) also show that fundamental indexation strategies are not significantly more volatile than the market cap-weighted equivalent trading at relatively similar levels of systematic or beta risk. Passive investors are therefore potentially better off on a risk-adjusted basis by investing in indices constructed on fundamental or valuation indifferent principles.

2.4.4 Market Cap-weighted Indexation

2.4.4.1 Advantages of Market Cap-weighted Indexation

Market cap-weighted indices can be considered fairly representative of the market portfolio in perfectly efficient markets where the prices of listed securities incorporate all known information in an unbiased manner and provide a fair estimate of true or intrinsic value. Under these conditions, Hsu (2006) suggests that a market cap-weighted indexation strategy allows investors to be optimally invested in the market portfolio as presented by Sharpe (1964). In efficient markets, the main advantages of market cap indexation are that it is easy for market participants to understand, is low cost, and has a rebalancing strategy that is relatively transparent and directly observable at the individual constituent level.

Market cap-weighted indexation is a relatively simple methodology on which to construct market, sector, industry, or asset portfolios for either passive investing or comparative portfolio benchmarking purposes. These benefits are potentially best understood in contrast to more active investment strategies pursued by market participants who perceive the market to be inefficiently priced. The strategy is well suited to passive investors because transaction costs can be maintained at relatively low levels compared to more active strategies where high portfolio turnover costs can partly be ascribed to the propensity of fund managers to buy and sell securities more frequently. Market cap-weighted indices are typically rebalanced on a less frequent basis, which should theoretically provide incremental return by incurring lower transaction costs. Rebalancing market cap-weighted indices are usually required as securities enter and exit the index as opposed to any pricing arbitrage, which active investment strategies would seek to periodically exploit. Market cap indices also tend to hold more liquid securities as an outcome of being skewed towards larger listed companies where price discovery is assisted by institutional and professional investors.

2.4.4.2 Disadvantages of Market Cap-weighted Indexation

Credit and Default Risk

The disadvantages of market capitalisation weighted indices for bond or fixed income securities include the methodology being relatively biased towards potentially higher risk assets. Market cap-weighted indices tend to allocate higher weights to entities with larger amounts of outstanding debt. According to Shepherd (2014), the increasing financial leverage of higher amounts of nominal debt can potentially adversely affect the ability of the issuing counterparty to service increasing interest and capital payments. By allocating higher weights to these securities in the index, investors typically push up the prices and consequently reduce the implied yields to levels where they are not adequately compensated in terms of the implied risk and return. This suggests that as the higher weighted constituent entities issue more debt, they potentially become less creditworthy as the increased burden on the entities' cash flow increases exposure at default for existing bondholders.

Pricing Bias

Equity market cap indices exhibit an implicit disproportionate primacy on market price. The market capitalisation of a company is defined as the market price of the company multiplied by the total number of shares outstanding. The dispersion around price fluctuation tends to be more volatile than the change in outstanding shares. More volatile market capitalisations are therefore more an outcome of changes in equity prices than increases or decreases in outstanding shares. Equity market cap indices are more likely to experience concentration in larger companies with relatively high share prices. The wider the dispersion between those higher prices and intrinsic or fair value, the wider the index will skew and distort the economic fundamentals of the market. In line with the behavioural economic theories of De Bondt and Thaler (1985), larger initial mis-pricings can be expected to contribute to especially pronounced corrections as the market price normalises towards a mean reverting fair value. The implication is that these pricing anomalies directly affect both the reliability and stability of market cap-weighted indices through their dependency on current market prices.

Bond and other fixed income market cap indices are also affected by market price but are especially dependant on the amount of outstanding debt a company has. Index weighting are typically more concentrated towards those companies with higher amounts of issued debt and could potentially also be skewed towards a relatively small group of companies with high financial leverage as an outcome of issuing multiple bonds in listed markets. The implication is that fixed income market cap-weighted indices could potentially be more exposed to higher credit and default risk at the individual constituent level.

Lagging Returns

Return drag is a potential outcome of mispricing at the index level where the overweighting expensive securities detract from the higher portfolio returns provided by cheaper underweight securities as the market adjusts its pricing towards fair or intrinsic value. Hsu (2006) indicates that more pronounced mispricing contributes to a larger drag on expected performance. All things being equal, where markets are inefficiently priced, underweight cheaper index constituents are likely to experience higher price appreciation than relatively more overweight expensive index constituents. The net effect is that market cap indices are likely to underperform fundamental strategies that hold a relatively higher percentage of mispriced cheaper securities. This is however disputed by Perold (2007). Other authors, including Arnott, Hsu and Moore (2005), and Hsu and Campollo (2006) also cite evidence of lagging returns from market weighted indices.

2.4.4.3 Alternative Indexation Strategies

The merits of alternative indexation strategies are predominantly based on addressing the shortcomings of the traditional market cap-weighted approach. They primarily differ in substance by being valuation agnostic to the extent that the primacy of market price, which is embedded in market cap-weighted indexation, is not included in the specification of alternative approaches.

Risk-Based Indexation

Some authors presented alternative risk-based approaches that vary substantially in terms of design and implementation. A common methodological specification in these strategies, however, is the reliance on systematic risk to determine requisite constituent weights during the index construction process.

Risk-based strategies are not directly comparable to market cap-weighted strategies as they are not explicitly premised on being representative of the overall market. By contrast, fundamental alternative strategies are consistent with the premise of market cap-weighted strategies to maintain indices that are both relevant and representative of the market, but they differ in how the market is approximated by constituent weightings. Advocates of risk-based indexation do not make explicit attempts to develop indexation strategies as viable alternatives for passive investment purposes.

Demey, Maillard and Roncalli (2010) suggest a weighting methodology constructed on the principles of risk parity where contributions of index constituents to portfolio risk can be a feasible alternative to using size proxies. There is an explicit focus on optimising the risk profile of the index or portfolio. Index weightings are partly determined by the price volatility of constituent securities and appropriate diversification between those constituents at the index or portfolio level. While not directly comparable in terms of methodology, other authors (Choueifaty & Coignard, 2008; Bruder & Roncalli, 2012) who examined risk-based strategies also found support for the principles of balancing risk through derivatives of portfolio risk diversification and risk budgeting.

Fundamental Indexation

Fundamental indexation strategies allocate the underlying index constituent weights using fundamental firm-specific accounting data as an approximation of relevance and size. For listed equity markets, the methodology mitigates concentration risk of exposure to expensive securities that are overweight, and therefore overrepresented, in market cap-weighted strategies. For listed bond and fixed income markets, the use of fundamental firm data potentially mitigates concentration risk in less creditworthy issuers as the amount of outstanding or issued debt is not explicitly specified in index construction. For both equity and bond or fixed income, fundamental strategies diversify the index away from the expected lower risk-adjusted return priced into market cap-weighted strategies. This is primarily an outcome of having lower exposure to expensive securities, which are priced to deliver relatively lower returns, as well as lower exposure to highly indebted counterparties with increasing levels of credit and default risk.

Arguments Against

Arguments against the improved efficiency of fundamental indices are that the underlying constituents are biased towards relatively undervalued securities, which suggests that the outperformance of the constructed index may be more attributable to the concentration of relatively lower priced traditional value investing securities. One of the main criticisms against fundamental indexations is that the approach is simply based on repackaging older empirical claims as presented under the traditional value investing principles of Graham and Dodd (1934). Asness (2006) contends that fundamental indexation simply repackages a value investing philosophy that benefits from buying into securities at below their fair values and generating excess returns as market prices adjust towards fair values over time. He suggests that it represents an active management approach and is therefore not suitable for traditional indexation techniques. Another criticism of fundamental indices is that they do not explicitly account for the effects of the transaction costs for implementing the strategy. The criticism is that fundamentally weighted indices require more onerous periodic reweighting and rebalancing to reliably incorporate historical financial information of the underlying constituents. Without specifically including the transaction costs of the reweighting and rebalancing, transaction costs understate the cost of implementation. Higher implementation costs potentially overstate the higher implied returns that earlier contributors to the literature (Arnott, Hsu & Moore, 2005; Hsu & Campollo, 2006) cite as a measure of the advantages of fundamentally weighted indices.

Chapter 3 | Data and Descriptive Statistics

3.1 Data Selection

Data has been sourced from Thomson Reuters Eikon and Datastream over the 12-year period between 1 January 2008 to 31 December 2019. The period was chosen to be representative of a sufficiently long enough time series to capture the opportunity set in hard currency bonds issued by JSE listed companies which could be verified with reliable source data in either Eikon or Datastream and checked against actual company annual or integrated reports. The hard currency bond universe was limited and especially small prior to 2008 which constrained extending the sample period beyond 12 years.

Eligible instruments comprise all non-South African Rand denominated interest-bearing instruments paying periodic fixed rate coupons over defined maturity terms and issued by companies with either primary or secondary listings on the JSE. The intention was to construct a hard-currency fixed income investment universe available to market practitioners and professional fund managers through regulated CISCA and Regulation 28 accredited structures to diversify asset allocation on behalf of both individual retail and institution clients. Eligible bonds can be issued by either operating company, holding company or any other subsidiary set up for the purposes of issuing debt obligations on behalf of the listed parent entity. This is especially important in the context of emerging market issuers where domestically listed companies may want to ringfence foreign currency debt to specific legal entities in the group to protect the operating entity in the possible event default on foreign currency bonds in issue. The criteria for including debt issued outside the listed operating entity is that the actual bond liabilities to repay interest and principle needs to serviceable through cash flows generated by the JSE listed entity. No selection criteria was based around bond tranche or seniority. The data set comprises both senior and subordinated or junior debt issued on either a secured or unsecured basis.

3.2 Data Filtering

The initial sample size consists of 1681 bonds issued by 33 companies.

- The first round of bond instrument selection effectively consisted of data cleaning and filtered out 306 bonds had missing data. The remaining sample contains 1375 bonds issued across 32 companies. One company exits the sample completely due to not having any non-Rand denominated bonds in issue.

- Second Round selection criteria excluded bonds not paying fixed rate coupons. This included standard floating rate notes (FRN), Fixed or Floating Rate securities (FIFL), Complex Coupon securities (CMPX) with embedded step-up or step-down features which results in periodic coupons fluctuating to changes in either interest rates, inflation or credit ratings. Zero Coupon Bonds (ZCB) are also explicitly excluded because index inclusion criteria is predominantly focussed on constructing an income generating portfolio that pays regular interest over time. The second-round selection criteria also filtered out preference shares, bonds with sinking fund provisions paying irregular coupons, asset and mortgage-backed securities as well as covered bonds. These exclusions were not material in the context of this study since the data did not contain any instruments matching these descriptions. Bonds with embedded put and call options are included as these mechanisms are useful to issuers and investors to manage risks associated with emerging markets. Convertible bonds are also included since they meet the index criteria of paying regular periodic coupons and contribute to the investment requirements of income generating funds in the South African context. The conclusion of the second round of data filtering resulted in the sample size being reduced from 1375 to 564 instruments issued across 30 companies. Approximately 80% of bond exclusions were to one issuing company which had 567 ZCB's and 84 FRN's removed from the sample. 2 financial companies exit the sample completely with all hard currency debt in issue by these institutions not meeting the fixed rate coupon selection criteria.

- Round three selection criteria filtered out bonds which expired before the start of the examined sample period between 1 January 2008 to 31 December 2019. An additional filter was introduced to exclude any existing bonds with less than 12 months remaining to maturity or redemption as at the start of the sample period of 1 January 2008. These instruments are effectively viewed as money market securities. This resulted in the exclusion of a further 60 bonds to leave a remaining sample of 504 instruments across 29 companies one company exiting completely as bonds had matured prior to the start of 1 January 2008.

- The fourth and final selection criteria excluded bonds with outstanding US Dollar nominal amounts in issue of less than $50,000. This resulted in 5 bonds being excluded and one issuer, exiting the sample completely. After concluding this screening process, the total sample consisted of 499 fixed income securities issued across 28 companies with a listing on the JSE. The summary statistics of these issuers and bonds are shown in the table below.

3.3 Data Characteristics

Table 1: Summary statistics

Characteristic	Number of Issuers	Number of Bonds	Average Duration (Years)	Average Term (Years)	Senior Bonds	Amount Outstanding ($mil)	TRACE Compliant
Aggregate index	28	499	5,0	9,8	429	230,30	253
Listing (1)							
Primary Listing	17	83	4,5	7,6	63	21,5	30
Secondary Listing	11	416	5,8	13,3	366	208,7	223
Issuer Rating (2)							
Investment Grade	16	430	4,7	8,8	384	218,3	236
Non-investment grade	12	69	5,5	11,2	45	11,9	17
Sector (3)							
Resources	7	178	4,2	8,2	154	62,7	94
Industrials	10	263	5,7	9,1	233	156,6	155
Financials	5	31	4,6	9,5	26	5,6	2
Real Estate	6	27	5,1	13,2	16	5,3	2

(1) Listing type is segmented by primary country of domicile and incorporation. Primary listings are domiciled and incorporated in South Africa

(2) Issuer Rating is based on the long-term foreign currency rating of the issuer by either Moody's, Fitch or S&P. The Moody's equivalent rating has been applied across the sample to ensure consistency and comparability.

(3) Sector type is segmented by the issuers primary sector of operation and is allocated across the main JSE index sectors

** Index constituents: African Bank, Anglo American, Anglogold Ashanti, Anheuser Busch, Arcelor Mittal, British American Tobacco, BHP, Brait, Capital And Counties, Firstrand, Glencore, Growthpoint, Hammerson, Impala Platinum, Intu, Investec, Mondi, MTN, Naspers (Prosus), Old Mutual, Redefine, Remgro, Richemont, Sappi, Sasol, Sibanye Stillwater, Standard Bank, Steinhoff

Table 1 shows summary statistics of the data used in this thesis. A few sample characteristics warrant additional comments in the context of this study.

3.3.1 Currency

Figure 1: Issuance Currency

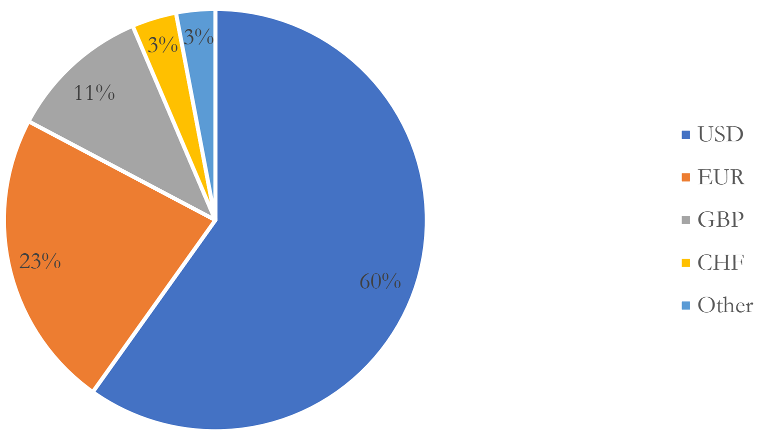


Figure 1 shows a breakdown of bonds by issuance currency for the sample.

The sample is concentrated towards US Dollar denominated bonds. Over 60% of the bonds are issued in US Dollars (USD) followed by 23% in Euros (EUR), 11% in Sterling (GBP) and 3% in Swiss Franc (CHF).

3.3.2 Credit Ratings

Figure 2: Individual bond ratings

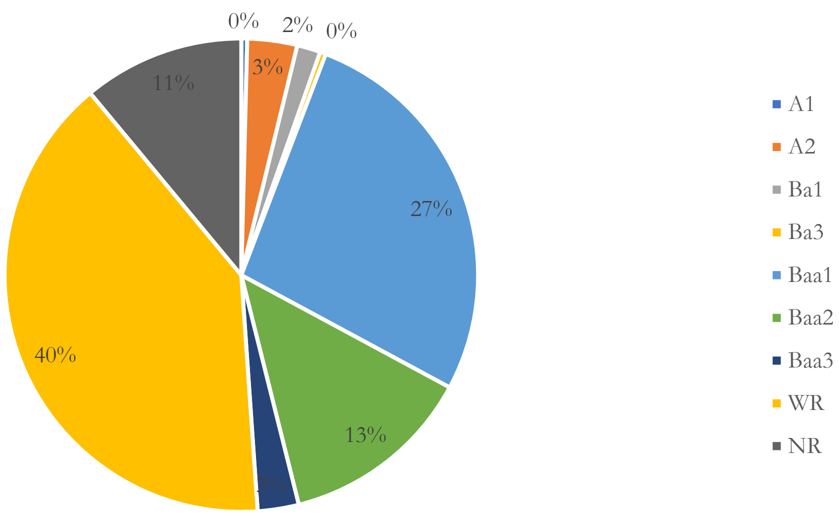


Figure 2 shows individual bond ratings for the sample.

40% of the bonds in the SA opportunity set do not have ratings coverage (WR) over the full sample period of 12 years. In addition, another 11% are not rated (NR). In total 51% of the sample of the investable bond universe has unreliable ratings data. The is largely a function of underlying issuers being relatively new to international bond markets with very little issuance prior to 2008. The lack of reliable ratings data at the bond level is prevalent in emerging markets like South Africa which limits comparability to developed market peers, that have historically had much wider ratings coverage across the major credit ratings agencies. It is important to note that this lack of more robust data is not limited only to ratings but also to more updated pricing as well as liquidity data that is relatively more available for developed and some larger emerging market issuers. These data constraints are systemic and, although the transparency and reliability are improving, would in part provide some explanation for the gap in the asset pricing literature around emerging and frontier market corporate bonds.

The inconsistent ratings data is highlighted as a constraint and limitation in this thesis. However, the lack of granular credit rating data at the individual bond level is partly mitigated by using assigned third party ratings by Moody's, S&P or Fitch at the issuer level. More specifically, the substantive chapters of this thesis, and chapters 5 and 6 in particular, will use the issuer long-term foreign currency ratings to compare investment grade (IG and non-investment grade or high yield (HY bonds). A breakdown is shown in Figure 3.

Figure 3: Issuer level ratings

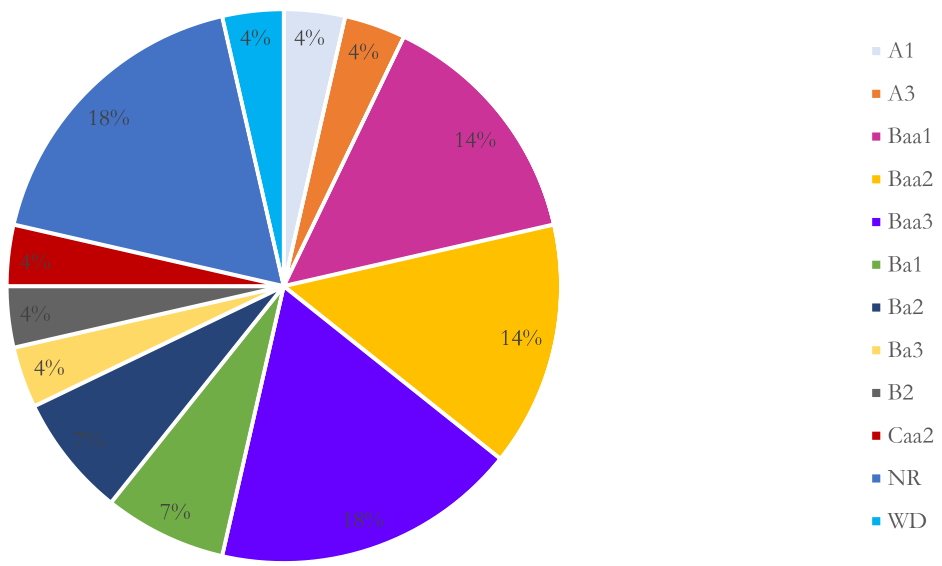


Figure 3 shows a breakdown by issuer rating level for the sample.

3.3.3 Bond Maturities

Figure 4: Bond maturities

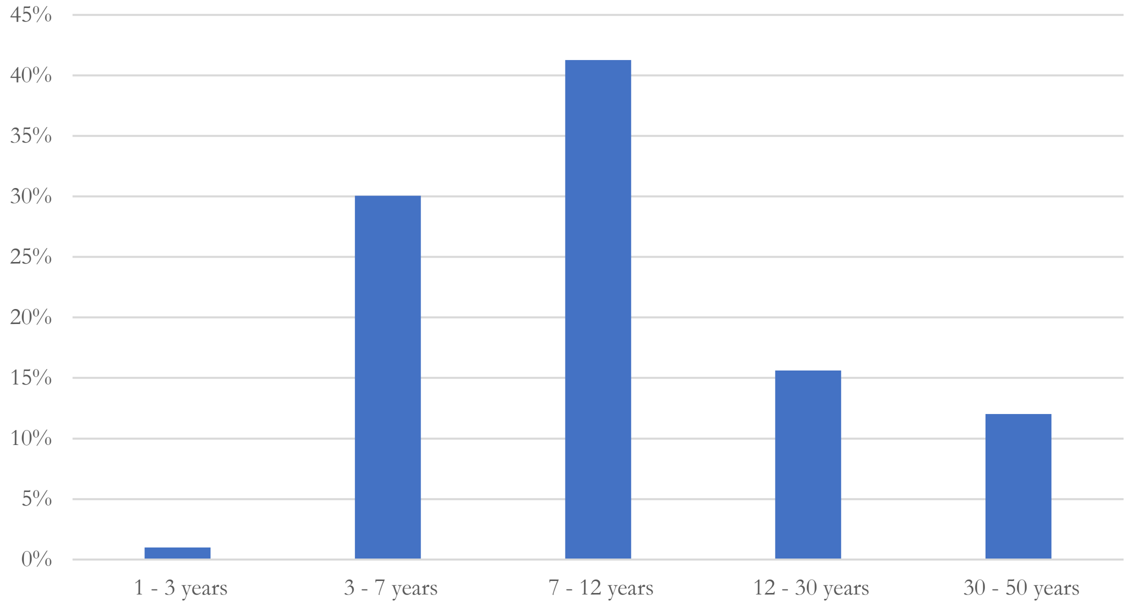


Figure 4 shows a breakdown of bond maturities for the sample.

Figure 4 shows the different maturity buckets typically allocated to by South African fund managers – Short maturity (1 – 2.99 years), medium maturity (3 – 6.99 years), medium to long maturity (7 to 11.99 years), long maturity (12 – 29.99 years) and ultra-long maturity (30 – 50+ years) buckets. The SA hard currency corporate bond opportunity set has approximately 41% of bonds with medium to long term maturity while the medium maturity bucket accounts for around 30%.

3.3.4 Survivorship Bias

Survivorship bias in an outcome of bonds being redeemed at contracted maturity dates or prior to maturity at the option of either bondholder or issuer discretion. Convertible bonds which have the conversion options to equity triggered over the 12-year sample period would also exit any index of which they are constituents. Survivorship bias is considered negligible since all eligible fixed income securities were included at the start of the study and only exit the sample once debt has been fully redeemed, either at maturity or through the exercising of embedded options, de-listings due to default or corporate action, or converted to equity in the case of convertible bonds. The relatively small risk of survivorship bias adversely affecting results in this study is further mitigated by the homogenous data set being applied to both the constructed fundamental indices as well as to the constructed market cap weighted against which performance is assessed.

3.3.5 Secondary Listings

Five of the companies in the sample, Anheuser-Busch Inbev, British American Tobacco, Capital and Counties, Glencore and Hammerson, all have their primary listings on international stock exchanges.

All these companies have a secondary listing on the JSE to access capital in the South African financial markets in addition to the capital raised in the countries and jurisdictions where they have their primary stock exchange listing.

- Global Brewer Anheuser-Busch Inbev ("AB InBev"), JSE share code ANH, listed on JSE in January 2016 after buying South African Breweries ("SAB").
- Global Tobacco company British American Tobacco, JSE share code BTI listed on the JSE in August 2008.
- Property company Capital and Counties, JSE share code CCO, only listed on JSE in 2010.
- Diversified Commodity company Glencore, JSE share code GLN, only listed on JSE in 2013.
- Hammerson, JSE share code HMN, is a Real Estate Investment Trust ("REIT) only listed on JSE in 2016.

These bonds are only eligible to enter the sample after the company has listed on the JSE. This is consistent with the methodology applied to all bonds in the sample including those where the issuing company has a primary listing on the JSE. The rationale for this approach is in line with the premise of constructing a South African passive bond index where issuing companies meet the minimum requirement of maintaining a listing on the JSE. The primary criteria for the purposes of this study is that the companies be listed on the JSE and that the equity of the company be available for purchase by South African fund managers in Regulation 28 portfolios as part of their domestic investable universe.

3.3.6 Fundamental Data

3.3.6.1 Fundamental Accounting Data

For index weighting purposes, fundamental accounting data for the sales, cash flow and book value metrics are collected on an annual basis at the end of the financial year for each of the 28 companies comprising the universe of eligible bond issuers in this study. All accounting data is obtained from Datastream and checked against company annual and integrated reports at financial year end over the whole sample period.

Net Sales represents gross income less any discounts and allowances. More specifically it represents only income earned in the ordinary course of business and comprises predominantly service income. Net sales explicitly exclude non-operating, exceptional or extraordinary income. Items like sales of fixed asset, sales of investments, sales of discontinued operations, dividend income and foreign exchange adjustments are excluded for all companies. Interest income has also been excluded except for financial services companies and banks were revenue earned from interest is a core part of the business model.

Cash Flow from Operations (CFO) is shown as the net value cash receipts and disbursements from the normal operations of the company. It also explicitly considers working capital and capital expenditure of companies.

Tangible Book Value includes the value of ordinary shares, retained earnings, capital premium as well as gains and / or losses on foreign currency translation. It has been adjusted to exclude items including goodwill, intangibles and treasury shares. All fundamental metrics have been treated in a consistent manner over the full 12-year sample period with *Datastream* values checked against audited annual financial reports of the constituent companies comprising the constructed indices.

Chapter 4 | Constructing Hard Currency Corporate Bond Indices for JSE Listed Companies

4.1 Introduction and Background

The objective of this chapter is to construct a hard currency corporate bond index with the underlying constituents comprising foreign currency denominated bonds issued by companies listed on the JSE. The total investment universe comprised of the 1 681 bonds issued by 33 companies as at the end of December 2019. No such index currently exists, and this study both identified the broader opportunity set available to domestic fund managers as well as present alternative indexation strategies to invest in the asset class or use as a risk management tool. Furthermore, investigating these indices on both a market cap-weighted and alternative index basis provided a framework for professional investors to contrast the market pricing of the constituent hard currency bonds relative to their fundamentals.

It should be noted that the purpose was not to propose these indices as a passive investing approach. The current composition of the opportunity set was considered too skewed toward large cap listings that would require further analysis of indexation, and more specifically, capped indexation strategies to assess the feasibility of directly investing in the constructed indices. The fundamental indices do present a systematic approach for constructing indexation strategies that is consistent with both the methodologies presented in the seminal literature contributions by Arnott, Hsu and Moore (2005) on equities and Arnott et al. (2010) on fixed income. This systematic approach was also successfully applied in practice with Arnott's investment management firm Research Affiliates LLC, which successfully implemented and commercialised fundamental indexation strategies across its fund product range. The Research Affiliates Fundamental Indices (RAFI) also have an existing footprint in South Africa, and fundamental equity indices were launched by the JSE in 2007 in association. The underlying methodology of using company fundamentals, including sales, cash flow, book value and dividends, are currently applied to JSE AllShare and Top 40 indices. Ferreira and Krige (2011) made early contributions to the literature on alternative indexation on South African equity markets using RAFI strategies.

However, applying a fundamental approach is not well established in the domestic bond market with regards to either local or hard currency debt. The constructed indices developed in this paper present the full foreign currency denominated, fixed rate investable universe available to investors. The opportunity set incorporates bonds issued by companies with both primary and secondary equity listings on the JSE. Companies with primary equity listings on foreign stock exchanges dominate the constructed indices. This study did not attempt to control for any size effects by capping aggregate or constituent weightings. This was done to consistently capture the economic footprint of these underlying issuing companies and bonds irrespective of whether a market cap or fundamental indexations weighting approach is used. This is consistent with most of the contributions to the existing literature that examines alternative indexation strategies for equity and bonds.

This chapter is arranged as follows:

- Firstly, there is an overview of the primary capital market and behavioural finance theories that frame the discussion around fundamental indexation as an alternative to market cap indexation strategies. The is done to provide an overview of seminal contributions to the literature that were developed across both equity and corporate bond markets.

- The next section is a comprehensive literature review that frames the analysis. It introduces the case for and against fundamental indexation and references the main literature contributions from both developed and developing or emerging markets. It includes evidence from different asset classes, including equities, that have been relatively widely covered, as well as more recent contributions on corporate bond and real estate markets.

- This is followed by a section explaining the methodology of constructing the fundamental indices. The fundamental data used to construct the indices are consistent with Arnott, Hsu and Moore's (2005) historical cash flow, net sales and book value data, which were used to construct individual fundamental indices. The constructed, net sales, and book value indices are used to construct a composite index. All four fundamental indices are compared and benchmarked against a market cap index that is constructed using the same underlying issuers and constituent bonds. The indices used to investigate the performance of fundamental versus market cap-weighted indexation are all constructed by rebalancing the constituent bond portfolios once a year. The indices are not capped at any specific number for any of the years being examined. Therefore, index reconstitution does not occur because individual bond issuers are excluded as a consequence of any maximum number of constituents being reached in any of the years for which the indices are constructed. All eligible companies and bonds were included as part of the available population of investable assets. The selected approached aimed to objectively model for size of the company without attempting to weight constituents away from the larger companies that dominate a market cap indexation strategy. This was done to more reliably capture the economic footprint of the investable universe as opposed to applying a maximum limit or capping index constituent weightings.

- The last part analyses both the absolute and relative performance of the constructed fundamental indices as well as the constructed market cap-weighted index, which was also used for benchmarking purposes. The empirical analysis considers the economic significance of the absolute and relative performance of the constructed fundamental indices, and more specifically, compares the total return generated by these indices relative to a market cap-weighted alternative. The results are presented in five sections that can be described as follows:
    - The absolute returns section focuses on an empirical analysis that investigates the evidenced empirical return of all four of the constructed fundamental indices against the benchmark market cap-weighted index. Performance results at both the individual

index and realised annual return level are presented for each of the fundamental indices and compared against the benchmark market equivalent across the period January 2008 to December 2019. These results are presented using monthly data and are assessed for consistency using weekly data. The main findings showed that all fundamental indices generate superior cumulative and annualised average total returns relative to the market cap-weighted counterpart index before adjusting for risk, and with the exception of the cash flow index, the fundamental indices are demonstrated to deliver those returns at higher volatility when calculating the annual standard deviation over the 12-year period. These findings are consistent when using both the higher frequency weekly data points and the monthly data points to construct the indices.

- The section on performance attribution compares the underlying index constituents and weighting of the fundamental indices relative to the market cap benchmark. The main purpose was to identify the sectors that most meaningfully contributed to or detracted from the performance of the fundamental indices when compared to the benchmark market cap equivalent.
- The risk-adjusted performance analysis section investigates the quality of returns generated by the fundamental indices compared to a market cap-weighted counterpart. More specifically, it contrasts the risk-adjusted excess returns generated by the four fundamental indices relative to the constructed market cap-weighted benchmark. The index performance was calibrated for measures of total risk (Sharpe ratio) and market risk (Treynor and information ratios). An analysis of downside risk using the Calmar ratio is also included to understand index performance during periods of market drawdowns. The main conclusions from this section are that the constructed fundamental indices generate superior absolute nominal and excess returns versus a market cap equivalent, and that it does so by taking less total, systematic and downside risk. This suggests that passive investors looking for the highest risk-adjusted return, lower maximum and average drawdowns, and fewer periods underperforming the risk-free rate would be better served by investing in the fundamental indices over the market cap-weighted alternative.
- The section focused on modified duration considers duration as a contributor to outperformance. The purpose of this section is to consider whether there is any evidence to support the argument that mean variance outperformance by fundamentally constructed indices is attributable to taking on higher levels of interest rate risk or duration. The findings of this study show the opposite. Despite taking on higher levels of interest rate or duration risk over the 12 years from January 2008 to

December 2019, the market cap index has underperformed the constructed fundamental indices. The first four sections specifically assess the absolute and relative returns generated by the constructed fundamental indices and attempt to demonstrate economic significance over the 12-year sample period between 2008 and 2019.

- The purpose of the final section on capital asset pricing model (CAPM) analysis was to investigate the statistical significance of the risk-adjusted returns generated by the fundamental indices. This section uses the CAPM to investigate whether any excess return generated above an appropriate risk-free benchmark is significant when compared against the excess returns generated by a comparable market cap-weighted benchmark index.

4.2 Overview

Observable security market values is widely used in traditional market cap-weighted indices, and the vast majority of global indices for both listed equity and bond securities are based on this approach. The principles of market cap-weighted indexation are supported by traditional capital market theories where the market portfolio can be considered representative of the most optimal risk-adjusted investment strategy.

The seminal contributions to the traditional capital market theories, including the modern portfolio theory (MPT), the mean variance framework proposed by Markowitz (1952, 1959), the CAPM presented by Sharpe (1964), and the efficient market hypothesis (EMH) specified by Fama (1970), suggest that investing in the market portfolio represents the most optimal strategy for allocating capital. These theories are linked by simplifying assumptions that in perfectly efficient markets the prices of listed securities incorporate all known information in an unbiased manner and provide a fair estimate of true or intrinsic value.

Even prior to the development of traditional capital pricing theories, Graham and Dodd (1934) asserted that the true fair or intrinsic value of a security can differ from its observable market price. This suggests that the pricing of listed market securities is potentially less efficient than implied by advocates of the MPT, CAPM and EMH. Investors using fundamental company or firm-specific information can generate superior returns by deviating from the Sharpe (1964) market portfolio and investing in undervalued securities.

Various arguments have been presented against the merits of traditional asset pricing frameworks that suggest that the underlying assumptions are contradicted by empirical and behavioural observations of the average market participant or investor. Roll (1977) contends that the market portfolio as specified in the CAPM is not empirically observable and potentially mis-specifies the systematic risks faced by investors.

The assumptions of investor behaviour underpinning capital market theory have also been disputed by some authors. Kahneman and Tversky (1977) found that rational decision-making is inherently conflicted by systematic thinking errors that impair the ability of the average investor to process information in as unbiased a manner as assumed under the assumption of efficient markets. De Bondt and Thaler (1985) present an investor overreaction hypothesis that indicates that investors either over- or underreact to news in the short term and correct their initial reaction at a later stage. Fama and French (1993) suggest that the investors' overreaction hypothesis presented by De Bondt and Thaler's (1985) is a useful framework to understand the market pricing anomalies that have shown both smaller and so-called value style companies to deliver superior risk-adjusted returns than the market portfolio.

Other authors more recently expanded the debate on market efficiency to the merits of active versus passive investing. Grinold and Kahn (2000) suggest that active investors choosing to deviate from the market portfolio can potentially fall into the trap of the greater fool theory where attempts to arbitrage security prices when markets are efficiently priced are likely to result in negative investment outcomes that trail the average market return. Malkiel (2003) contends that the debate about whether markets are efficient or inefficient is irrelevant since the probability of outperformance by active investors in either scenario is unlikely. In efficient markets, securities are already priced at their intrinsic value, and in inefficient markets, where price differs from intrinsic value, increased trading and transaction costs negate any gains from active management strategies.

Fundamental indices were proposed as a valuation agnostic alternative to address the structural shortcomings of market cap-weighted indices and have received increased attention in both developed and emerging equity markets. Seminal contributions to the developed market literature have been provided by both Arnott, Hsu and Moore (2005) and Hsu and Campollo (2006); they found evidence that fundamental indexation delivers superior risk-adjusted performance to market cap-weighted alternatives. The authors use valuation indifferent firm-specific fundamental metrics, including sales revenues, cash flows, book value, and dividends, to approximate the size and economic footprint of index constituent securities. Their work is supported by a noisy price hypothesis (Siegel, 2006), which suggests that mis-pricings in observable market securities may be carried over into valuation sensitive indices, attaching primacy to price in the index construction process. Noisy prices are an outcome of irrational investors trading securities at above or below the fair or intrinsic values.

However, the findings of Arnott, Hsu and Moore (2005) and Hsu and Campollo (2006) are not without contention, and Schoenfeld and Ginis (2006), Perold (2007) and Amenc, Goltz and Lodh (2012) dispute the premise, significance and interpretation of their results. Other detractors (Asness, 2006; Edesess, 2008) contend that the superior mean variance results attained by advocates of fundamental indexation are attributable to the already empirically evidenced value and size pricing anomalies. This is disputed by Hsu and Campollo (2006), who show that their fundamentally constructed index outperforms the traditional value-oriented Russel Value 1000 and 2000 market cap-weighted equivalents. Asness (2006) also suggests that fundamental indexation is akin to an active management approach, and therefore, not suitable to traditional indexation techniques. This opposes the assertions of Arnott, Hsu and Moore (2005) who indicate that fundamental accounting data is highly correlated with the observable market capitalisation of listed companies, which should mitigate the risk of a fundamentally constructed index deviating significantly from a market cap-weighted alternative. This suggests that fundamental indexation could still be an appropriate strategy for passive equity investors to pursue.

The fixed income indexation literature is less well developed. Arnott et al. (2010) made a meaningful early contribution, and De Jong and Wu (2014) provide a perspective on both investment and high yield bonds in developed markets. From a structural perspective, various authors cite fundamental differences in the functioning of debt and equity markets that could potentially result in alternative approaches being investigated for index construction.

Kwan (1996) and Downing, Underwood, and Xing (2009) consider corporate bond markets with over the counter (OTC) trading platforms as relatively less transparent with weaker price discovery than evidenced in structurally more liquid equity markets. These structural challenges in corporate bond and fixed income markets potentially impair the efficient pricing of listed securities to a greater extent than in listed equity markets. For market cap-weighted indices to be a robust and reliable indexation and benchmarking strategy, the basket of underlying constituents should represent the most optimal mean variance investment portfolio available to market participants. The evidence presented by critics of both traditional capital market theories and more recently by opponents of market cap-weighted indexation on equity markets suggest that the market portfolio as presented by Sharpe (1964) may not be the most optimal mean variance portfolio. If corporate credit and fixed income securities can be considered structurally less liquid with structurally weaker OTC trading functionality, then there is a possibility that fixed income indices constructed on a market cap-weighted basis are less optimal than their equity counterparts. This is the premise for investigating the merits of fundamental indexation on corporate bond and fixed income securities. The implications for constructing fixed income indices are potentially more pronounced because prioritising market values could actually result in indices being more concentrated in lower credit quality, highly indebted companies. Market cap is partly an outcome of the outstanding market value of debt issued by a company, which could bias the index towards firms with a relatively high amount of nominal debt in issue.

Arnott et al. (2010) made a seminal contribution to the literature on fundamental indexation with regards to listed corporate bonds. They found that security selection contributes significantly to return outperformance for both investment grade and emerging markets fundamentally weighted bond portfolios. The authors do however suggest that security selection is an outcome of passive reweighting strategies and does not constitute active de facto security selection. Importantly, they also refute the size and value argument presented by critics on the evidence that the traditional Fama-French equity market risk factors fail to explain the outperformance of the three fundamental bond indices used. The authors also state that there should be no theoretical basis that would result in other asset classes not delivering the same outperformance over market cap-weighted indices as evidenced in equity and bond markets.

The majority of the existing indexation studies are on developed markets with equity as an asset class. The emerging market equity literature has increased over the last few years but fixed income contributions in emerging are sparse. The South African evidence on fundamental indexation is mostly limited to equity markets. Ferreira and Krige (2011) made a meaningful contribution to the emerging market literature by analysing the listed equity market in South Africa. Their study adopted a similar framework and methodology as that of Arnott, Hsu and Moore (2005) and found support for the conclusions of Arnott and Shepherd (2012) that fundamental indexing delivers superior risk-adjusted returns for emerging markets equities.

4.3 Literature Review

4.3.1 The Case for Fundamental Indexation

4.3.1.1 The Noise-in Pricing Framework

Fundamental indices are proposed as a valuation agnostic alternative to address the structural shortcomings of market cap-weighted indices. Arnott, Hsu and Moore (2005) contend that market cap-weighted indices are adversely affected by irrational investors engaging in so-called noisy trading where listed securities and the observable market price deviates from the fair value of the company. These mis-pricings at constituent company levels are carried over into market cap-weighted indices where primacy is attached to noisy market prices that may potentially be over- or undervalued at specific points in time.

Arnott et al. (2008) propose a noise-in-price framework, which attempts to disentangle the intrinsic fair value of a security from its observable market prices, to create a fundamental theory in support of the superior performance of alternative strategies. The theory suggests that security market prices can be deconstructed to comprise both a fair value and so-called random error variable. The random error is an attempt to capture the residual between a securities' current and fair value. It is effectively an approximation of the relative over- or undervaluation of a security at any point in time.

The principles of the theory presented by Arnott et al. (2008) are consistent with early contributions on asset pricing by Black (1986), who also contends that listed security prices are affected by noise. His argument is based less on any shortcomings in the specification of traditional capital market theories and is more rooted in the behavioural finance literature. Black (1986) asserts that investors are risk averse and slow to allocate capital when new information is disseminated. This lag between the new information being priced into the security imply that the market is less efficiently priced in the short term and could potentially present arbitrage opportunities. Other early proponents of pricing anomalies include Blume and Stambaugh (1983), who use a noise in-price framework to consider the size premium for companies with larger market capitalisations.

Siegel (2006) also presents a noisy market hypothesis to contest the assumptions of market efficiency. His theories dispute the rational investors' assumption underpinning traditional capital market theories. More specifically, some market participants display more speculative behaviour that seeks to maximise their short-term benefit as opposed to the less short-term oriented rational investor framework assumed in traditional asset pricing theories. The noise or pricing discrepancies created by these short-term traders and speculators manifest as the observable market price deviating from it true fair or intrinsic value.

The different contributions to noisy pricing theories also support the arguments of Arnott, Hsu and Moore (2005), who applied the hypothesis to their seminal work on fundamental versus market cap-weighted indices. The main contention from the authors is that noisy prices lead to market cap-weighted indices being biased toward larger cap securities because of index construction attaching primacy to market prices. The implication is that the index will be underweight smaller cap securities, which may not necessarily be less efficiently priced than the larger cap index constituents.

This pricing inefficiencies suggested under noisy pricing theories (Arnott et al., 2008; Black, 1986; Siegel, 2006) are carried over into market cap indexation strategies were index construction is specified on observable market prices. Noisy prices can also be viewed as contributing to the evidenced market anomalies of size and value presented by Banz (1981) and Basu (1977), respectively. In theory, it can be argued that the market pricing primacy built into the specification of market cap-weighted indices directly leads to overweight positions in large capitalisation securities and underweight smaller cap securities. On average, an increase in the market cap of a company can mostly be ascribed to an increase in it security price over time, as opposed to continuously increasing shares in issue. Arnott et al. (2010) also found evidence supporting the over-representation of large cap securities in market weighted indices. They contend that valuation indifferent strategies, like fundamental indexation, can be expected to deliver superior risk-adjusted returns when markets are less than efficiently priced and noisy prices provide meaningful upside potential.

4.3.1.2 Passive Investment Alternative

The contribution by Arnott, Hsu and Moore (2005) is not an attempt to dispute the suitability of market cap-weighted indexation as a passive investment strategy. The authors identify what they consider structural issues in valuation biased indexation and attempt to present an alternative approach that is less biased toward security valuation and potentially more suitable to passive investors. Their fundamentally weighted index is not presented as an active investment strategy or as a way to arbitrage the size and value effects that other authors cite as reasons for the evidenced outperformance relative to market cap-weighted indices. Arnott, Hsu and Moore (2005) explicitly attempt to construct a reliable representative index that maintains the benefits of traditional passive investment strategies. In selecting fundamental firm-specific accounting data, the authors were cognisant of building an index that maintain a relatively high correlation with liquidity and size of the underlying constituent companies.

Despite attempts to maintain the integrity of fundamental indexation for advocates of passive investors, some authors suggest that the approach deviates from the traditional framework for passive investment strategies. Schoenfeld and Ginis (2006) contend that fundamental indexation is representative of a quasi-active approach and requires less transparent periodic rebalancing to maintain lower exposure to relative less expensive large cap companies. Estrada (2008) suggests that the periodic rebalancing also exposes investors to increased portfolio turnover and higher trading costs, which are lower in traditional passive investment strategies.

4.3.1.3 Equity market Evidence

Developed Markets

Treynor (2005) shows that valuation indifferent indexations strategies have outperformed their market cap-weighted counterparts. This assertion is primarily premised on mean reversion in security prices where initial market pricing errors are adjusted and corrected over time. Security mispricing results in individual securities being either over- or undervalued in the market, which adversely affects the inclusion of these securities in valuation biased indices. The index is therefore likely to be overweight expensive large market cap securities and underweight cheaper small cap securities. Valuation indifferent indices can generate superior performance by having lower exposure to expensive growth securities, which have been found to lag the capital appreciation in cheaper small cap securities as the market corrects initial mispricing. Treynor (2005) also cites the compounded effect of being under-invested in smaller cap securities as a meaningful drag on the performance of indices constructed on a market cap-weighted basis. He further advocates for the merits of valuation indifferent indexations strategies by suggesting that outperformance can be more persistent if diversification and maintaining low trading costs are explicit considerations.

Arnott, Hsu and Moore (2005) made one of the earlier seminal contributions to the literature on alternative indexing strategies. They use historical financial information, including sales, book value, cash flow, and dividends, to construct a fundamentally weighted index of the US equity market. They demonstrate that the index significantly outperforms a market capitalisation weighted Standard and Poor (S&P) 500 index across different business cycles between 1962 and 2004. The fundamental index generated through the cycle returns approximately 2% higher than the S&P 500 index, which supports their conclusions that the fundamental index would have returned more than double the market cap-weighted index over the full sample period. Excess returns are attributed to inefficient market pricing and superior index construction, which more efficiently prices distress in the underlying index constituents. The authors also show that indices constructed using individual fundamental metrics on a standalone basis yield similar results to the composite index. The sales weighted fundamental index generates the highest outperformance of all the metrics with an excess annual return of approximately 2.4% above the market weighted S&P 500 index over the full 43-year sample period.

Importantly, the authors also found that the fundamental composite index has a lower systematic risk, which they use as evidence for fundamental indices being mean variance superior to market capitalisation indices. Their findings support the conclusion that fundamentally weighted equity indices generate superior long term returns at lower risk than market capitalisation indices. Fundamental indices are shown to be less sensitive to noisy prices. The authors note that their conclusions are consistent across multiples business cycles. The fundamental composite index is also shown to be more liquid with lower concentration risks in the portfolio constituents and higher portfolio turnover rates relative to the market cap-weighted alternative. These results of superior risk-adjusted returns and better liquidity are also consistent for each of the fundamental indices constructed using standalone metrics.

However, Arnott, Hsu and Moore (2005) concede that fundamental indexation strategies are exposed to value and size effects that tilt the portfolio in favour of undervalued smaller cap securities. They qualify this by indicating that if fundamental indexation is biased towards value and size, market cap-weighted indexation is inherently skewed towards more expensive growth securities.

An important distinction is that the use of indexation approaches that are valuation agnostic does not explicitly result in indices being concentrated in smaller, more value-oriented securities. Index construction is an outcome of using fundamental accounting data, which is independent of market price. By contrast, an index approach that explicitly specifies market price as a determinant can, in theory, be argued to directly promote the inclusion of larger companies that are or have been experiencing relatively high growth in their security prices. For market cap-weighted indices, being overweight expensive, large cap growth companies can be directly attributable to the index approach and specification. For fundamental indices constructed using historical firm-specific accounting data, being overweight less expensive, smaller cap companies, which have experienced relatively low price appreciation, is an outcome of *not* attaching any primacy to price in index specification. In theory it can be argued that the primacy on price in the specification of market cap indexation causes exposure to large high-growth companies whereas the exposure to smaller value-oriented companies in fundamental indices is a merely a symptom of adopting a price agnostic approach.

Hsu and Campollo (2006) demonstrate that earlier support for superior risk-adjusted returns for fundamental or valuation indifferent indexation as evidenced by Arnott, Hsu and Moore (2005) could be applied to a global listed equity peer set. They expand on Arnott, Hsu and Moore's (2005) study by examining the performance of both US and global equity markets over the 20-year period from 1984 to 2004 using a fundamentally weighted index strategy across a sample of 23 countries. They also use book values, sales, and cash flow to construct the index. The authors' findings support the conclusions of Arnott, Hsu and Moore (2005) by showing that fundamental indexation delivers superior returns for US equities by outperforming the market cap-weighted index by approximately 2.8%. They demonstrate that the constructed fundamental global index also outperforms the market cap-weighted MSCI World Index by around 3.5%. The authors found that this outperformance is consistent for each of the 23 countries in their sample.

Their contribution also incorporates additional segmental analysis and specifically considers both bull and bear phases of the market cycle as well as expansion and contraction phases of the business cycle. The authors demonstrate that fundamental indices underperform during bull markets where listed equity prices are excessively high. Hsu and Campollo (2006) found that the correlation between fundamental and market cap indices decreases during periods where extreme market exuberance manifests in asset pricing bubbles. Elevated prices contribute to relatively higher weightings in market capitalisation indices where fundamental indices would typically be reweighted as the price and intrinsic value diverge. A fundamentally weighted index can be expected to underperform because of being underweight in those securities whose excessively high prices drive higher weighting and performance in market cap-weighted alternatives. Their paper also attempts to address two of the more common concerns around fundamental indexation, namely transaction costs and value bias. Fundamental indexation is shown to produce superior returns to value-oriented market cap indexation across the business cycle when using the Russell 1000 value index as a benchmark. The authors assert that market cap weight indices have potentially higher transaction reweighting costs relative to fundamentally weighted alternatives as constituents move in and out of the index.

Stotz, Döhnert and Wanzenreid (2010) investigate fundamental indexation in listed European equity markets over a 14-year period between 1993 and 2007. They found evidence of superior performance for their fundamentally weighted index over the market cap weighed Dow Jones (DJ) Stoxx 600 index. Their findings are consistent those of Arnott, Hsu and Moore (2005) and Hsu and Campollo (2006), but their contribution further indicates that the reliability of fundamental indexing can be improved by using a combination of accounting-based ratios and market values as opposed to using either on its own.

Chen, Chen and Bassett (2007) take an alternative approach to fundamental indexation by using a smoothed time series average of initial market cap weightings as opposed to historical financial accounting information. They construct a basket of 1 000 listed US equities and use a 5-year moving average of historical prices to calculate a hypothetical fair value prices over a 40-year period. They consider the difference between security price and theoretical fair or intrinsic values. The authors assume that current market prices are unbiased but noisy estimates of the true fair or intrinsic price of the security. Their findings support the conclusion that fundamentally weighted indices generate superior risk-adjusted returns but are highly reliant on the underlying constituent security prices mean reverting over time.

Hemminki and Puttonen (2008) expand the European literature on fundamental indexing by investigating European large cap listed companies between 1996 and 2006. They found evidence of superior risk-adjusted performance for their composite fundamental index over the market cap-weighted DJ Euro Stoxx 50 index. This finding is consistent for each of the individual fundamental weighted indices used in the study with dividend and book value constructed indices being especially meaningful for providing superior mean variance returns. They also found evidence that shows the suitability of combined metrics as implemented by Stotz, Döhnert and Wanzenreid (2010) for improving the robustness of constituent weightings on fundamental indices.

Emerging Markets

Arnott and Shepherd (2012) propose that fundamentally weighted indices in emerging market economies should provide higher risk-adjusted prospective returns to market cap-weighted indices. They test the hypothesis by comparing the fundamental emerging markets RAFI index to the market cap-weighted FTSE AW emerging markets index between 1994 and 2009. The 15-year time series was especially relevant given the frequency of market distress in both developed and emerging markets with event risks including the Asian Crisis in 1997, the Russian Crisis in 1998, the Internet Bubble in 2000 and the Global Credit Crisis in 2008. Arnott and Shepherd (2012) found further support for the return drag of market cap indices versus the fundamental indices by demonstrating that the emerging market RAFI outperformed the FTSE AW EM by approximately 9% a year over the period. They also contend that market cap-weighted indexation can be expected to experience a more pronounced performance lag in emerging markets because security prices are relatively more affected by noisy trading.

Estrada (2008) takes a different approach to examine the back-tested empirical evidence in support of fundamental indexing. They construct the constituent weightings for 16 countries using the aggregate dividends per share of each individual market for the period from 1973 to 2005. This fundamental global dividend weighted index produces superior risk-adjusted returns relative to the global market cap-weighted benchmark alternative over the full sample period.

Hsieh (2013) makes another contribution to the emerging markets literature on fundamental indexing in listed equity markets. He specifically attempts to examine the substance of the relative outperformance of fundamental indexation being more attributable to the large cap size and value bias cited by critics of the strategy. He conducts a performance attribution analysis of fundamental emerging market equity indices based on the Fama and French's (1993) three-factor model over a 15-year period from 1996 to 2010. The study uses constituents from the S&P's emerging large-mid-cap (LM) index. The results of the study show that fundamental indexation only outperforms the market cap alternative after controlling for the size and value bias effects. These findings contradict the conclusion of earlier contributions from Hsu and Campollo (2006), Arnott et al. (2010), and the emerging market contribution of Arnott and Shepherd (2012). The fundamentally weighted sales index was, however, evidenced to be an exception and supported the attribution analysis of those earlier contributions. The authors also indicate that the fundamental indexation constructed on emerging market constituents experience significant drawdowns during specially pronounced periods of increased market risk.

Hsieh, Hodnett and Van Rensburg (2012) examine the performance of fundamental indexation against market cap-weighted alternatives using constituents from the DJ Global Sector Titans composite index over an 18-year period from 1991 to 2008. They construct fundamental weight indices using the average values of trailing five-year book value, earnings, dividends, sales, and cash flow. They also explicitly consider the effects of index concentration by segmenting the sample further into constituent baskets comprising 30, 50, 100, and 200 companies. The study found that fundamental indices generate superior risk-adjusted returns against the market cap-weighted alternative as well as the market cap-weighted MSCI World Index across the whole sample period. They also demonstrate that the outperformance by the fundamental indexation strategies were consistent across both expansionary bull and contractionary bear markets. Furthermore, Hsieh, Hodnett and Van Rensburg (2012) show that the performance of fundamentally weighted indices are unaffected by the number of index constituents while the performance of market cap-weighted indices is negatively affected at lower levels of concentration in constituent portfolios.

In a study conducted across 28 developed market and 22 emerging market countries, Walkshäusl and Lobe (2010) show that, in aggregate, fundamental indexation outperforms a market cap weight approach. However, they indicate that there are some countries in the sample, namely Taiwan, Columbia, Morocco, and Venezuela, that delivered performances that lagged the market cap-weighted portfolio.

More recent contributions have been relatively varied and studies on individual countries and regions have evidenced different outcomes. Abadi and Silva (2019) examine the performance of fundamental indexation using sales, cash flows, book value, dividends, and composite indices against a smoothed market cap-weighted portfolio in Middle East and North Africa (MENA) markets. The study is conducted on equity markets across a sample of 13 countries in the MENA region. The results show that only the fundamental sales portfolios outperforms the smoothed market cap-weighted portfolio over a 10-year period between 2005 and 2015. All other fundamental portfolios underperform. The results also show that the fundamental portfolios have higher risk factor loadings towards factors, including size and value, that are likely to account for outperformance over a market cap-weighted strategy. The authors suggest that given the shortcomings of fundamental indexation in an emerging market context, alternative weighting strategies should be considered to improve risk-adjusted performance.

These conclusions can be contrasted against studies by Küçükşahin and Coşkun (2020) on the Turkish stock market and by Kumar and Tiwari (2021) on the Indian stock market where fundamental indexation strategies delivered excess returns over the market cap strategy.

South Africa

The South African contributions to the literature are not particularly extensive. Ferreira and Krige (2011) made a meaningful contribution to the emerging market literature by analysing the listed equity market in South Africa. Their study adopts a similar framework and methodology as that of Arnott, Hsu and Moore (2005) and examine the South African equities listed on the JSE over the 14 years between 1995 and 2009.

They examine the performance of the fundamental JSE RAFI index against the market cap, the JSE AllShare (ALSI) index. The JSE RAFI is shown to generate superior risk-adjusted returns of approximately 4.7% relative to the JSE ALSI on an annually compounded basis over the sample period. The JSE RAFI also demonstrated relatively consistent performance and only underperformed the JSE ALSI in four of the 14 years analysed by the study. Ferreira and Krige (2011) also use the individual accounting measures of sales, dividends, book value and cash flow to evaluate the performance attribution of fundamentally constructed JSE index based on each of these metrics. Their analysis includes the use of the Sharpe, Treynor and Sortino ratios to understand and interpret outperformance drivers. The authors found that fundamental indices constructed using any of these accounting measures outperform the market cap-weighted JSE ALSI benchmark. They argue that diversifying a fundamental index using these measures potentially improves the risk and return profile across the business or economic cycle. However, they found that indices constructed with dividends and sales deliver the highest outperformance versus the JSE ALSI market cap index. These findings further support the conclusions of Arnott and Shepherd (2012) that fundamental indexing delivers superior risk-adjusted returns for emerging markets equities. An interesting conclusion from this study is that both standalone indices constructed using only sales and dividends outperform the index constructed using book values. The authors assert that this outperformance of both of these metrics suggests that the evidenced outperformance of fundamental indices of market weight indices cannot be ascribed to the valuation tilt or bias cited by critics of fundamental indexation. The outperformance of the standalone fundamental dividend index also contradicts the assertions of Fama and French (2007) that question the relevance of constructing fundamental indices.

Other Asset Classes

Arnott et al. (2010) made a seminal contribution to the literature on fundamental indexation with specific regard to listed corporate bonds. Their study covers both investment and non-investment, or high yield, corporate bonds in the US. The authors also increase the scope of their research to include emerging market sovereign bonds. They attempt to address concerns identified in the earlier literature on the outperformance of fundamental indexation strategies relative to market cap alternatives being primarily attributable to size and value effects. Their hypothesis is that demonstrating superior risk-adjusted returns in less transparent listed corporate bond markets would refute arguments against the construction and selection bias against fundamental indexation expressed by other authors.

Following on from their index weighting methodology applied to fundamental indexing in listed equity markets, they retain the use of historical financial accounting information, including book values, sales, cash flow, and dividends. To calibrate the approach for listed corporate bonds, they add the face value of the issued debt. The authors' theoretical premise for adopting a relatively similar approach to their previous equity centric research is that both shareholders and bondholders would have relatively similar claims on company cash flow to the extent that higher sustainable future cash flows can be expected to increase demand and price for both listed bonds and equities.

Arnott et al. (2010) found that security selection contributes significantly to the return outperformance for both the investment grade and emerging markets fundamentally weighted bond portfolios. The high yield portfolio also benefits but to a lesser extent. The authors do however suggest that security selection is an outcome of passive reweighting strategies and does not constitute active de facto security selection. Security selection for all three the fixed income sub-asset classes examined are based on the size of the issuer. Attribution of outperformance for all three of the fundamentally weighted portfolios can be further differentiated by the contribution of so-called risk factors. The high yield portfolio benefits substantially from duration or interest rate risk while the investment grade and emerging market portfolio benefit only slightly given that their index durations are similar to the benchmark market cap-weighted indices. The authors results provide further evidence of the advantages of fundamental or valuation indifferent indexing over market cap-weighted alternatives. Importantly, they also refute the size and value argument presented by critics on the evidence that the traditional Fama-French equity market risk factors fail to explain the outperformance of the three fundamental bond indices used. The authors also state that there should be no theoretical basis that would result in other asset classes not delivering the same outperformance over market cap-weighted indices as evidenced in equity and bond markets.

Hsu, Li and Kalesnik (2010) examine the fundamental indexation on listed real estate and segment their sample into US and non-US entities. They use the same accounting weighting metrics of book values, sales, cash flow, and dividends used by Arnott, Hsu and Moore (2005) to study the listed US equity market. The authors found evidence supporting fundamental indexation generating superior returns across both the US and global portfolios constructed. However, they found that the volatility of the real estate fundamental index is slightly higher on an aggregate basis. This is an anomaly to the vast majority of earlier research on listed equity markets, but when adjusting for return per unit of risk using the Sharpe ratios, the evidence supports the premise that valuation indifferent indices are superior to market weighted alternatives on a risk-adjusted basis. Hsu, Li and Kalesnik (2010) also attempt to assess the ability of a fundamentally weighted real estate indexation strategy to generate excess returns during the different phases of the broader economic cycle. Fundamentally indexed real estate is evidenced to act as a superior risk mitigation or hedge strategy relative to market cap-weighted alternatives during periods of high inflation and deflation. The effectiveness of the hedge from investing in the fundamental index is, however, shown to be relatively stronger during periods of high inflation. It should be noted that the authors do not explicitly address the size and value arguments that critics of fundamental or valuation indifferent indexing identified. The scope of the research does not allow any significant conclusions to be made for or against the outperformance of fundamental indices being attributable to size and value.

De Jong and Wu (2014) investigate the performance of both fundamental and market cap-weighted indexation strategies on the Merrill Lynch Investment Grade Euro Corporate Index over a 5-year period between 2008 and 2012. The fundamental index is shown to produce superior risk-adjusted returns by generating an additional return of 0.8% a year at approximately the same volatility. The authors also found that sector weight account for a meaningful amount of the outperformance with an underweight position in banks contributing to the outperformance by the fundamentally constructed index. They further assert that their findings support the conclusion that sector weighting are more important than firm-specific weighting for fundamental indexation strategies. However, their findings do not support fundamental indexation strategies performing better in pronounced market declines, as experienced during the 2008 Financial Crisis. This is consistent with the findings of Hsieh (2013) that fundamental indexation performs especially poorly in periods of pronounced market drawdowns. His study specifically considers emerging markets so the evidence suggests that valuation indifferent strategies may not be the optimal way to invest in both emerging and developed countries during severe market shocks. In addition, De Jong and Wu (2014) found no evidence of a size anomaly or bias and that the fundamental and market cap indices have similar levels of concentration. Importantly, they also found that more frequent rebalancing detracts from the outperformance of fundamental indexation. On the whole, their findings of fundamental indexation as a superior mean variance indexation strategy over a market cap-weighted alternative is in line with the results of Arnott et al. (2010)

Piljak and Swinkels (2017) investigate the risk-adjusted performance of market cap-weighted indices to comparable fundamental weighting strategies across a sample of emerging, frontier and developed government bond markets. They found that fundamental indexation strategies applied to emerging and frontier markets produce excess returns relative to a market cap alternatives but that results are not statistically significant. An interesting finding from their study is that there is evidence of positive excess returns for investment grade issues but only when currency risk is unhedged. This suggests that understanding currency fundamentals may be least as important as understanding contributors to the government bond returns.

Bolla (2017) shows that fundamental indexation delivers superior performance compared to a market-value-weighted index. However, this finding indicates that outperformance can be attributed to increased duration, liquidity, default and carry trade risks exposures in global bond markets.

4.3.2 The Case Against Fundamental Indexation

The advantages of fundamental indexation strategies have generally been well supported by contributions to the literature on both developed and emerging markets. The majority of the arguments against fundamental indexation as a superior investment or benchmarking strategy to the market cap-weighted alternative focused on listed equity market and centre predominantly around a supposed bias towards traditional value and size factors.

Some authors dispute both the substance and relevance of fundamental indexation by questioning whether the methodology is actually a new contribution to the literature or simply another way to consider market anomalies. Chow et al. (2011) evidence the significance of both value and size factors to explain the outperformance of both US and global equities constituted in a fundamentally weighted index over a market cap-weighted strategy. This support the earlier assertion made by both Asness (2006) and Edesess (2008) that the performance of fundamentally constructed indices are mostly attributable to well-established size and value effects.

Most critics also raise concerns around the theoretical and empirical premise of both the purported superiority of fundamental indexing and considering the methodology a new contribution to the existing literature. These criticisms predominantly relate to the consolidation of previously identified empirical biases that have been evidenced to significantly contribute to market outperformance at certain times in the broader business or economic cycle. Fama and French (2007) explicitly question the merits of the approach and ascribe the evidenced risk-adjusted superiority of fundamental indexation strategies to market mispricing of traditional value stocks trading below their fair or intrinsic price. The outperformance of fundamental indexation can therefore be attributed to the convergence of observable market price and theoretical fair value, the so-called value discount, which is already well established in the literature on market efficiency. Asness (2006) also contends that fundamental indexation is simply the repackaging of a value investing philosophy that benefits from buying into securities at below their fair values and generating excess returns as market prices adjust towards fair values over time. He suggests that it represents an active management approach and is therefore not suitable to traditional indexation techniques. Edesess (2008) agrees with these contentions and further disputes the embedded value investing premise that market price and fair value mean revert over time. He argues that security values are normally distributed around security price and that price and value are effectively equal. This is disputed by Arnott (2008), who suggests that the security prices and values are highly unlikely to mean revert simultaneously and are highly sensitive to external market and economic shocks.

Amenc, Goltz and Lodh (2012) consider the flaws in fundamental indexation from another perspective by taking issue with the theoretical basis and argue that the constituents comprising fundamental and market cap indices should be identical and weighted in the same manner. They indicate that in the absence of a methodology based on these conditions, fundamental indexation cannot be described as a superior risk-adjusted strategy to a market cap-weighted counterpart.

Critics of fundamental indexation also argue that the strategy has an inherent bias towards companies for lower market capitalisations, so-called small cap stocks, which is especially pronounced in markets with strong upward price movements. Schoenfeld and Ginis (2006) found evidence of both size and value effects and show that the combination of the market pricing anomalies of size and value, as well as industry exposure, explain approximately 90% of the outperformance of the RAFI from 2000 to 2005, with the attribution of that excess return being substantially concentrated between 2000 and 2002. The correlation with the US Russell and S&P value indices is also substantially higher than that exhibited by the respective composite market weighted indices.

The overall findings of Schoenfeld and Ginis (2006) are contradicted by the findings of Hsu and Campollo (2006) that show that their fundamental indices outperformed both the Russel Value index and market cap-weighted S&P 500 over a longer sample period from 1979 to 2004. More importantly, the authors found that their fundamental indices also outperformed the S&P 500 over bull markets and that the Russell value index actually underperformed.

Other authors are somewhat more elaborate in communicating supposed structural shortcomings in the approach. Perold (2007) argues strongly against fundamental indexation as a superior risk-adjusted performance strategy over more widely used market capitalisation alternative. The author specifically disagrees with the conclusions of Arnott, Hsu and Moore (2005) that market cap-weighted indexation is negatively affected by a so-called return drag relative to fundamental weighted index strategy. Hsu and Campollo (2006) also support the performance lag effect on market cap-weighted indexation strategies as an outcome of the index being more concentrated in relatively overvalued securities and less concentrated in undervalued securities, which provide greater capital appreciation potential. Perold (2007) disputes that being invested in a market cap-weighted index has a significant effect on the probability of the underlying securities being under- or overvalued. The substance of his argument is based on the premise that if the pricing error is uncorrelated with the constituent securities; fair or intrinsic value, it must also be uncorrelated with the constituent securities' current market price. He suggests that if the price error is uncorrelated with both the current price and intrinsic value, there is no evidence to support a performance or return drag from holding the index. The author asserts that the equity returns would need to be evidenced to be negatively autocorrelated or mean reverting over time for fundamental indexation to be demonstrated as the superior risk-adjusted performance strategy. Perold (2007) concludes that inconclusive academic evidence on negative autocorrelation of equity returns does not support the premise of fundamental indexation mean variance superior to market cap indexation.

Kaplan (2008) argues that fundamental indexing is not necessarily the most optimal valuation indifferent indexing strategy and contends whether the approach is more mean variance efficient than the market cap-weighted alternative. He specifically addresses the premise by Arnott, Hsu and Moore (2005) that fundamental indexing considers the pricing error between constituent companies true intrinsic or fair value and its observable market price. The author questions the assumption that the constituent weightings under the fundamental indexing methodology are not necessarily unbiased estimators of the intrinsic value of the underlying company. He asserts that the company specific accounting variables used in the weighting methodology of the index would potentially have a positive correlation with both market prices and pricing errors. This would dispute the assumption that these accounting variables are statistically independent from observed market values of the listed constituent companies. Kaplan (2008) further suggests that fundamental indexation introduces value bias into the index portfolio by allocating lower weights to constituent equities that are considered relatively expensively priced. The index is therefore heavily concentrated in less expensive value equities. This is in contrast to the findings of Arnott, Hsu and Moore (2005) that fundamental indexation actually reduces concentration risk to expensive large cap equities and is invested towards a more diversified basket of both value and smaller cap equities.

Blitz and Swinkels (2008) argue that fundamental indexing is not suitable for passive investment strategies. The construction of fundamental indices is subjected to more judgement around constituent weighting metrics than market capitalisation indices. The authors suggest that fundamental indexing is more akin to an active management strategy given that relatively higher investors need to apply judgement and discretion to the relevance of constituent company fundamentals to fully understand the strategy.

As part of the same study that supports the relative superiority of fundamental indexation of market cap-weighted indices, Estrada (2008) explores alternative indexing strategies and demonstrates that both equally weighted and dividend yield weighted indices across their 16-country sample generate superior risk-adjusted returns to the market cap-weighted benchmark. An important further contribution is that both these indices also outperformed their constructed dividend per share fundamental index on a risk-adjusted basis. This finding disputes the claims by proponents of fundamental indexation that the approach is the most optimal risk-adjusted indexation strategy as relatively simple alternative indexation approaches have been shown to be more robust.

4.4 Methodology

4.4.1 Index Construction

The reference or benchmark portfolio was constructed using a traditional market cap-weighted approach. No benchmark index currently exists so this portfolio was developed using the available data described in Chapter 3. Four fundamental portfolios were constructed using a valuation indifferent approach and were benchmarked against the market cap reference portfolio. The selected approach aimed to objectively model for the size of the company without attempting to weight constituents away from larger companies that dominate a market cap indexation strategy.

The current study selected fundamental metrics that are representative of the size and scale of the underlying companies issuing hard currency bonds. The weighted individual and composite weighted indices using these fundamental metrics were constructed to be representative of the full investable universe for both domestic and foreign investors in hard currency debt issued by these companies. The purpose was not to address the theoretical and empirical shortcomings of market cap indexation but to use historical firm-specific metrics that reliably incorporate the fundamental drivers of the economic footprint of the issuing company. This approach is agnostic of market price or valuation and does not explicitly attempt to address the concentration bias towards more leveraged evidenced under a market cap indexation. Furthermore, the selected approach makes no attempt no deviate away from potentially less creditworthy companies as the more globally diverse companies listed on the JSE would typically have higher nominal amounts of outstanding bonds but are potentially also more investable given greater market visibility from the equity being listed on multiple stock exchanges around the world. By not choosing to control or adjust the weightings of these global companies, the approach mitigated the risk of selection bias and maintained the integrity of the index as a reliable representation of the economic footprint of the constituents available to outside minority passive investors.

4.4.1.1 Constructing Fundamental Indices

The current study used sales revenues, cash flows, and book values as the selected accounting metrics to construct hard currency corporate bond indices. The three metrics were selected to provide an audited base for the financial position, financial performance, and cash generative ability of the underlying firm constituents comprising the individual and composite fundamental indices. Consistent with previous contributions on equity markets by Arnott, Hsu and Moore (2005) and Hsu and Campollo (2006), and on corporate bond markets by Arnott et al. (2010), these company specific metrics were expected to contribute to a fundamental index that is both reliable and representative of the investable opportunity set available to passive investors seeking exposure to hard currency debt issued by JSE-listed firms. However, this paper differs from previous contributions to the literature by excluding dividends and earning measures. It also deviates from previous contributions to corporate bond indexation literature by using tangible book value of equity as opposed to book value of assets. The motivations for not including certain accounting measures and deviating from previous contributions is explained in section 4.4.1.2.

Arnott et al. (2010) use five measures, namely sales, cash flow, dividends, book value, and face value of debt outstanding, to construct their fundamental corporate bond index. De Jong and Wu (2014) use only sales revenues as a metric for the construction of their fundamental index on both investment grade and high yield corporate bond markets. Their reasoning is that sales revenues are relevant and relatively widely available for constituent companies, are also relatively simple to interpret across economic cycles, and are directly comparable across the sample firms. Furthermore, they contend that using a single metric is theoretically a more reliable way of constructing a representative index that captures the size of the underlying constituent universe. The authors make no attempt to assess the creditworthiness of the index and suggest that the exclusive use of sales revenues is an objective approach to analysing the merits of fundamental indexation relative to the market cap-weighted counterpart.

4.4.1.2 Fundamental Metric Selection

The current study used five-year trailing averages for net sales and cash flow from operations (CFO) fundamental metrics. Tangible book value was computed on the latest available audited financial statements and considered to be a sufficiently robust representation of a company's financial position in each sample year to use current, as opposed to historically averaged, values. This approach is consistent with the approach used by Arnott et al. (2010). Some adjustments were made to these metrics to improve comparability and consistency across the full 12-year time series of the study.

Net Sales

The use of sales as a proxy for size is consistent with De Jong and Stagnol's (2016) suggestion that the measure is useful for approximating market relevance. They further indicate that it may also be a reliable metric to assess solvency to the extent that companies with more sizeable operations are relative less likely to experience financial distress versus smaller peers.

The economic importance of sales is that it is considered a relatively reliable proxy for the size of the issuing company. This is particularly relevant for emerging market issuers with hard currency bonds. Sales from normal operations drive the quality of earnings in the business that both debt and equity investors use to assess long term sustainability. Generating adequate sales to maintain access to international debt capital markets at acceptable funding rates plays an important role in the ongoing strategic operations of emerging market bond issuers. These companies typically earn a meaningful percentage of their sales revenues in their local currencies, which can create a mismatch with the hard currency denomination of existing bonds in issue. Generating a sufficiently high level of sales and growing that sales base over time are necessary conditions to partly mitigate the increased risk of default that arises when dislocations occur in global currency markets.

Another compelling economic argument for including sales as opposed to an earnings metric is that it improves the comparability of the underlying companies constituting the index. The earnings power of different companies can be expected to vary substantially across sectors and industries. The use of a pure earnings measure like operating income or net profit before or after tax over the simplicity of a pure sales measure can therefore inadvertently tilt index weightings towards companies operating in industries that typically earn higher margins.

Cash Flow from Operations

CFO is considered a reliable proxy for the liquidity position of underlying constituent companies. Companies that are unable to generate positive CFO will experience difficulties funding the core ongoing operations of the business and would need to consider additional funding sources to ease liquidity constraints. An important consideration in the context of this study was that index construction needed to account for cash flows from operations being negative over any historical 12-month financial period for any of the underlying constituent companies. This specifically represented a challenge in terms of constructing a reliable cash flow and aggregate index where weighting percentages are not reduced below zero because of negative cash flow values. This potential problem was addressed and mitigated by applying a rolling average, as opposed to using a single year CFO value, to construct the cash flow index. The individual cash flow index was constructed using rolling five-year periods to more closely approximate the normal cash flow of the business as opposed to using a single cash flow number in any of the sample years where the company may have experienced a temporary or cyclical downturn in its operations. The second additional approach that was considered was setting any negative rolling five-year CFO averages to zero to prevent any constituent companies being allocated a negative weight in any of the sample years. This approach was not used since none of the included constituent companies had negative CFO values sustained over any rolling five-year period. For the sake of completeness, any persistently negative five-year rolling average CFO values would have needed to be set to zero in the context of this study since the individual and aggregate indices only allow long positions, whereas any constituent being negatively weighted in the index would technically have implied a short position in the underlying bonds. The index construction methodology used for the purposes of the current study was explicitly mandated and modelled on long-only positions in the underlying constituent bond portfolios. Furthermore, the individual and aggregate indices were constructed to assess the performance of fundamental indexation relative to market cap-weighted indexation in the context of passive investment strategies. Allowing a negative or short position in the weighting of any index constituents would have more closely resembled an active management strategy and contradicted the intention of this study.

Tangible Book Value

This study deviated from previous contributions to the corporate bond indexation literature by using tangible book value of equity as opposed to book value of assets. This approach is more consistent with the contribution to the literature for fundamental equity index construction. This approach was used in the current study because book value of equity is considered a more representative measure of the balance sheet strength of the company and a relatively more reliable proxy for solvency. Using only the book value of assets may overstate the relative strength of the company by not explicitly considering the amount of both listed and unlisted debt on the balance sheet. In addition, book value of equity includes historical profits generated by index constituent companies. Since this study did not use an earnings metric in any of the fundamental indices, it was important to capture historical profits through retained earnings. Using book values as opposed to asset values was considered a more reliable way to capture the historical profitability of a company.

Dividends

This study also differs by not including dividends as a metric as specified by Arnott et al. (2010) and the majority of equity and corporate bonds market contributions to the literature on valuation indifferent indexation. There were several reasons for this. Galai and Masulis (1976) assert that dividends potentially increase the risk of default on outstanding debt in issue and transfer wealth from bondholders to shareholders. Smith and Warner (1979) cite dividend payments as a source of agency conflict experienced by bondholders between bondholders and shareholders. Dividends are paid from the same cash resources to pay both dividends to equity as well as interest and capital to debt claims. There is also evidence that bondholders perceive dividend payments to be less beneficial than the gains experienced by shareholders. Dhillon and Johnson (1994) show that bond market participants react negatively to both the initiation of dividend programmes and increases of more than 30%. By contrast, dividend cuts and decreases are positively perceived. More recently, Billett, Mauer, and Zhang (2010) found that announcements relating to distributions accruing to equity are positive for shareholders and negative for bondholders. Lease et al. (1999) suggest that dividend payments reduce available cash balances, which not only decreases the ability of firms to service existing debt but also reduces tangible assets that help mitigate risk in the event of bankruptcy or liquidation. They indicate that bondholders are not necessarily compensated for the increased risks while the gains to shareholders are net positive.

An important difference in this study relative to prior contributions is that both market cap and fundamental indices were constructed from scratch. There is not an existing index to use as a benchmark.

4.4.2 Index Weighting

The individual fundamental indices used in this study were constructed by applying a weighting methodology at two levels, namely aggregate index weighting and individual bond weighting.

4.4.2.1 Aggregate Index Weighting

The first weighting was applied at the aggregate index level with constituents comprising all companies with bonds outstanding in any specific year. Weightings were applied to the individual companies based on the respective fundamental metrics. The company specific weighting was calculated as the arithmetic contribution of that firm to the total fundamental metric being used to construct the index. These weightings remained in place for a period of 12 months to the end of the calendar year in December when the index was reweighted and rebalanced.

The individual fundamental indices were constructed using the individual accounting metrics, sales, book value, and cash flow. Using the book value index as an example, the nominal book values for each of the constituent companies in any sample year were consolidated. The individual company weight was therefore calculated as the individual book value of that specific company expressed as a percentage of total consolidated book values; for example, if Company X had a nominal book value of $1 Billion relative to the total cumulative book values for all constituent companies of $10 Billion, then Company X would have a weighting of 10% when the aggregate book value index was constructed for that specific year.

4.4.2.2 Individual Bond Weightings

The second weighting approach had to be applied to weight the individual bonds issued by each company. This is one of the most important differences in constructing bond indices versus equity indices. The vast majority of listed companies typically only have a single issue of ordinary shares but usually have multiple bond issues outstanding over different periods of time. There are exceptions with some listed companies issuing multiple classes of shares but the companies included in this study only have one class of listed share.

To overcome the challenge of weighting multiple bonds at company specific level, Arnott, Hsu and Moore (2005) propose using the total nominal value of outstanding bonds for each company and allocating relative weights to each bond individual as a percentage of that bond's outstanding nominal value relative to the company. However, the authors also indicate that following and applying an equally weighted approach to bonds issued by a single company did not significantly affect the conclusions of their study.

The current study used an equally weighted approach at company specific level, which is consistent with the suggestions by Arnott et al. (2010). The primary motivation for selecting this approach was to maintain data integrity and ensure that results under both the constructed market cap and fundamental indices were directly comparable. Some observations would have been lost if the weighting methodology used nominal outstanding values to calculate bond weights at the company specific level. By following an equally weighted approach, the constituents of both the market cap and fundamental indices were identical and no data was lost for the population of investable companies and bonds.

4.4.3 Market Cap Index

The market cap-weighted index was also used as a proxy for the benchmark portfolio against which the performance of all four fundamental indices were examined. This market cap-weighted index was constructed using the same methodology applied to the fundamental indices. A weighting was applied to the individual companies based on the market capitalisation at the end of the calendar year and was applied to the index for the next 12 months from January to December. Specifically, the market capitalisation for each bond in the sample was collected on an annual basis from Datastream and consolidated under the issuing company where an aggregate index weighting was calculated. The total market cap for all the companies in the sample was calculated as the cumulative market capitalisation of each individual bond in issue. The company specific weighting was calculated as the arithmetic contribution of that firm to the total market capitalisation of all bonds issued by each of the companies used to construct the index. Equation 1 shows the general formula for the approach.

$$Weight\ MV = \frac{MV_{(t\ -\ 1)}}{\sum \text{MV}_{(t\ -\ 1)}}$$

1

Where,
$MV_{(t\ -\ 1)}$= Market value of single company's bonds as at prior financial period, and
$\sum \text{MV}_{(t\ -\ 1)}$= Total market value of all constituent company bonds as at the last financial period.

4.4.4 Fundamental Weights

There were some differences in the weighting methodology for the book value index versus the sales and cash flow indices.

4.4.4.1 Book Value Index

The book value index used the actual historical nominal book values for all the underlying constituent companies taken from Datastream at the end of the last financial year. Equation 2 shows the formula that was used.

$$Weight\ Book\ Value = \frac{BV_{(t\ -\ 1)}}{\sum \text{TBV}_{(t\ -\ 1)}}$$

2

Where,
$BV_{(n\ -\ 1)}$ = Book value as at last prior financial period, and
$\sum \text{TBV}_{(t\ -\ 1)}$ = Total book value of all constituent companies as at the last financial period.

4.4.4.2 Sales and Cash Flow Indices

In contrast, the sales and cash flow index weightings were calculated over the previous five financial year-end periods and based on a rolling five-year average, as opposed to an actual spot number as used to calculate the book value index weights. This simple moving average was applied across a five-year rolling window to better capture the economic fundamentals of the sample companies and smooth the data for any anomalies that could potentially occur in a specific financial year. The formulas for both the sales and cash flow indices are in Equations 3 and 4 and apply to series of values X_1, $X_{(2)}$ ..., and X_n , where n = number of periods, which is has been set to 5.

$$Weight\ Sales = \frac{X_{(1)} + X_{(2)} \ldots + X_{(n)}}{n}$$

3

$$Weight\ CFO = \frac{X_{(1)} + X_{(2)} \ldots + X_{(n)}}{n}$$

4

4.4.5 Composite Fundamental Index

The composite fundamental index was constructed using the aggregated three fundamental accounting indices that was equally weighted at 33% each. A total of four fundamental indices were therefore constructed and compared to the market cap-weighted index constructed earlier.

$$Weight\ Composite = \frac{w_{(1)} + w_{(2)} \ldots + w_{(n)}}{n} \quad 5$$

where n = 3
$w_{(1)}$ = the book value index;
$w_{(2)}$ = the sales index and
$w_{(3)}$ = the cash flow index.

4.4.5.1 Financial Period Lag

It is important to note that the accounting values used for each of the fundamental metrics were taken from the financial year-end nominal amounts as per the *prior* year annual financial statements. The weightings for all fundamental indices in the current period were calculated against accounting metrics that were lagged by a *financial* year. This was done because the release of audited company financial statements lags the market by at most 12 months; for example, continuing to use the book value index, assume Company X has a financial year-end of December, and for the purposes of weighting the book value index for the 12-month period from January to December 2012, the weighting was calculated on 31 December 2011 using the latest audited financials for the company as reported at 31 December 2010. This can be contrasted with Company Y that has a June financial year-end. The weighting for this company on 31 December 2011 was calculated against the audited financial statements for the financial year ending 30 June 2011. The book values used for Company X therefore has a 12-month lag based on its December year-end, while Company Y's book values only have a 6-month lag due to its financial year ending in June. The effective lag for annual weighting purposes therefore varied between 3 and 12 months for the underlying constituent companies comprising the fundamental indices. The minimum lag of 3 months is an outcome of listed companies typically only issuing audited statements approximately 90 days after financial year-end.

The variance in these lags were not considered material because regardless of year-end for the underlying companies, the weighting applied at the end of any calendar year used data from the last audited position of the company as recorded in the previous financial period. This was consistent for all companies included in the sample. Any seasonal variances were accounted for by using a homogenous data set over the 12-year sample period.

The economic significance of following this approach was data integrity. Relying on an audited base for financial information is considered an important mitigant in maintaining the integrity of data. Having third party oversight reduces the risk of the data being compromised by less onerous periodic management accounts reporting where accounting numbers are more likely to be revised or restated.

4.4.5.2 Index Reconstitution

The indices were not capped at any specific number for any of the examined years. Index reconstitution did therefore not occur because of individual bond issuers being excluded as a consequence of any maximum number of constituents being reached in any of the years for which the indices were constructed. All eligible companies and bonds were included as part of the available population of investable assets. The entry of new assets was an outcome of companies having new bonds in issue at the end of the years when the indices were rebalanced. The exit of existing assets was an outcome of companies having repaid their bond obligations and no longer having those bonds in issue at the time of year-end rebalancing.

4.4.5.3 Rebalancing

The indices used to investigate the performance of fundamental versus market cap-weighted indexation were all constructed by rebalancing the constituent bond portfolios once a year, on the last trading day of each calendar year, using closing end of day prices. The underlying bond portfolios comprising the individual and composite indices were therefore constructed to match an investment holding period of a full calendar year from January to December over the 12-year time series of the study. This approach was adopted for the reasons discussed in this subsection.

Most studies across both the equity and corporate bond indexation literature propose an annual rebalancing approach. Previous contributions also cite that rebalancing frequency does not significantly affect the return advantage of fundamental indices over market cap indices. Arnott, Hsu and Moore (2005) test rebalancing strategies for monthly, quarterly, and semi-annual periodicities and do not find any significantly higher return contribution for any of these versus annual rebalancing. Hemminki and Puttonen (2008) also construct fundamental indices by reweighting the underlying constituent equity portfolio on an annual basis and hold those portfolios for a period of 12 months. Blitz, Van der Griet and Van Vliet (2010) show that fundamental indexation outperforms market cap strategies irrespective of the end point of the annual rebalancing exercise. The authors rebalance once a year and use March, June, September, and December month-ends to investigate the relative performance of each indexation approach. The index rebalanced with a December month-end outperforms the market cap-weighted index by approximately 200 basis points a year, and June year-end shows the lowest outperformance of around 140 basis points.

The economic argument for only rebalancing on an annual basis is centred around maintaining the reliability and integrity of the data. The indices are only rebalanced on audited financial statements signed by third party auditors. Most companies listed in South Africa only report interim results on a semi-annual annual basis while companies that have a dual listing may be required to report interim results on a quarterly basis. Using an annual weighting approach is considered the most reliable way to rebalance the portfolio without compromising data integrity in terms of not only validating the consistency of the numbers but also to not unfairly prejudice companies with business operations that are more seasonal or cyclical in terms of generating sales and cash flows.

The objective of this study was oriented from a passive investor perspective where buy-to-hold is the preferred strategy. Asness (2006) suggests that fundamental indexation is akin to an active management investment strategy. More frequent rebalancing could inadvertently result in a more active investment strategy where the underlying bond constituents are being more heavily weighted towards companies that are generating relatively higher sales and cash flows over shorter periods of time.

An important consideration was that more frequent reweighting incurs higher trading costs. The academic literature on fundamental indexation is not especially well developed with regards to controlling for trading costs and adjusting the relative outperformance of fundamental indexation for asset turnover in constituent equity or bond portfolios. There are numerous nuances that are likely to affect the transparency of trading costs as the underlying assets as purchased and sold into index portfolios. Costs can be expected to vary substantially by both asset class and country or region. Trading costs may also be skewed by the size of the investor or fund manager executing the trades. This is especially relevant in fixed income markets where bonds still trade OTC. The South African corporate bond market is a good example: Fixed income costs vary substantially in the South African market and are exaggerated for corporate credit as an asset class. Trading costs would vary meaningfully between fund managers, with intermediary brokers typically offering more attractive pricing and trading rates to larger more established managers over smaller managers with lower assets under managements (AUM). This study did not attempt to address the issue of trading costs, predominantly because data availability is an especially limiting constraint. This further supports the argument for annual rebalancing, which is not only a relatively more passive approach but also more likely to result in lower trading costs compared to more frequent rebalancing strategies.

4.4.5.4 Total Returns

The dataset comprised total returns for each of the 499 bonds included in the study that were collected weekly from Datastream. To ensure consistency over for the full 12-year period, data was collected on the Friday of each week for all the sample bonds in the study.

Total Returns can be described as the total return on the bond, including interest payments and any capital appreciation or depreciation on the bond price. Equation 6 was used to calculate total return.

$$TR_t = TR_{t-1} X \frac{P_t + A_t + NC_t + CP_t}{P_{t-1} + A_{t-1} + NC_{t-1}} \qquad (6)$$

Where,
TR = Total return;
P = Clean price, which is the price of the bond excluding any accrued interest;
A = Accrued interest, which is the amount of *interest* that has already been earned on the bond but has not been paid by the borrower;
NC = Next coupon, which is the percentage rate payable on the bond, and the adjustment made when a bond goes ex-dividend;
CP = Value of any coupon received on t or since t – 1;
t = Time; and
t – 1 = Time less previous period

4.4.6 Index Returns

This study considered changes in the total returns of corporate bonds over rolling weekly periods. For the purposes of this study, both monthly and weekly indices were constructed for the fundamental and market cap indices. All monthly constructed fundamental and market cap indices were developed using 4-weekly periods, and all weekly constructed fundamental and market cap indices were built on 1-week periods. Total returns were calculated in accordance with Equation 6 with end of day prices and other relevant bond specific information, as set out in Equation 6, captured on the Friday of each week. When the Friday fell on a national holiday in the country on whose exchange the bond is listed, the last trading day preceding that holiday was used.

The argument for using weekly as opposed to both shorter daily or intraday frequencies data is supported by a number of factors. Firstly, most bonds comprising the sample were not TRACE compliant, and therefore, shorter frequency OTC trading data were not readily available. Therefore, shorter frequency daily or intraday pricing information could not be reliably and consistently captured for all bonds across the 12-year time series of the study. Secondly, the intention of this study was to explicitly orient from the perspective of a long term HTM passive investor and not from the perspective of a more speculative trading approach where daily price movements affect markets participants' propensity to buy and sell the underlying index constituent bonds. This was an important consideration because the constructed fundamental indices rely on an annual rebalancing strategy based on annual changes in fundamental revenue, cash flow, and book value measures. The intention was to construct index portfolios by balancing company and bond fundamentals with the prices of the underlying bonds and not to overweight short-term intraday movements. Thirdly, the approach was considered more appropriate to emerging market debt where trading and liquidity data is relatively sparse with relatively weaker price discovery versus more developed markets.

The above considerations are consistent with Bittlingmayer and Moser's (2014) argument that longer frequency data potentially facilitates improved price discovery. The approach is also consistent with the gradual information diffusion model proposed by Hong and Stein (1999) in which the dissemination of information at firm-specific level is better served by sampling data at longer frequencies. The potential risk of not using more frequent daily data was further mitigated by using a relatively long 12-year times series capturing important market inflection points, including pronounced market drawdowns and recoveries.

4.5 Empirical Analysis

This section of the study analyses both the absolute and relative performance of the constructed fundamental indices and the constructed market cap-weighted index, which was also used for benchmarking purposes. The results are presented in the following five sections:

- Absolute returns: The first section presents the constructed indices and investigates the evidenced empirical return of all four of the constructed fundamental indices against the benchmark market cap-weighted index. Performance results at both the individual index and realised annual return level are presented and analysed for each of the fundamental indices and compared against the benchmark market equivalent across the period January 2008 to December 2019. These results are presented using monthly data and are assessed for consistency using weekly data.
- Performance attribution: This section compares the underlying index constituents and weighting of the fundamental indices relative to the market cap benchmark. The main purpose was to identify the sectors that have most meaningfully contributed or detracted from the performance of the fundamental indices. Performance of the fundamental indices is attributed at the sector level to quantify the effects of asset allocation and security selection relative to the benchmark.
- Risk-adjusted performance analysis: The third section investigates the quality of returns generated by the fundamental indices compared to a market cap-weighted counterpart. More specifically, it contrasts the risk-adjusted excess returns generated by the four fundamental indices relative to the constructed market cap-weighted benchmark. Index performance is calibrated for measures of total risk (Sharpe ratio) and market risk (Treynor and information ratios). An analysis of downside risk using the Calmar ratio is also included to understand index performance during periods of market drawdowns. The purpose was to examine whether the constructed fundamental indices generate superior absolute nominal and excess returns versus a market cap equivalent by taking less total, systematics and downside risks.
- Modified duration: This section considers duration as a contributor to outperformance. The purpose of this section is to consider whether there is any evidence to support the argument that mean variance outperformance by fundamentally constructed indices is attributable to taking on

higher levels of interest rate risk or duration; the findings in this study show the opposite. Despite taking on higher levels of interest rate or duration risk over the 12 years from January 2008 to December 2019, the market cap index has underperformed the constructed fundamental indices.

- CAPM analysis: This section investigates the statistical significance of the relative performance of each of the fundamental indices against the benchmark market cap-weighted index. For the purposes of this study, the CAPM was used to test for the significance of any outperformance by each of the fundamental indices. The intention was to investigate if any excess return generated above an appropriate risk-free benchmark is significant when compared against the excess returns generated by a comparable market cap-weighted benchmark index.

4.5.1 Descriptive Statistics

Table 2: Descriptive statistics for weekly bond returns

	Minimum	Maximum	Mean	Median	Std Dev	Skewness	Kurtosis	Jarque-Bera
Market Capitalisation	-0.045	0.038	0.000	0.001	0.008	-0.325	6.356	0.000
Sales	-0.046	0.032	0.001	0.001	0.008	-0.394	6.577	0.000
Cash Flow	-0.049	0.032	0.001	0.001	0.007	-0.444	7.412	0.000
Book Value	-0.044	0.033	0.001	0.001	0.007	-0.507	6.729	0.000
Composite	-0.046	0.030	0.001	0.001	0.007	-0.451	6.658	0.000

Note: The table shows weekly corporate bond returns for the period January 2008 to December 2019. The columns represent the minimum, maximum, mean, median, standard deviation, skewness, kurtosis and Jarque-bera p-values.

The descriptive statistics for the weekly bond returns of all 5 indices is shown in Table 2. The data covers the period January 2008 to December 2019. In total there are 628 observations. All indices have similar minimum, maximum, mean, median and standard deviation values. While all indices display negative skewness, the book value index displays the highest level of skewness relative to the other indices. The skewness statistic may be interpreted as representative of frequent small gains and few large losses. The kurtosis statistic indicates that the indices have similarly peaked distributions, indicative that the returns are leptokurtic in its peakedness. Finally, the Jarque-Bera statistic evaluates the hypothesis that each index is normally distributed. For all the indices, the p-value from the Jarque-Bera test is 0.000, implying that the null hypothesis of a normal distribution is rejected at the 5% level of significance, confirming that the weekly bond returns are not normally distributed.

4.5.2 Absolute Returns

4.5.2.1 Total Monthly Returns

Figure 5 shows the performance in terms of total returns of the three individual fundamental indices constructed using net sales, cash flow, and book value metrics for each of the constituent sample companies with eligible bonds in issue. Figure 5 also shows the composite fundamental index constructed by theoretically investing equally in each of the three individual fundamental indices, and a constructed market cap-weighted index that was used as a benchmark to assess relative performance over the 12-year sample period. These indices were all constructed using monthly total return data that were calculated using 4-week periods.

Figures 5 show that all three fundamental indices outperformed the market cap-weighted index over the 12-year period from January 2008 to December 2019. The sales index in Figure 5 delivered the highest cumulative return at 64.84%, which amounts to an average total return 5.4% on a compounded annual basis over the 12-year period. The cash flow and book value indices delivered cumulative total returns of 55.64% and 50.28%, respectively. This amounts to a compounded annual return of 4.64% for the cash flow index and 4.19% for the book value index. This can be contrasted against the market cap-weighted index that produced a cumulative total return over the full period of 43.60% and 3.63% on a compounded annual basis. This is approximately 21.24% below the sales index over the full 12 years, and 1.77% on a compounded annual basis. The cash flow and book value index each respectively outperformed the market cap-weighted index by 12.04% and 6.68% over the full period and 1% and 0.56% on a compounded annual basis. All the individually constructed fundamental indices were therefore shown to outperform the market cap-weighted index on both a cumulative and annually compounded basis when using these total returns metrics without adjusting for risk.

In Figure 5, the composite fundamental index constructed by an equal allocation to each of the three individual fundamental indices also exhibited superior total returns against the market cap-weighted index. The composite fundamental index returned 57.03% over the full period and 4.75% on a compounded annual basis. This amounts to a cumulative outperformance of 13.43% and compounded annualised outperformance of 1.12% against the benchmark market cap index.

With the exception of the cash flow index, the fundamental indices were demonstrated to deliver those returns at higher volatility when calculating the annual standard deviation over the 12-year period. This is examined further in section 4.5.4 using various ratios to analyse the risk-adjusted returns of each index.

Figure 5: Monthly return indices

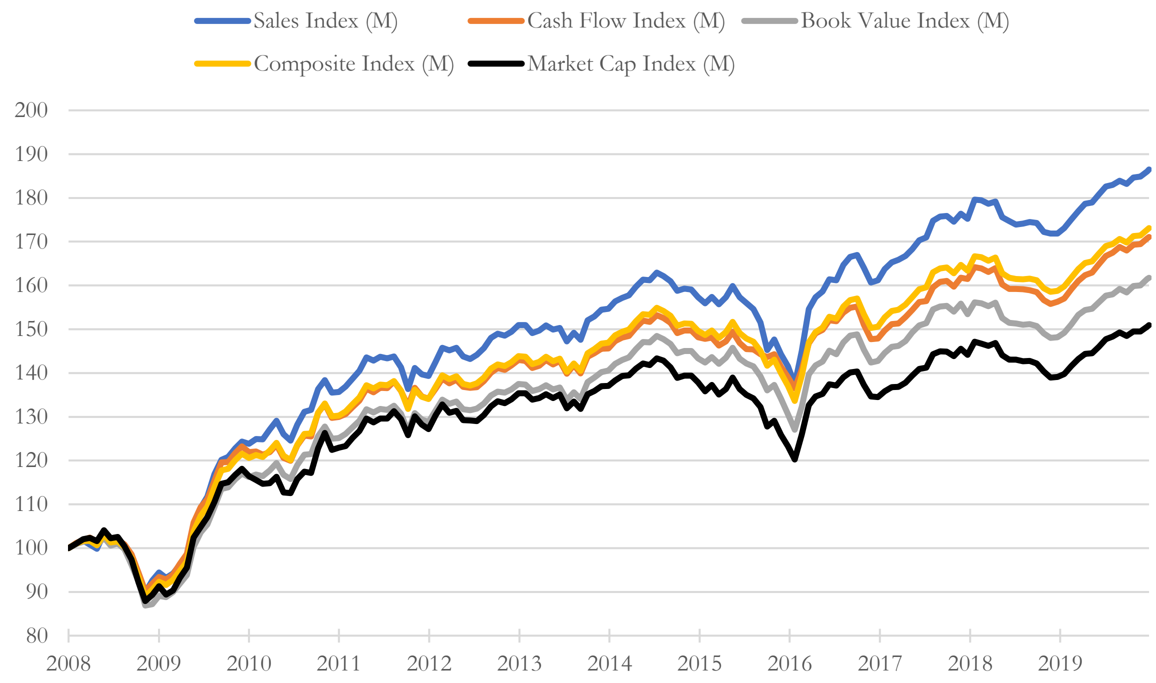
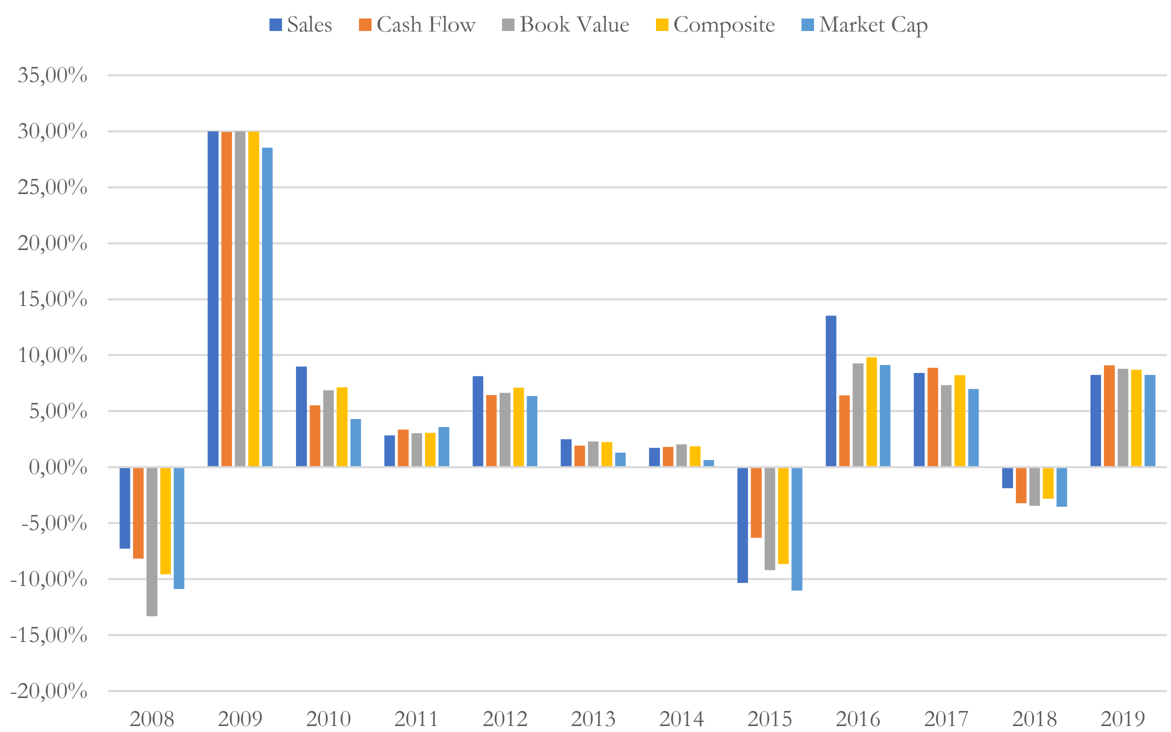


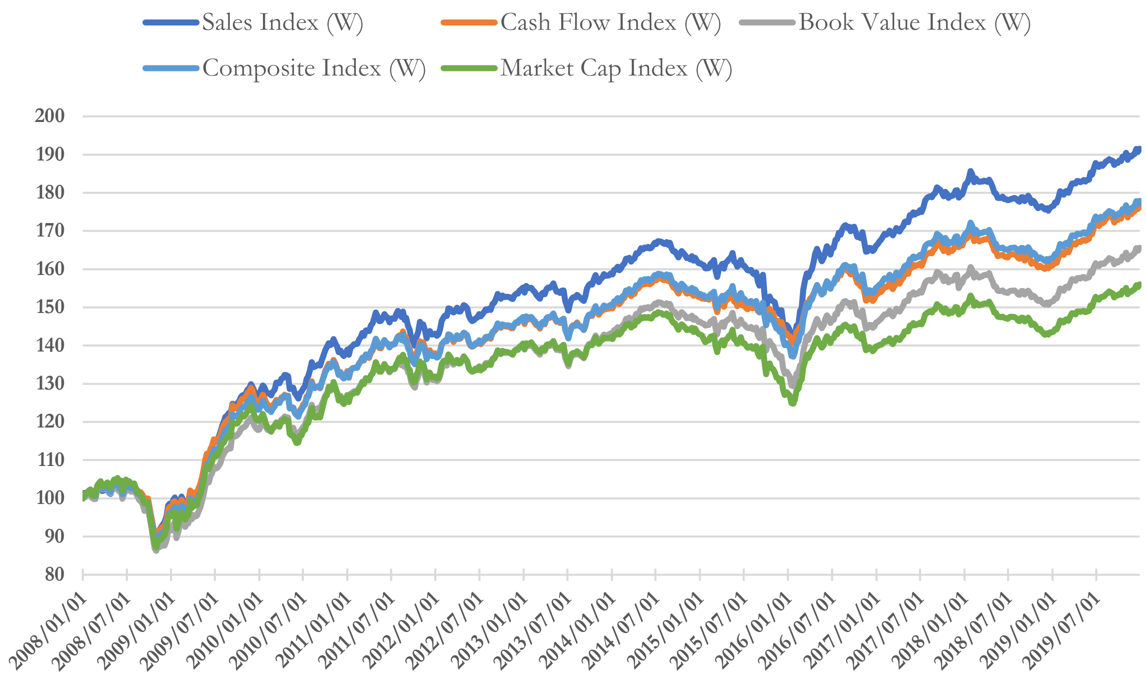
Figure 6: Index performance: Annual nominal returns (2008 – 2019)



4.5.2.2 Total Weekly Returns

The subsection investigates whether the aggregate results are consistent when calculating annual returns using weekly data. Further analysis was done to test the robustness of the monthly total return results against a shorter 1-week period. The results showing the superior performance in terms of total returns using monthly indices, constructed over the 4-weekly periods, as shown in Figures 5 and 6 are consistent with the results using indices constructed using total returns calculated over periods of 1-week as shown in Figure 7.

Figure 7: Weekly return indices



In Figure 7, the sales index was again shown to deliver the highest cumulative return at 67.06%, which amounts to an average total return of 5.59% on a compounded annual basis over the 12-year period. The cash flow and book value indices delivered cumulative total returns of 58.72% and 52.39%, respectively. This amounts to a compounded annual return of 4.89% for the cash flow index and 4.37% for the book value index. This can be contrasted against the market cap-weighted index, which produced a cumulative total return over the full period of 46.73% and 3.89% on a compounded annual basis. The composite fundamental index also exhibited superior total returns against the market cap-weighted index, generating 59.51% over the full period and 4.96% on a compounded annual basis.

All fundamental indices therefore generated higher returns on both a cumulative and annually compounded basis. The sales index generated a cumulative outperformance over the market cap index by 20.33%, while the cash flow, book value, and composite indices outperform by 11.99%, 5.66% and 12.78% respectively. Incremental outperformance was also observed on a compounded annual basis with the sales, cash flow, and book value indices generating respective total returns of 1.69%, 1% and 0.47% above the market cap benchmark. The composite also delivered 1.07% more than the benchmark.

The findings using higher frequency weekly data points are consistent with the conclusions using monthly data points. Fundamental indices delivered superior cumulative and annually compounded returns relative to a market cap weighed strategy before adjusting for risk. Using the standard deviation of the weekly returns as the proxy for investment risk, it can be observed that with the exception of the cash flow index, all the fundamental indices delivered those returns at higher volatility. This is again consistent with the findings using monthly data points (Figures 5 and 6).

From a total return perspective, the robustness of results demonstrated in Figures 5 and 6 are supported by the evidence shown in Figure 7 where fundamental indices outperformed their market cap-weighted counterparts using both longer 4-weekly and shorter 1-week periods. However, it must be determined whether the fundamental indices can demonstrate superior mean variance returns, and therefore, section 4.5.4 considers the quality of returns generated by all the constructed indices. The fundamental and market cap indices were compared on a risk-adjusted basis after accounting for volatility of returns over the sample period. The statistical significance of these returns, and more specifically, the excess returns above both the benchmark and risk-free rate is further tested through the CAPM model in section 4.5.6.

4.5.3 Performance Attribution

This section analyses the observed differences in the fundamental indices relative to the benchmark market cap-weighted index. The first section looks at the relative weightings of each of the fundamental indices at the sector level and compares performance and positioning relative to the benchmark. The second section considers which underlying constituent or individual bond portfolios most contributed or detracted from the performance of the fundamental indices. It is important to note that the underlying company and bond constituents are identical for each comparative year and differ only by relative weightings. The constructed portfolios for each of the indices consist of a homogenous basket of assets across the full 12-year holding period examined. The third section, therefore, presents attribution models based on the Brinson application to disentangle any excess total and average returns generated by the fundamental indices.

It should be noted that the composite index is a hybrid portfolio that is equally weighted across the sales, cash flow, and book value portfolios. It is a derivative of the other three fundamental portfolios and assumes an investor allocates one-third of their capital to each index. This portfolio was therefore modelled as a blended index. Specifically, the asset allocation and security selection in the composite index were an outcome of those metrics in the sales, cash flow, and book value indices.

4.5.3.1 Sector Performance

The graphs in Figure 8 disaggregate the constructed market cap and fundamental indices into the primary sectors into which the underlying constituent companies fell. They show the monthly returns of each of the indices between 2008 and 2019. The indices for the financial sector start in 2010 since that was the first year that a constituent company issued hard currency debt matching the eligibility criteria. Figure 8 shows that the benchmark market cap index underperforms the fundamental indices in both the financials and resources sectors but shows relative outperformance in the industrials sector. By contrast, the best performing sales index is shown to outperform all indices in the resources, financials and real estate sectors, while underperforming in industrials sector.

Figure 8: Sector performance

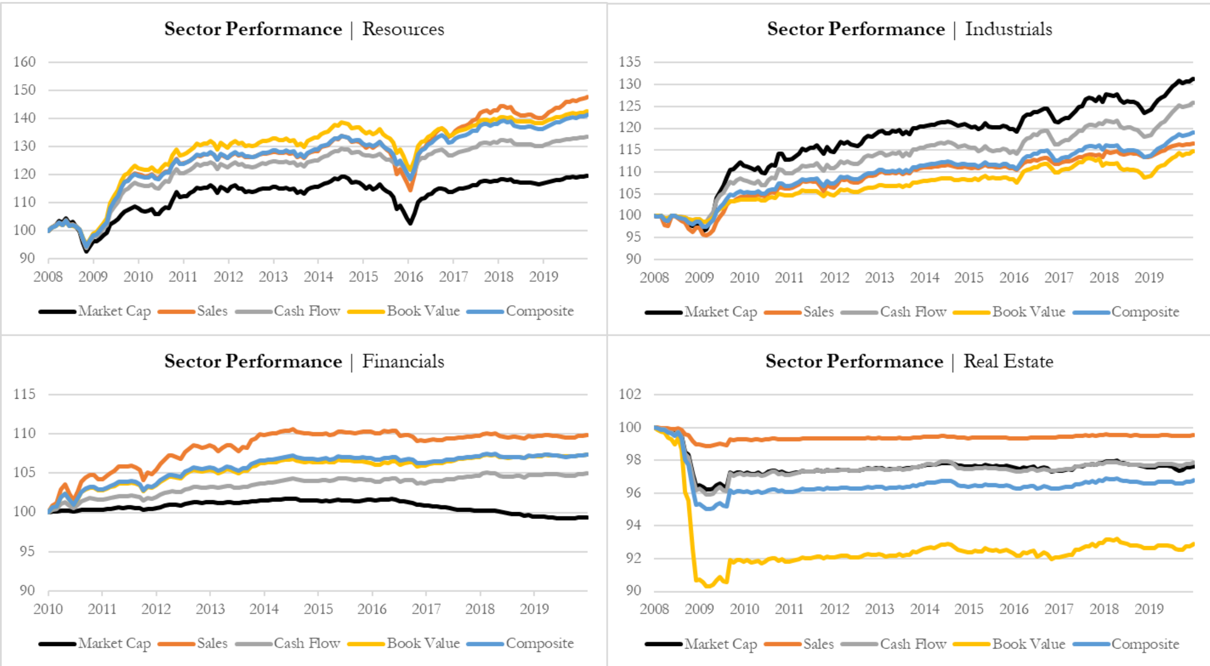


Figure 8 shows sector performance across the benchmark market cap and fundamental indices.

Figures 9 and 10 show that resource exposure was the most meaningful contributor to cumulative returns over the 12-year period from January 2008 to December 2019. Figure 9 shows the percentage contribution from resources was approximately 62% for both the best performing sales index and the blended composite index portfolio. The highest percentage contribution was towards the book value index where resources accounted for 72.5% of the total cumulative return of 50.3%. The resources sector also made up 53.3% of the cumulative return generated by the cash flow index, which was still substantially higher than the 43.3% it contributed towards the benchmark market cap index.

Figure 9: Performance attribution – Cumulative sector returns

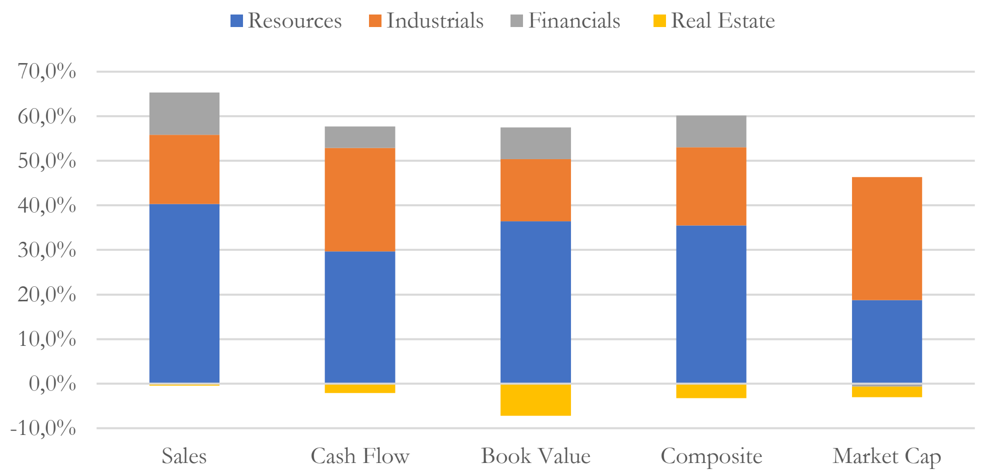


Figure 9 shows cumulative sector contributions to total return over the 12-year period from January 2008 to December 2019.

Figure 10: Performance attribution – Percentage sector contribution

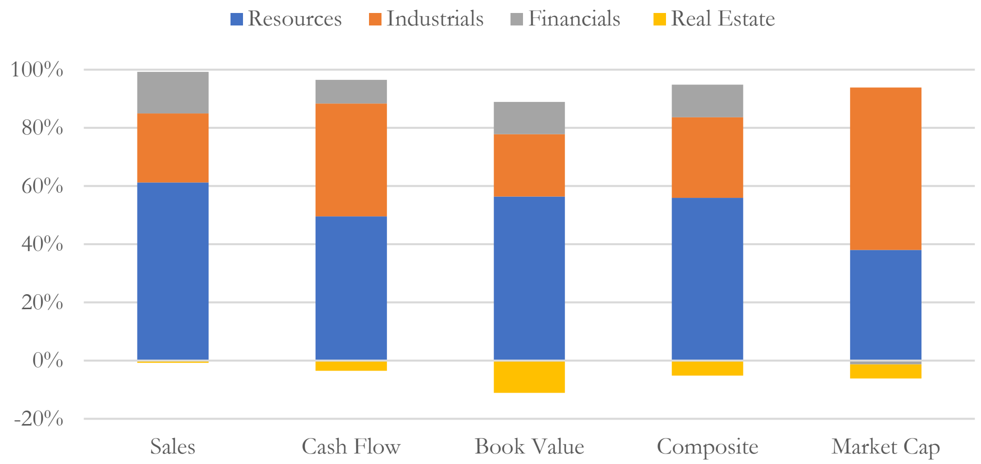


Figure 10 shows percentage sector contributions to total cumulative return over the 12-yearperiod from January 2008 to December 2019.

Compared to the benchmark market cap index, the cumulative return contribution from the industrial sector towards all the fundamental indices was relatively low. Industrials accounted for 63.3% of the total benchmark return and contributed only 24% of the return generated by the best performing sales index. Percentage contributions to the book value and cash flow indices amounted to 27.6% and 41.8%, respectively, while accounting for around 30% for the composite index.

It is evident form Figures 9 and 10 that resources and industrials comprised the majority of returns generated by all the indices. Financials contributed positively towards total cumulative returns by all the fundamental indices across the 12-year period but detracted 0.70% from the benchmarks' total return. Real estate was the standout detractor across all indices with an especially pronounced effect on the book value index where it cost the portfolio -7.2% in returns over the whole period.

4.5.3.2 Sector Allocations: Index Weights

Figures 11 and 12 show the average sector positioning of each of the fundamental indices relative to the benchmark market cap index. It is important to note that positioning is exclusively an outcome of annual rebalancing and is reflected as the average static over- or underweights sector exposure over the 12-year period. The graphs show that all fundamental indices, with the exception of the cash flow index, were holding relatively higher resources positions and that the sales index had the highest average overweight allocation at 12.5% above the benchmark. The composite and book value indices were holding 6.5% and 8% overweight positions, respectively, while the cash flow index was 1% underweight resources relative to the benchmark. This is an interesting observation given that the underweight resource position accounted for 53.3% of total index returns while only making up 43.4% of the market cap index. Put differently, from an effective weight benchmark position, the resource sector accounted approximately 10% towards total returns for the cash flow index over the 12-year period between 2008 and 2019.

Figure 11: Sector exposure – benchmark market cap index

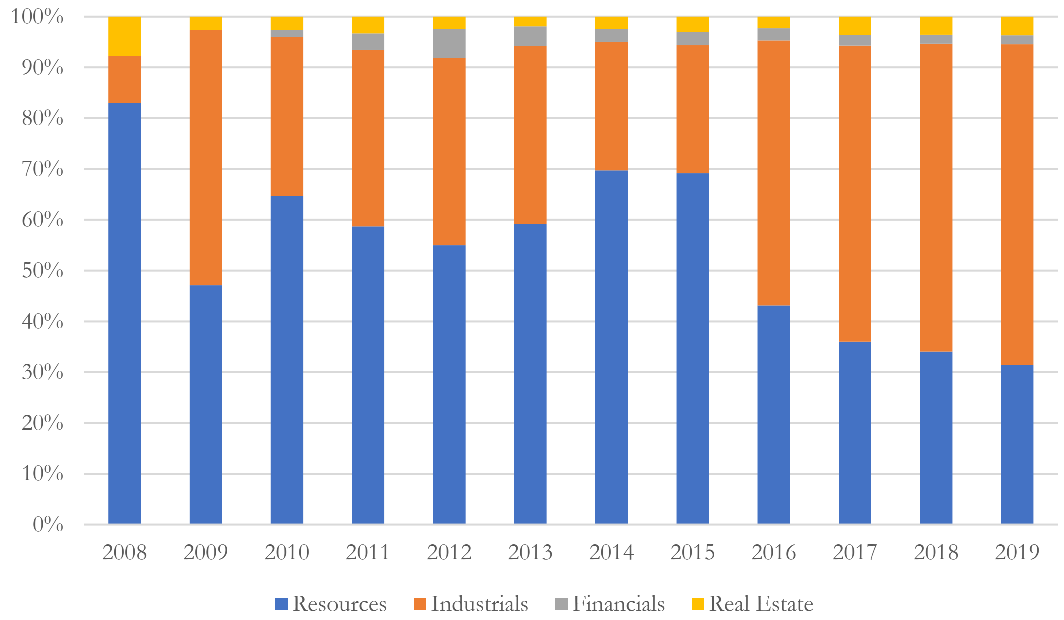


Figure 11 shows market cap exposure over the 12-year period from January 2008 to December 2019.

Figure 12: Sector exposure – positioning versus benchmark

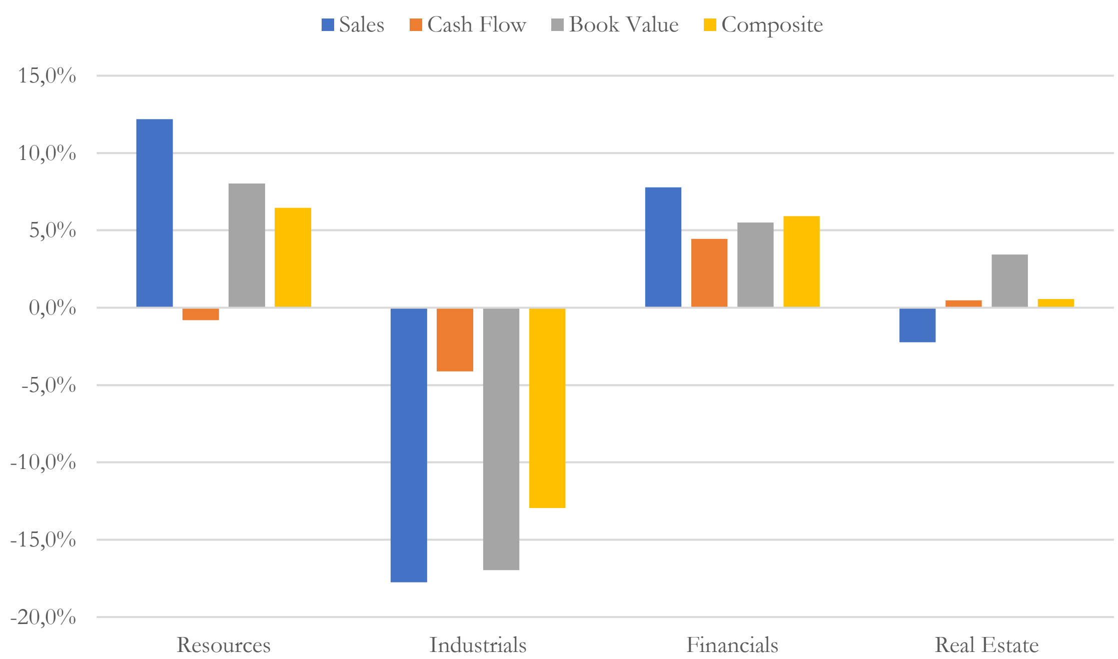


Figure 12 shows the average sector exposure of fundamental indices relative to benchmark market cap index over the 12-year period from January 2008 to December 2019.

4.5.3.3 Performance Attribution

Brinson and Fachler (1985) and Brinson, Hood, and Beebower (1986) made early contributions to performance attribution models that are still widely used today. Their application is generally used in equity markets, but the Brinson approach was considered appropriate for the purposes of this study given the general lack of fixed income data available to perform more risk- or factor-based analysis. The current study used the principles of Brinson attribution to attribute the evidenced outperformance of all the fundamental indices over the constructed benchmark market cap index. This follows the approach used by Arnott et al. (2010), but it was adopted for the current study to allow for analysis at the sector level in the context of South African capital markets. This is an especially important point given that JSE-listed companies are generally categorised as falling into one of the broader resources, industrials or financials sector categories. Real estate has been added as a standalone sector but is consistent with the categorisation of companies generally included as property companies on the JSE. The South African listed equity market has historically been heavily concentrated around these sector categories.

The methodology for disaggregating portfolio and benchmark returns is shown in Equations 7–22. Equation 7 shows the formula for return on the fundamental index portfolio(s).

$$R = \sum_{i=1}^{i=n} w_i R_i \tag{7}$$

Equation 8 shows the formula for return on the benchmark market cap portfolio.

$$B = \sum_{i=1}^{i=n} W_i B_i \tag{8}$$

Where,
w_i = Weight of the ith sector in the portfolio;
R_i = Return of the portfolio assets in the ith sector;
W_i = Weight of the benchmark in the ith sector;
B_i = Return of the benchmark in the ith sector; and
n = Number of sectors or securities

The sum of the weights in both the portfolio and benchmark is required to equal 100%, so that Equations 9 and 10 are true.

$$\sum_{i=1}^{i=n} w_i = 1 \tag{9}$$

$$\sum_{i=1}^{i=n} W_i = 1$$

10

The allocation return is given Equation 11.

$$B_S = \sum_{i=1}^{i=n} w_i B_i$$

11

From Equation 11, the contribution from the asset allocation can be calculated as the difference between the allocation return and the benchmark return as shown in Equation 12.

$$B_S - B = \sum_{i=1}^{i=n} (w_i - W_i) B_i = \sum_{i=1}^{i=n} (w_i - W_i)(B_i - B)$$

12

The contribution to allocation in the ith sector is shown in Equation 13.

$$A_i = (w_i - W_i)(B_i - B)$$

13

The sum of sector contributions to allocation equals the arithmetic excess return from the allocation shown in Equation 14.

$$\sum_{i=1}^{i=n} A_i = B_S - B$$

14

The selection return is given by Equation 15.

$$R_S = \sum_{i=1}^{i=n} W_i R_i$$

15

The contribution from selection is the difference between the selection return and the benchmark return, given in Equation 16.

$$R_S - B = \sum_{i=1}^{i=n} W_i R_i - \sum_{i=1}^{i=n} W_i B_i = \sum_{i=1}^{i=n} W_i \ X \ (R_i - B_i)$$

16

The contribution to selection in sector *i* is shown in Equations 17 and 18.

$$S_i = W_i(R_i - B_i)$$

17

$$\sum_{i=1}^{i=n} S_i = R_S - B$$

18

By design, selection and allocation do not explain the arithmetic difference in full. From the above, selection plus allocation is $(R_S - B) + (B_S - B)$. To ensure that the attribution factors sum to the arithmetic difference between the portfolio and benchmark returns, a third, called interaction, is introduced. Interaction is given by the formulas in Equations 19 and 20.

$$\underbrace{R_S - B}_{Selection} + \underbrace{B_S - B}_{Allocation} + \underbrace{R - R_S - B_S + B}_{Interaction} = R - B$$

19

$$R - R_S - B_S + B = \sum_{i=1}^{i=n} w_i R_i - \sum_{i=1}^{i=n} W_i R_i - \sum_{i=1}^{i=n} w_i B_i + \sum_{i=1}^{i=n} W_i B_i$$

20

It simplifies to Equation 21.

$$\sum_{i=1}^{i=n} (w_i - W_i)(R_i - B_i) = \sum_{i=1}^{i=n} I_i$$

21

The contribution of sector *i* to interaction I_i is $(w_i - W_i)(R_i - B_i)$, or as shown in Equation 22.

$$\sum_{i=1}^{i=n} I_i = R - R_S - B_S + B$$

22

The following three attribution effects arise from the notation above:

- The asset allocation effect is shown in Equation 13 and attributes to the incremental return, resulting from the active weight in the fundamental portfolios against the passive weight in the market portfolio. It measures the return attributable from either being over or under the benchmark weight in a particular sector.
- The selection effect is shown in Equation 18 and refers to the contribution from the fundamental portfolios holding underlying securities within a specific sector in weights that differ from the benchmark. It is typically viewed as a measure of active stock selection relative to the passive weighting in the reference benchmark portfolio.
- The interaction effect shown in Equation 22 links the asset allocation and the selection effects but is less intuitive given that it does not necessarily represent an explicit investment decision. It measures the overweight or underweight asset allocation against the performance from security selection relative to the benchmark within a specific sector.

The results from the attribution analysis should be interpreted relatively prudently in the context of this thesis. The intention was to compare the performance of the fundamental indices to the constructed benchmark for the purposes of attributing returns over the 12-year sample period and understanding relative performance of all the indices. The market portfolio is not observable as would be the case had a comparable hard, or even local, currency corporate bond index existed to benchmark the performance of the constructed fundamental indices. Any over- or underweight positions relative to the benchmark weighting by the fundamental indices are not interpreted as taking higher or lower levels of risk. The analysis presented here is purely to quantify the returns that can be attributed to asset allocation or security selection relative to the constructed benchmark portfolio. The mean variance efficiency of the respective portfolios is examined further in section 4.5.3.

4.5.3.4 Results

The previous section showed that all fundamental indices were overweight resources and underweight industrials relative to the benchmark market cap index. Figure 13 disaggregates the excess cumulative outperformance generated by the fundamental indices into the returns attributable to asset allocation, security selection, and the interaction of those two components. It can be seen that all fundamental indices generated a positive security selection effect. This amounted to 9.4% and 9.8% for the cash flow and book value indices, respectively, while security selection accounted for 9.7% of the total excess return generated by the composite index. The sales index showed the highest attribution over the period, with 12.3% coming from its security selection to the underlying constituent bond issuers. These findings are relatively consistent with those of Arnott et al. (2010), who also found that security selection contributes significantly to the return outperformance; however, the authors indicate that security selection is an outcome of passive reweighting strategies and does not constitute active security selection.

Figure 13: Sector performance attribution – cumulative returns

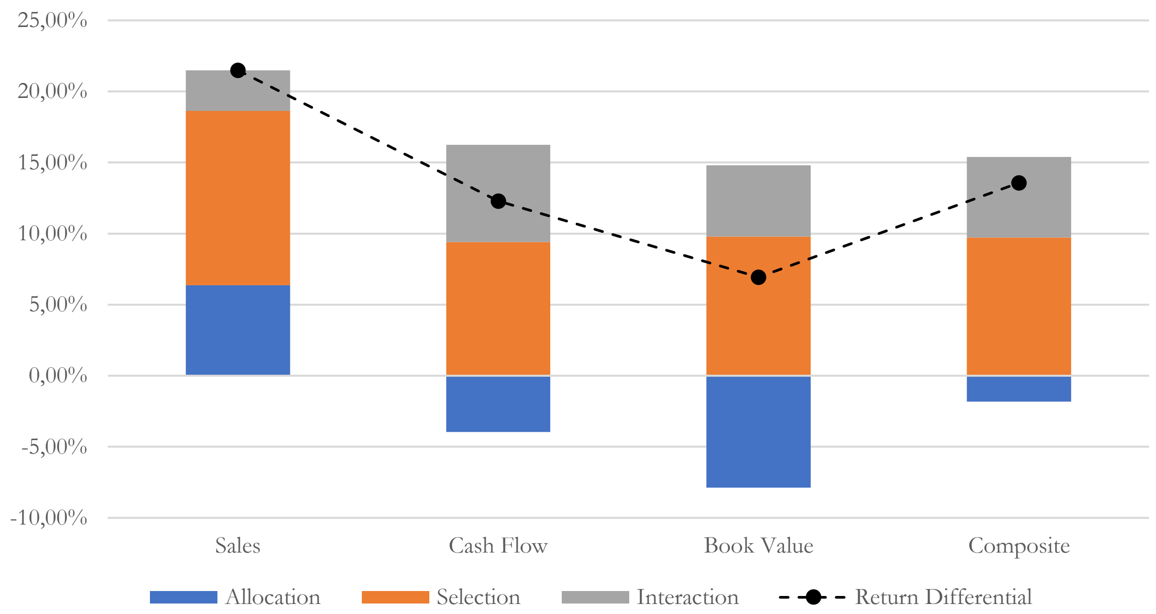


Figure 13 shows the attribution of excess cumulative returns generated by the fundamental indices over the 12-year period from January 2008 and December 2019.

The asset allocation attribution shows a different picture. Asset allocation was a net detractor over the period for the cash flow, book value and the blended composite indices. Relative over- and underweight positions cost the cash flow index 4%, while the book value index lost 7.9% due to asset allocation over the period. Asset allocation also detracted 1.9% from the composite index. By contrast, Figure 13shows that the asset allocation effect was net positive only for the sales index. Asset allocation accounted for 6.4% of the total excess returns generated by the sales index. Considering that asset allocation was a detractor for all the other fundamental indices, the net effect of its positive contribution towards total returns of the sales index explains a sizeable amount of the relative outperformance. Put differently, the asset allocation contribution towards the total returns of the sales index accounted for a nominal 10.4% of its outperformance over the cash flow index, 8.3% over the composite index, and a substantial 14.3% over the book value index.

However, this masks the lumpiness of the asset allocation positioning over the full period. Figure 14 shows that 2010 and 2016 were meaningful contributors while the asset allocation actually detracted meaningfully from 2017. This coincides with a period where the sales index was heavily overweight resources and underweight industrials in it positioning. Figure 15 shows that this positioning actually detracted from excess returns.

Figure 14: Sector performance attribution – sales index

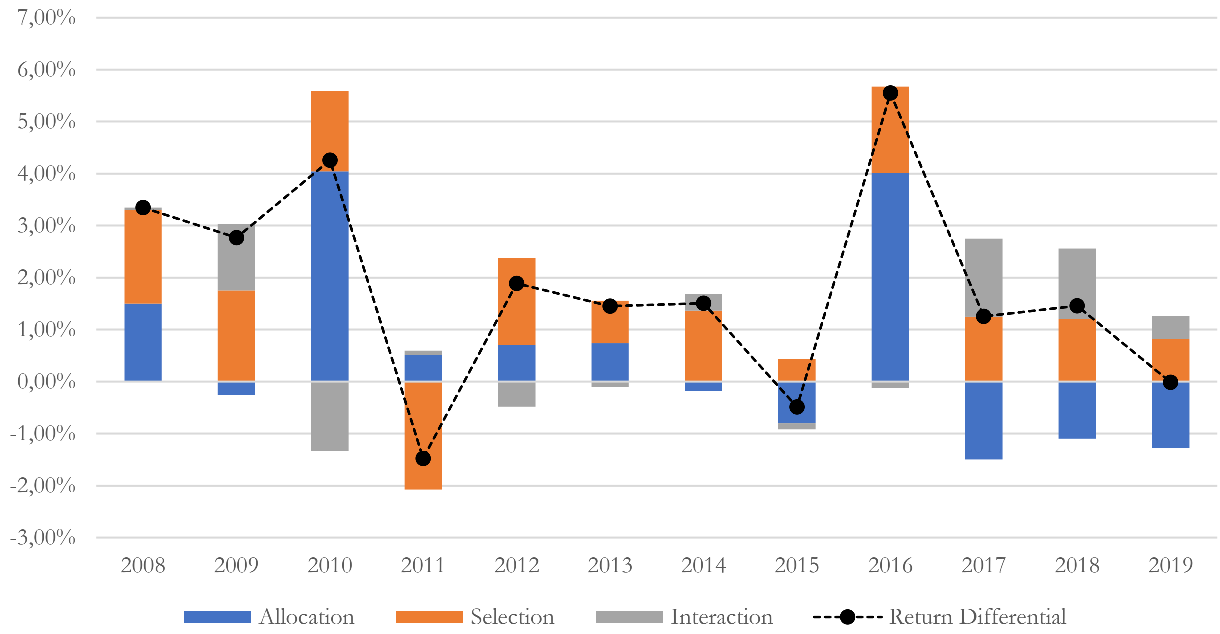


Figure 14 shows the attribution of sales index annual returns over the 12-year period from January 2008 and December 2019.

Figure 15: Asset allocation – sales index versus benchmark

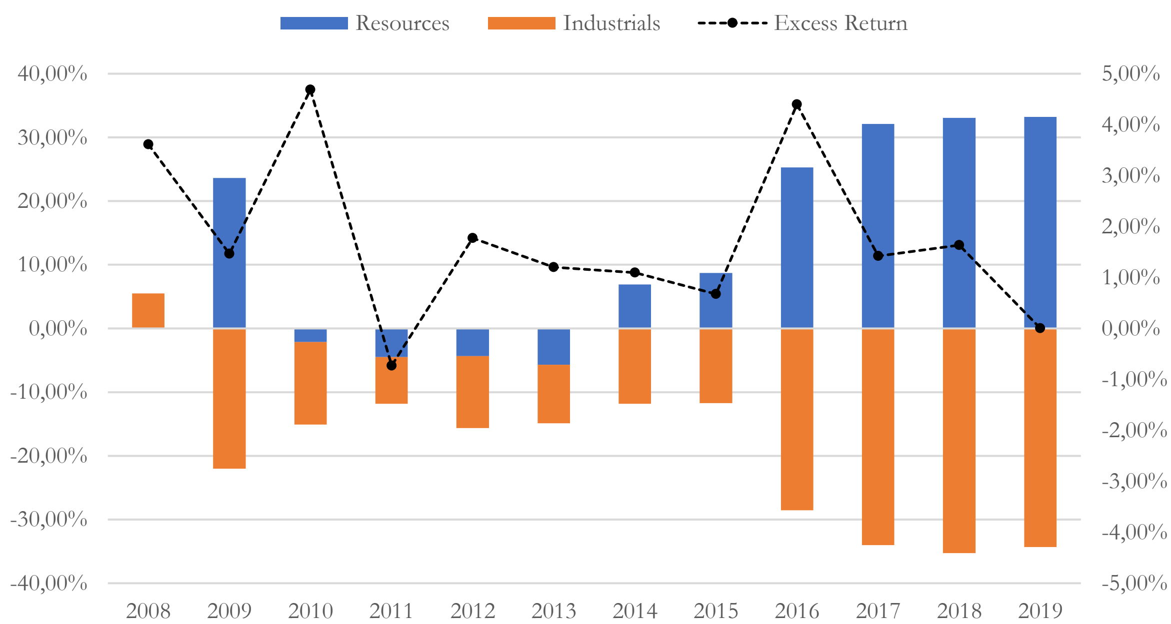


Figure 15 shows the attribution of sales index annual returns over the 12-year period from January 2008 and December 2019. Excess Return to be read of right-hand side, Attribution effects to be read off left hand side.

4.5.4 Risk-adjusted Performance Analysis: Quality of Returns

Using average monthly returns as shown in Figure 5 provides an overview of the nominal returns generated over the 12-year period from January 2008 to December 2019. A key objective of this study was to assess the absolute and relative excess returns of fundamental corporate bond indices. This section expands on the empirical analysis in the previous section by introducing performance ratios to assess the risk-adjusted performance of all constructed indices.

This section analyses the relative risk-adjusted performance of each of the constructed indices using a series of commonly used portfolio management ratios. The total return analysis in Figure 5 shows that all the fundamental indices delivered higher returns than the market cap-weighted benchmark. However, with the exception of the cash flow index, the fundamental indices were also shown to have delivered those returns at higher levels of volatility. In general, investors prefer to generate high returns by taking on lower levels of investment risk. Specifically, investors seek to maximise investment returns while simultaneously minimising investment risk. This purpose of this section is to frame the balance between risk and return by examining incremental risk that must be taken on to generate higher returns. The objective is to better qualify and quantify the quality of the returns produced by the different indices. Furthermore, it attempts to explicitly consider the excess returns generated by the fundamental indices relative to a relevant benchmark.

For the purposes of this study, rolling 12-month returns were used instead of simply annualising the monthly returns over the period. Using rolling returns mitigated the impact of market timing from the analysis to the extent that annual returns could be calculated as the average for any consecutive 12-month periods as opposed to defined start and end dates. This approach does not rely on point-in-time estimates but allows a more robust evaluation of the consistency of index performance capturing both market drawdowns and recoveries. Utilising a rolling 12-month rolling average captures the return over the sample period that an investor would have generated had they been invested in the underlying securities for any consecutive 12 months. This was considered more consistent with the real-world investor experience where capital can be withdrawn from open ended funds as and when required by the investor.

This investment approach is also more consistent with a less active investment strategy with the holding period of 1 year matching the frequency of rebalancing both the market cap and fundamental indices presented in this study. The capital market literature supports this approach, and Ghysels, Santa-Clara, and Valkanov (2004), and Pesaran and Timmermann (2002) apply a rolling window approach to forecast asset price returns.

4.5.4.1 Measuring Risk-Adjusted Performance

Four ratios or metrics were used to quantify the trade-off between risk and return, namely the Sharpe ratio, the Treynor ratio, the information ratio, and the tracking error. The Sharpe and Treynor ratios consider index or portfolio performance against a risk-free rate, and the tracking error and information ratio consider index or portfolio performance relative to a benchmark rate or return. The Calmar and Sortino ratios were specifically used to assess downside risk.

Sharpe Ratio

The Sharpe ratio is used to adjust the excess holding period returns of an asset for the additional risk taken by that asset relative to a suitable risk-free rate. The measure was initially developed by William Sharpe (1966) as a *reward-to-variability ratio* for assessing the performance of mutual funds. In the context of this study, the Sharpe ratio was used to calculate the excess annual return earned by the constructed market capitalisation and fundamental indices over a US Treasury risk-free rate across the 12-year period from January 2008 to December 2019. The ratio is shown in Equation 23.

$$\mathrm{SR} = \frac{\mathrm{Rp} - \mathrm{Rf}}{\sigma \mathrm{p}} \tag{23}$$

Where,
SR = Sharpe ratio;
Rp = Portfolio return, shown as the realised annual return of the individual fundamental and market cap indices;
Rf = Risk-free rate, shown as the rate on a 10-year US Treasury bond; and
σp = Portfolio risk, shown as standard deviation of the realised annual returns on the individual fundamental and market cap indices.

A higher Sharpe ratio is generally preferable to a lower ratio. The economic interpretation is that a higher Sharpe ratio suggests that the portfolio is generating higher returns per unit of risk.

Treynor Ratio

The Treynor ratio is another reward-to-variability or reward-to-risk ratio that can be used to assess risk-adjusted performance. This measure was introduced by Jack Treynor and predominantly differs from the Sharpe ratio through the metric used to estimate risk. The Treynor ratio uses the beta of a portfolio to measure portfolio risk, and the Sharpe ratio uses the standard deviation of portfolio returns. The ratio uses systematic risk to assess the relative excess returns generated by a given portfolio over an appropriate proxy for the risk-free rate, which can be seen in Equation 24.

$$\mathrm{TR} = \frac{R_p - R_f}{\beta} \tag{24}$$

Where,
TR = Treynor ratio;
β = The beta of historical returns used as a measure of systematic risk in the index or portfolio. Systematic risk is defined as market risk that cannot be diversified away;
R_p = Portfolio return, shown as the realised annual return of the individual fundamental and market cap indices; and
R_f = Risk-free rate, shown as the rate on a 10-year US Treasury bond.

Tracking Error

Tracking error is used to quantify the extent to which the performance of an asset portfolio deviates from the performance of a selected benchmark. In the context of this study, tracking error reflects the extent to which the performance of the fundamental indices deviates relative to the market cap index constructed as a benchmark. Standard deviation is used as the key measure to quantify the dispersion between the total returns on the fundamental indices and the market cap benchmark. Tracking error is measured as the standard deviation of the difference between the annualised returns of a portfolio and its selected benchmark, as can be seen in Equation 25.

$$\mathrm{TE} = \sigma\,(R_p - R_b)$$

25

Where,
TE = Tracking error;
Rp = Portfolio return, shown as the realised annual return of the individual fundamental indices;
Rb = Benchmark return, shown as the realised annual return of the market cap index; and
σ = Standard deviation of the difference between the annualised returns of the fundamental indices and the benchmark market cap index.

The interpretation of tracking error is relatively simple. Passive investors who are particularly cognisant of generating investment returns in line with the benchmark would try to generate returns without meaningfully deviating from the index and would therefore prefer a relatively low tracking error. Active investors with mandates to generate returns in excess of the benchmark can be expected to deviate substantially and are likely to prefer a higher tracking errors.

Information Ratio

The information ratio is calculated using tracking error as an important input to quantify the risk taken by investors to generate returns in excess of a given benchmark. More specifically, the ratio is used to understand the extent to which a portfolio has deviated from the benchmark to generate a certain level of outperformance over that benchmark. It is calculated by dividing that outperformance or excess return by the tracking error. Fund managers typically apply the ratio to quantify their so-called active return by making independent investment decisions agnostic of the market benchmark. In the context of this study, the quality of returns were assessed by measuring the realised annual return on the fundamental indices relative to the risk taken in deviating from the benchmark market cap index. Similar to the interpretation of tracking error, passive investors will view perceive risk to be higher where the deviation from the index is more pronounced. The information ratio is shown in Equations 26 and 27.

$$\mathrm{R} = \frac{R_p - R_b}{\mathrm{TR}}$$

26

$$\text{IR} = \frac{R_p - R_b}{\sigma\left(R_p - R_b\right)}$$

27

Where,
IR = Information ratio;
$\sigma(R_p - R_b)$ = Tracking error; and
R_p, R_b and σ have the same meaning and interpretation as explained in the tracking error in Equation 25.

4.5.4.2 Risk-Adjusted Returns

The remainder of this section looks at how the excess returns shown for all indices were adjusted by the risk taken to generate those returns. Both the Sharpe and Treynor ratios show excess nominal returns of all indices above the yield on 10-year US Treasuries used as a proxy for the risk-free rate. The Sharpe ratio quantifies excess return relative to total risk, measured as the standard deviation of evidenced annual returns from their historical average over the sample period. The Treynor ratio shows those excess returns relative to market risk as measured by the deviation of the returns from the market benchmark or beta.

This study also assessed downside risk by analysing performance using the Calmar and Sortino ratios. Previous contributions to the literature largely excluded these performance measures. All these ratios focus on quantifying the extent to which the constructed indices experience market drawdowns over the sample period. Standard deviation, as used in both the Sharpe and Treynor ratios, measures both upside and downside risk as determined by the dispersion around average returns, but the Calmar and Sortino ratios focus exclusively on downside risk. This was considered important in the context of emerging market assets that have historically suffered pronounced drawdowns during severe market dislocations. The motivation was to better understand and quantify how fundamental indices perform relative to a market cap-weighted alternative in market drawdowns.

Calmar Ratio

The Calmar ratio is an important measure of downside risk and can be especially useful when comparing investment portfolios. It measures the efficiency of an investment by considering excess returns over a relevant risk-free rate and compares that return to the risk of the portfolio incurring drawdowns. A higher ratio suggests that the portfolio return was at lower risk of experiencing meaningful drawdowns relative to portfolios with relative lower ratios. This Calmar ratio formula can be seen in Equation 28.

$$\text{CR} = \frac{R_p - R_b}{\text{MDD}}$$

28

Where,
CR = Calmar ratio;
R_p = Portfolio return, shown as the realised annual return of the individual fundamental and market cap indices;

R_f = Risk-free rate, shown as the rate on a 10-year US Treasury bond; and
MDD = Maximum drawdown, which is the maximum loss suffered by the portfolio as measured from peak to trough over rolling 12-month periods.

Sortino Ratio

The Sortino ratio is another measure that explicitly focusses on downside risk. The ratio is named after Frank Sortino. Excess portfolio returns over a relevant risk-free rate are measured against a minimum threshold return referred to as the minimum acceptable return (MAR). For the purposes of this thesis, the threshold return was set at the yield to maturity (YTM) on a 10-year US Treasury bond as a proxy for the global risk-free rate. The Sortino ratio is similar to the Sharpe ratio but only uses downside deviation instead of standard deviation to calibrate for portfolio risk. Downside deviation only considers the portfolio's negative portfolio returns or returns below the stated MAR. This can be seen in Equation 29.

$$\mathrm{SR} = \frac{R_p - R_f}{\sigma_d} \tag{29}$$

Where,
CR = Calmar ratio;
R_p = Portfolio return, shown as the realised annual return of the individual fundamental and market cap indices;
R_f = Risk-free rate, shown as the rate on a 10-year US Treasury bond; and
σ_d = Downside deviation, which is a measure of downside risk that specifically considers returns that are below a MAR.

4.5.4.3 Results

Nominal and Excess Returns

Table 1 shows that using average rolling 12-month returns yielded the same outcomes shown in the previous empirical analysis in section 4.5.2 that shows monthly and weekly returns. The sales index delivered the highest average nominal returns at 5.46% on a rolling 12-month basis over the period from January 2008 to December 2019. This was 1.87% ahead of the market cap-weighted index, which returned an average of 3.60%. This can be further compared to the cash flow, book value, and composite indices delivering returns of 4.59%, 4.26%, and 4.78% respectively. All fundamental indices delivered higher average and median nominal returns than the market cap-weighted alternative.

A key objective of this study was to quantify the economic and statistical significance of the excess returns generated by the fundamental indices over the market cap index. This excess return is described as the average outperformance of the fundamental indices above 10-year US Treasuries as a proxy for the risk-free rate. The sales index is shown to produce the highest return above the yield on a 10-year US Treasury bond on a rolling 12-month basis at 2.84%. This can be compared to the market cap-weighted index that only generated an excess return of 0.98%. Before adjusting for risk, the average excess return produced by sales index was 2.9 times higher than the market cap-weighted index. The cash flow, book value, and composite index all generated average excess returns above the market cap index at 1.97%, 1.63%, and 2.16%, respectively.

Table 3: Excess returns

Index	Average Return	Median Return	Excess average return vs Reference	Excess median return vs Reference	Excess average return vs risk free rate	Excess median return vs risk free rate
Market Cap (Reference)	3,60%	3,02%			0,98%	0,64%
Sales	5,46%	4,60%	1,87%	1,58%	2,84%	2,55%
Cash Flow	4,59%	3,79%	0,99%	0,77%	1,97%	1,46%
Book Value	4,26%	3,75%	0,66%	0,73%	1,63%	1,59%
Composite	4,78%	4,06%	1,18%	1,04%	2,16%	1,71%

Table 3 shows the excess returns for the benchmark market cap and fundamental indices.

Using median returns demonstrated an even larger outperformance by the fundamental indices with each index outperforming the market cap-weighted index by at least two times. The sales index generated a median return of 2.55%, which is approximately four times higher than the 0.64% returned by the market cap index. The composite index performed 2.7 times better than the market cap index with an excess median return of 1.71%. The cash flow and book value indices were 2.3 and 2.5 times ahead of the reference market cap portfolio, with excess returns of 1.46% and 1.59%, respectively.

The results show that all fundamental indices generated excess returns over the reference benchmark market cap portfolio. The rest of this section focuses on quantifying the risks taken by these indices to generate superior average nominal returns.

Risk-Adjusted Performance

It's important to note that the empirical methods applied in this section are intended for use consistent with application in practice. The main objective is to assess whether there is evidence of superior risk adjusted performance using standard industry return measures relative to various underlying risk metrics. As such, these ratios are intended to provide context to the economic significance of the outperformance demonstrated earlier.

Sharpe and Treynor Ratios. The fundamental sales index delivered the most attractive risk-adjusted performance with a Sharpe ratio of 0.63. All the other fundamental indices also had higher Sharpe ratios than the market cap-weighted index of 0.45. The book value index had the lowest Sharpe ratio of all the constructed fundamental indices at 0.52. The cash flow index and composite index both had a Sharpe ratio of 0.59. The higher Sharpe ratios indicate that all fundamental indices delivered superior risk-adjusted excess returns over the risk-free rate after considering the volatility of those returns on a rolling 12-month basis.

Per unit of total risk, as measured by the standard deviation of the excess returns from their mean, all fundamental indices delivered higher returns than the market cap index.

The risk-adjusted analysis using the Treynor ratio yielded similar results. All fundamental indices again outperformed the market cap-weighted index. The Treynor ratio effectively deleveraged the beta of the fundamental indices, effectively adjusting their performance for taking an equivalent level of market risk as the market cap-weighted index. The results show that if all indices take the same level of market risk, the fundamental indices outperform the market cap-weighted index. Per unit of market or systematic risk, the sales index produced a return of 5.15% versus the 3.60% returned by the market cap index. This is an important risk-adjusted measure that directly compares the beta of the best performing sales index relative to all other indices. The sales index had a higher Treynor ratio of 2.69% versus the reference market cap index at 0.98%. Table 4.2 shows that both the cash flow and composite indices also had higher ratios measuring 2.06% and 2.14%, respectively. The book value index delivered the lowest level of outperformance of all the fundamental indices with a Treynor ratio of 1.61%, which was still higher than the market cap index. The findings show that after adjusting for market or systematic risk, all fundamental indices delivered superior risk-adjusted returns when compared to the reference market cap portfolio.

Table 4: Standard Risk Metrics

Index	Standard deviation of average returns	Beta (Slope)	Sharpe Ratio	Treynor Ratio	Tracking Error	Information Ratio
Market Cap (Reference)	7,93%	1,00	0,45	0,98%		
Sales	8,66%	1,06	0,63	2,69%	2,12%	0,88
Cash Flow	7,74%	0,96	0,59	2,06%	1,51%	0,66
Book Value	8,21%	1,02	0,52	1,61%	1,50%	0,44
Composite	8,15%	1,01	0,59	2,14%	1,37%	0,86

Table 4 shows downside measures of risk affecting portfolio returns. The main empirical risk reward ratios, namely the Sharpe and Treynor ratios have been tested for statistical significance for the sake of completeness. As expected, they do not demonstrate statistical significance using a bootstrapping approach using rolling 12 month returns comparing the individual fundamental indices relative to the market cap weighted benchmark.

Tracking Error and Information Ratio. Another widely used measure of assessing portfolio risk is the extent to which each of the fundamental indices deviated from the market cap index in order to generate higher incremental returns. This was observed and assessed by calculating the tracking error and information ratio of each index.

Table 4 shows that the sales index had the highest tracking error at 2.12%, and that the other fundamental indices had relatively smaller tracking errors. The cash flow index and book value indices had similar tracking errors at 1.51% and 1.50%, respectively, while the composite index had the lowest tracking error at 1.37%. This suggests that of the four fundamental indices, the composite index deviated the least from the market cap benchmark to deliver higher average nominal returns compared to the reference portfolio.

Tracking error and information ratio would ordinarily be important risk measures when closely tracking and maintaining portfolio positions in and around the benchmark index, especially for more risk averse passive investors looking to not deviate too far from the market index. In the case of this study, it was less important given that the key objective was to assess whether fundamental indices outperform the market cap counterpart on a risk-adjusted basis. The objective was not to track or hug the index; in other words, it was expected that the fundamental indices would deviate from the benchmark market cap-weighted index to deliver superior returns. Higher tracking error and information ratio did not necessarily imply higher risk in the context of this study. Of all the risk measurement ratios used, tracking error and information ratio outputs were the least useful when compared on a standalone basis to the market cap-weighted benchmark. However, they were especially useful when used to compare the relative performance of the fundamental indices as a group, especially to determine which of the fundamental indices deviated the most from the more accepted market cap-weighted indexation strategy in generating higher nominal returns.

Table 4 shows that the sales index deviated the most from the market cap-weighted index to return an average of 1.87% above that benchmark on a rolling 12-month basis over the 12 years from January 2008 to December 2019. The sales index had the highest beta of the fundamental indices, and therefore, the evidenced higher tracking error was expected. The sales index had the highest information ratio at 0.88, which indicates that although it deviated the most from the constructed benchmark, it still outperformed all other fundamental index peers on a risk-adjusted basis.

The composite index's information ratio was only slightly lower than that of the sales index at 0.86 and outperformed the market cap index by 1.18% over the period. It should be noted that the beta of the composite index was most in line with the market cap portfolio at 1.01, suggesting that the underlying constituent portfolio moves approximately in line with the market cap-weighted benchmark. The cash flow index had the lowest beta at 0.95, suggesting that it took less systematic risk than the market cap-weighted portfolio and still produced a 0.99% above the benchmark. Despite having a tracking error approximately equivalent to the book value index, the cash flow index generated a much better information ratio at 0.66 that the 0.44 for the book value index.

The tracking error and information ratio information support the conclusion that the sales index, despite taking the highest systematic risk in deviating from the market portfolio, outperformed the other fundamental indices. The composite index lagged only slightly behind, taking systematic risk approximately in line with the market portfolio but delivering average nominal returns of 0.68% below the sales index on a rolling 12-month basis over the sample period.

Downside Risk

As previously stated, using standard deviation as a proxy for quantifying drawdown risk in asset portfolios is limited since it calculates the dispersion of asset returns both above and below the average return over a given period. It therefore measures both upside and downside risk. This study attempted to expand on previous contributions to the literature by quantifying the downside risk of investing in hard currency corporate bonds issued by companies with primary or alternate listings on the JSE. This contribution is especially important in the context of emerging market asset pricing where both bond and equity markets have suffered severe drawdowns during historical market dislocations during the Asian Crisis in 1997, the Russian Crisis in 1998, the Dot Com Bubble in 2000, and the Financial Crisis in 2008.

Calmar and Sortino Ratios. Table 5 shows the calculated downside measures to quantify drawdowns experienced by all indices over the 12-year period from January 2008 to December 2019. The maximum drawdowns for all the indices occurred in November 2008. This corresponds to the general market selloff during the 2008 Financial Crisis, which originated in the sub-prime housing market in the US. It should also be noted that these are dollar denominated drawdowns, and therefore, there was no emerging market or South African Rand currency effect on the negative returns shown. It can be observed that the book value index experienced the highest drawdown with the total returns falling -13.11% from the January 2008 peak to the November 2008 bottom. The market cap index experienced a drawdown of -12.10% over the period, which was more pronounced than the sales and composite indices, which had drawdowns of -10.17% and -11.05%, respectively. The cash flow index experienced the least severe drawdown at -9.86%.

Table 5: Downside Risk Metrics

Index	Maximum Drawdown	Average Drawdown	Calmar Ratio	Downside Months	Semi Variance	Semi deviation	Sortino Ratio
Market Cap (Reference)	12,10%	1,84%	0,08	66	0,42%	6,48%	0,15
Sales	10,17%	1,70%	0,28	52	0,36%	6,04%	0,47
Cash Flow	9,86%	1,56%	0,20	53	0,31%	5,53%	0,36
Book Value	13,11%	1,84%	0,12	57	0,45%	6,73%	0,24
Composite	11,05%	1,70%	0,20	51	0,39%	6,22%	0,35

Table 5 shows downside measures of risk affecting portfolio returns.

The Calmar ratio is a risk-adjusted measure that compares the average return of each index relative to their maximum drawdowns. Table 5 shows that the sales index had the highest Calmar ratio at 0.28, and the market cap index had the lowest Calmar ratio at 0.08. All other fundamental indices exhibited higher Calmar ratios than the market cap reference portfolio, which suggests that the indices provided more attractive returns relative to the maximum drawdown risk in the underlying portfolios. However, it should be noted that in absolute terms these are not especially good numbers and suggest that the nominal returns were not sufficiently high to offset the extent of drawdowns evidenced by the respective indices. For the purposes of this study, the Calmar ratio was only used to compare the relative downside risk between the market cap reference portfolio and the fundamental indices.

The maximum and average drawdown findings are relatively consistent with the information presented in Table 5. The cash flow index was shown to have the lowest market risk with a beta of 0.95 and the lowest total risk with a standard deviation of 7.74%. These risk metrics would largely support the cash flow index experiencing lower price declines relative to the other indices.

Despite having a market beta of 1 and the lowest standard deviation of all indices, the market cap index experienced more pronounced maximum and average drawdowns than both the sales and composite indices. While the difference in the size of these drawdowns was not especially large, it was slightly unexpected that the market cap index experienced larger declines than the sales index, which was shown to take the highest market and total risk with a beta of 1.06 and standard deviation of 8.66%, versus 7.93% by the market portfolio. However, this finding supports the theoretical premise that standard deviation is not necessarily the best measure of downside risk in portfolios and warrants further investigation to better understand and quantify how constructed indices can be expected to perform in market downturns.

Semi-deviation is an alternative measure that can be used to assess fluctuations in returns that specifically fall below the average return generated by an index. It was therefore useful for understanding return volatility during periods of underperformance. Table 5 shows that the semi-deviation was lowest for the cash flow index at 5.53%. This is consistent with the cash flow index that had the lowest standard deviation (Table 5). The book value index had the highest semi-deviation at 6.73%. The semi-deviation of 6.04% for the sales index was also lower than the semi-deviation of the market cap index at 6.48%. This is consistent with the standard deviations of the two indices and does not provide any additional context to understand downside risk between these portfolios. While semi-variance is a useful measure to isolate volatility of below average returns, it only considers the performance of a portfolio relative to its own time series history. It is effectively an absolute measure of the underperformance of a specific index compared to the average return generated over the sample period by that index.

Downside deviation is an especially useful measure to understand the volatility of returns below a given benchmark or target return objective, and it also allows for the direct comparison of the indices by evaluating them relative to a minimum return objective. For the purposes of this comparison, the MAR was the risk-free rate, and downside deviation was therefore calculated as the volatility of index returns that fall below the yield on the 10-year US Treasury bond. The average nominal yield on the 10-year US Treasury over the period amounted to 2.62%. This is below the evidenced average returns on all indices (Table3). Table 5 shows that the cash flow index again demonstrated the lowest return volatility. It showed the lowest volatility to standard deviation, semi-deviation, and downside deviation at 5.53%.

An interesting observation is that the sales index, which had the highest standard deviation, showed the second lowest downside deviation at 6.04%. Except for the book value index, all fundamental indices had lower downside deviation than the market cap index. In addition, the market cap index experienced more periods of underperforming the risk-free rate than all the fundamental indices. Of the 132 months capturing the rolling 12-month returns over the 12-year period from January 2008 to December 2019, the market cap index experienced returns below the yield on a 10-year US Treasuries bond for 66 of those months. In other words, the market cap index delivered returns below the MAR 50% of the time over the 12-year period.

This provides a meaningfully different perspective on the market cap index having lower risk than most of the fundamental indices as suggested by using standard deviation as a risk measure. Using downside deviation as the primary risk measure indicated that with the exception of the book value index, the market cap index actually takes higher risks than most of the fundamental indices.

The evidence presented here shows that standard deviation, semi-deviation and downside deviation all provide indications of the relative risk rankings of all the indices. The rankings show that the cash flow index had the lowest level of total, systematic, and downside risk. The book value index, by contrast, exhibited the highest level of total, systematic, and downside risk. The sales index, which had the highest beta at 1.06 and exhibited the highest total risk, was actually shown to have lower downside risk than the market cap index constructed as a benchmark.

Using the Sortino ratio to rank the risk-adjusted return of the different indices showed that all fundamental indices delivered superior investment performance versus the market cap index. The ratio isolates downside volatility using the deviation of index returns below a MAR, which was set at the risk-free rate for the purposes of this study.[1] The sales index had the highest Sortino ratio at 0.47, which is more than three times higher than the Sortino ratio of the market cap index at 0.15. The cash flow index and composite indices had Sortino ratios of 0.36 and 0.35, respectively, and both of these are more than double that of the market cap index. The book value index, which had the highest downside deviation of all the indices, had the lowest Sortino ratio at 0.24 but still delivered superior risk-adjusted returns than the market cap index. For portfolios with a target return or MAR equal to the risk-free rate, the market cap-weighted index is the least suitable investment option given that the index had the lowest Sortino ratio and delivered rolling 12-month returns below the target 50% of the time.

4.5.5 Modified Duration

Modified duration is especially useful for measuring the sensitivity of bond prices to changes in yield. In general, the higher the modified duration, the more sensitive the price of the bond is to a change in interest rates. This applies to both individual bonds and bond portfolios. The inverse relationship between bond prices and yields suggests that in an economic environment where interest rates are rising, the price of the bonds can be expected to fall approximately in line with its modified duration. In economic environments where interest rates are falling, bond investors can expect the price of their bonds to increase. As indicated

[1] It can also be set up to only include negative returns.

by Arnot et al. (2010), higher duration has been evidenced to contribute towards higher total returns for corporate bonds. Higher duration is however also associated with greater interest rate risk.

4.5.5.1 Duration

Modified duration is used as a measure to analyse interest rate risk across the constructed portfolios. Modified duration is calculated using Equation 30.

$$MD = \frac{\mathrm{D}}{(1 + \frac{Yn}{n\,X\,100})}$$

30

Where,
MD = Modified duration in years;
Yn = Yield compounded n times per annum;
n = Coupon frequency; and
D = Duration to maturity in years.

Duration (D) can be further explained as shown in Equation 31.

$$D = \left(\frac{1}{P_d}\right) X \sum_{i=1} PVCF_i \; X \; T_i$$

31

Where,
D = Duration in years;
Pd = Dirty price;
Ti = Time in years to the i*th* cash flow; and
PVCFi = Present Value of it*h* cash flows.

PVCFi can be further explained by Equation 31.

$$PVCF_i = \frac{CF_i}{\left(1 + \frac{Y}{100}\right)^{T_i}}$$

32

Where,
Cfi = ith cash flow; and
Y = Effective annual yield in percentage points.

Figure 20 shows the modified duration of each of the constructed indices. The period under observation from 2008 and 2019 was characterised by particularly low global interest rates with central banks of developed market countries, including the US Federal Reserve, implementing stimulus programmes to boost their economies following the 2008 Financial Crisis. Falling interest rates are generally relatively benign on bond prices to the extent that bond prices tend to increase approximately in line with their modified duration.

Figure 20 shows that on average all constructed index portfolios increased modified duration after 2009. This is consistent with the general interest rate trend in the US after the 2008 Financial Crisis where interest rates were reduced to almost zero to assist in the economic recovery. In the majority of years following the 2008 Financial Crisis, portfolio duration was increasing for each of the constructed indices, suggesting that these portfolios were taking on greater interest rate risk. The only period after the financial crisis when the constructed indices lowered their portfolio duration was in 2016 when the US Federal Reserve started to raise interest rates, but it quickly reverted to lower interest rates in subsequent years.

Figure 16: Modified duration

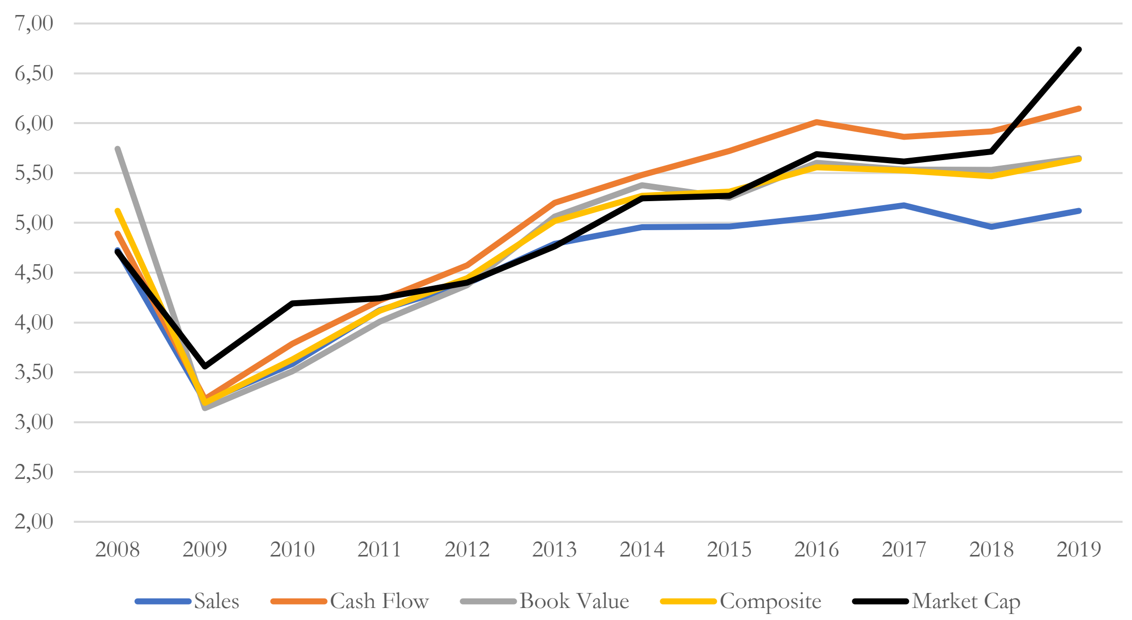


Figure 16 shows modified duration from 2008 to 2019.

The intention of assessing the indexation strategies relative to duration was to understand whether the data supports the argument that the superior performance evidenced by the fundamentally constructed indices was potentially an outcome of taking on higher interest rate risk. Longer maturity bonds generally pay higher yields than equivalent credit quality shorter maturity bonds, which, although exposing investors to greater interest rate risk, can be expected to contribute towards positive returns assuming a normal upward sloping yield curve.

The superior performance of the fundamental indices was not supported by higher average modified duration across the 12-year sample period. Figure 16 shows that the market cap index was running the highest average modified duration of all the index strategies at approximately 5.01, which was higher than all of the fundamental indices. The best performing sales index actually averaged the lowest modified duration over the period at 4.59.

4.5.6 Capital Asset Pricing Model Analysis

This section investigates the robustness of the findings shown in section 4.5.4.1. Specifically, the analysis explores whether the excess returns and the systematic risk taken by the fundamental indices are statistically significant. This is examined using the CAPM model and is consistent with the approach adopted by Arnott, Hsu and Moore (2005). Equation 33 shows the specification of the CAPM model that was applied.

$$(rp - rf) = \alpha i + \beta(rb - rf) + \varepsilon \tag{33}$$

Where,
rp = Portfolio return, shown as the realised annual return of the individual fundamental and market cap indices;
rf = Risk-free rate, shown as the rate on a 10-year US Treasury bond;
α = Alpha, shown as the outperformance of the constructed fundamental indices;
β = Beta, shown as the sensitivity of the fundamental indices relative to the market index;
$rp - rf$ = The difference between the historical realised annual return on the portfolio and the risk-free rate. In the context of this study, it shows the excess ex-post total return generated by the fundamental indices above a 10-year US Treasury bond; and
$rb - rf$ = The difference between the historical realised annual return on the benchmark and the risk-free rate. In the context of this study, it shows the excess ex-post total return generated by the benchmark market cap index above a 10-year US Treasury bond.

4.5.6.1 Results

Table 6 shows CAPM results for the full 12-year sample period as well as splitting the sample to the period before and after the so-called Fed taper tantrum in 2013.

The R^2 and correlation coefficients with the reference portfolio shown in Table 6 are expected. The indices were constructed from a homogenous basket of corporate bonds and differ primarily in weighting and exposure to the constituent issuers and debt securities. The high R^2 should not be interpreted as an indication of the fit or suitability as would be the case with standard linear or multiple ordinary least squares (OLS) regression analysis. The CAPM was used for this thesis to test the significance of the excess returns generated by the fundamental indices. The focus should be on the interpretation of the intercept and slope terms representing the alpha and beta measures.

Table 6: CAPM results

A) Full period (January 2008 to December 2019)

CAPM	Correlation with Reference	R Squared R^2	Beta (β)	Alpha (α)	Standard Error for α	t-statistic for α	P-value for alpha α
Market Cap (Reference)	1.000						
Sales	0.970	0.941	1.056	0.018	0.002	10.297	0.000
Cash Flow	0.982	0.963	0.953	0.010	0.001	8.358	0.000
Book Value	0.983	0.966	1.018	0.006	0.001	5.134	0.000
Composite	0.985	0.971	1.009	0.011	0.001	10.216	0.000

B) Pre Fed Taper Tantrum (January 2008 to May 2013)

CAPM	Correlation with Reference	R Squared R^2	Beta (β)	Alpha (α)	Standard Error for α	t-statistic for α	P-value for alpha α
Market Cap (Reference)	1.000						
Sales	0.960	0.923	1.012	0.024	0.004	5.905	0.000
Cash Flow	0.984	0.968	0.980	0.012	0.003	4.834	0.000
Book Value	0.981	0.963	1.039	0.004	0.003	1.556	0.126
Composite	0.980	0.960	1.011	0.014	0.003	4.709	0.000

C) Post Fed Taper Tantrum (June 2013 to December 2018)

CAPM	Correlation with Reference	R Squared R^2	Beta (β)	Alpha (α)	Standard Error for α	t-statistic for α	P-value for alpha α
Market Cap (Reference)	1.000						
Sales	0.980	0.962	1.113	0.016	0.001	12.730	0.000
Cash Flow	0.970	0.941	0.850	0.008	0.001	6.673	0.000
Book Value	0.981	0.963	0.974	0.007	0.001	6.428	0.000
Composite	0.993	0.987	0.981	0.011	0.001	16.227	0.000

Note: Alpha (α) = Outperformance of the fundamental indices versus the market cap index, which is used as the benchmark reference portfolio;
Beta (β) = Sensitivity of the fundamental indices sensitivity relative to the market cap reference portfolio; and
R-Squared (R^2) = Percentage of performance variation explained by the CAPM regression

4.5.6.2 Interpreting Alpha and Beta

Over the full 12-year period between January 2008 and December 2019, the t-stat and p-values presented Table 6 show the significance of the results at the 1% level of significance. All fundamental indices delivered significant excess returns over the constructed reference market cap index that was used as the benchmark.

The sales index generated an alpha of 1.8% or 180 basis points (bps) above the reference portfolio. This was delivered by taking on higher levels of systematic risk than the market cap benchmark with a reported beta of 1.06. The cash flow index showed an alpha of 1.0% (100 bps) above the benchmark market cap index at lower systematic risk as measured by the evidenced beta value of 0.95. The book value index took marginally higher systematic risk than the benchmark at a beta of 1.02 but also returned a significant alpha of 0.60% (60 bps). The composite index is a blended portfolio with an equal weight invested in each of the three fundamental portfolios. The results show that this hybrid portfolio delivered significant alpha of 1.10% (110 bps) with a level of systematic risk approximately in line with the benchmark at a beta of 1.01.

These findings are consistent with previous contributions to the literature for both bond and equity markets. Arnott, Hsu and Moore (2005) found that the sales index delivers the highest outperformance of all the fundamental indices with an excess annual return of approximately 2.4 over the market weighted S&P 500 benchmark over a period of more than 40 years. Other equity market studies demonstrate significant levels of outperformance from the sales index, including Ferreira and Krige (2011) who demonstrate outperformance of the JSE ALSI.

These results are consistent with the empirical results and performance attribution presented in section 4.5.3. The higher betas for the sales, book value, and composite must be interpreted relative to the returns generated by the respective portfolios. The sales index was the best performing portfolio and delivered the highest cumulative, average, and excess returns and was shown to incur lower incremental levels of total, systematic, and downside risk. Specifically, the Sharpe, Treynor and Calmar rations presented earlier showed that per unit of total, systematic, and downside risk, the fundamental indices delivered higher incremental returns versus the market cap benchmark index. Despite higher betas on both an absolute and relative basis, the fundamental indices delivered superior mean variance returns.

Furthermore, using the Brinson approach modelled in 4.5.3.3, Figure 17 below shows that only the sales index delivered positive allocation effect. All other indices have generated excess returns through tactical security selection, as an outcome of annual rebalancing of the index portfolios.

Figure 17: Sector Performance Attribution – Average excess returns

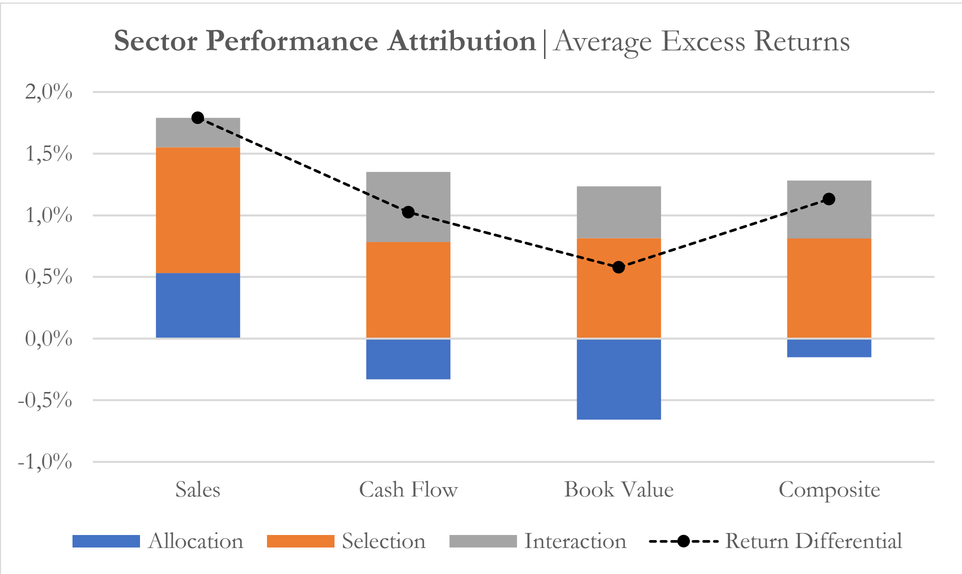


Figure 17 shows excess returns as indicated by the CAPM attributed by the Brinson approach.

Table 6 also examines the significance of excess returns generated by the fundamental indices following the period before and after a market shock event. The full 12-year sample period has been split in two to analyse the performance of the fundamental indices relative to the market cap benchmark. The most meaningful market event over the 12-year period between 2008 and 2019 was the so-called Fed Taper tantrum. The

2008 Financial Crisis had the most impactful effect on markets but occurred at the start of the sample period and does not allow for sufficient observation prior to the shock. The same can be said for the European Debt Crisis between 2011 and 2012 as well as the downgrade of US credit rating in 2011, with both events contributing to bond market drawdowns but also occurring relatively early in the 12-year sample period. The Fed Taper Tantrum refers to the spike in US Treasury yields stemming from comments from the US Federal Reserve that it would be changing its quantitative easing policy by reducing the pace of Treasury bond purchases in May 2013.

There are a few noteworthy observations after splitting the sample. The level of excess returns generated by all fundamental indices over the benchmark, both pre and post the shock, are shown to be significant. The exception is the Book Value Index in the period prior to the tantrum between January 2008 and May 2013. The 0.4% outperformance is not significant. The Composite Index is shown to take relatively lower levels of risk, as indicated by beta, relative to the benchmark. An interesting finding is that the best performing Sales Index delivered the majority of outperformance during the period leading up to the Taper Tantrum with an excess return of 2.4%.

4.6 Conclusion

The primary objective of this chapter was to construct a hard currency corporate bond index for issuers listed in South Africa. This was done using both a market cap and fundamental indexation approach. The main findings showed that the constructed fundamental indices not only generated superior absolute nominal and excess returns versus a market cap equivalent, but did so by taking less total, systematic, and downside risks. This suggests that investors looking for the highest risk-adjusted return, lower maximum and average drawdowns, and fewer periods underperforming the risk-free rate would be better served by following a fundamental over the market cap-weighted approach.

The sales index was shown to deliver the highest risk adjusted returns after calibrating for risk.

Furthermore, there was no evidence to support the suggestion that any outperformance is attributable to either taking on higher levels of interest rate risk. The market cap index was running the highest average modified duration of all the index strategies and delivered the lowest annualised, average and cumulative returns over the period. Portfolio attribution showed that only the sales index delivered a positive allocation effect over the full sample period. However, that outperformance is demonstrated to be relatively lumpy and over the 12-year period between January 2008 and December 2019.

All other indices have generated excess returns through tactical security selection, as an outcome of annual rebalancing of the index portfolios. The statistical significance of the excess returns generated by the fundamental indexation strategies was also demonstrated by using the CAPM. The findings in this chapter are consistent with previous contributions to the literature for both bond and equity markets. Arnott, Hsu and Moore (2005) also found that the sales index delivers the mean variance returns of all the fundamental indices with an excess annual return of approximately 2.4% over the market weighted S&P 500 benchmark over a period of more than 40 years. Other equity market studies demonstrate significant levels of outperformance from the sales index, including Ferreira and Krige (2011) who demonstrate outperformance of the JSE ALSI.

Chapter 5 | Market and Real Economy Determinants of Corporate Bond Return Volatility in South Africa: A GARCH-MIDAS

5.1 Introduction

A long-standing question in finance is whether macroeconomic factors or measures of economic activity anticipate changes in asset return volatility. Schwert (1989) is one of the first authors to shed light on this question by investigating the role of a range of macroeconomic and financial variables on stock market volatility over time. While he focuses on the role of macroeconomic factors and time-varying stock market volatility, he also investigated the relationship between bond and stock return volatility. Schwert (1989) reviews a rich body of research on the relationship between macroeconomic factors and stock market volatility. Expanding on the set of macroeconomic factors first investigated by Schwert (1989), Paye (2012) introduces a broad set of variables, such as current and expected economic growth; the two additional ratios, namely consumption to wealth and investment to capital stock, to be more representative of the aggregate economy. Variables such as the default spread, bond spread, and the ratio of investment to capital in the aggregate economy are used in the specification and was significant.

Traditional analysis of asset return volatility, such as stock market volatility, relied upon GARCH modelling developed by Engle (1982) and Bollerslev (1986). However, these traditional GARCH-class models require data that is reported at the same frequency, limiting researchers in the types of analysis that can be conducted. Ghysels, Santa-Clara and Valkanov (2004) developed a mixed data sampling (MIDAS) methodology where stock market volatility is modelled as a combination of macroeconomic factors and time series dynamics. This mixed frequency methodology arose due to differing frequencies of financial and economics time series data, especially of variables of interest and common macroeconomic and finance regressors (Ghysels, Santa-Clara and Valkanov, 2004). Engle, Ghysels and Sohn (2013)[2] were the first to investigate stock market volatility and macroeconomic fundamentals by introducing a new class of models that enable a separation of the short- and long-term volatility movements. Known as GARCH-MIDAS, this new type of model allows for the direct incorporation of macroeconomic and financial fundamentals into the long-term component to distinguish from short-term fluctuations. Research on stock market volatility largely supports findings that the GARCH-MIDAS model is superior to more traditional models on this topic. This research includes Asgharian, Hou and Javed (2013) who examines US stock market volatility using both a GARCH-MIDAS and GARCH (1,1) model, as well as the seminal contribution on corporate bond market volatility by Nieto, Novales and Rubio (2015).

[2] There is a working paper version of this article available under the title *On the economic sources of stock market volatility* dated 2009. This chapter references the 2013 version. For all intents and purposes, the methodology in the two versions is identical. This thesis references the 2013 version of Engle, Ghysels and Sohn as it is the peer-reviewed version as published in *Review of Economics and Statistics*, No 3, 2013.

This chapter is motivated by the large and dominant literature on stock market volatility. In contrast to the extensive literature on stock market volatilities, relatively little work exists on corporate bond market volatilities across developed, and especially, developing economies. One reason may be that researchers believe stock markets also capture bond market dynamics (see Schwert, 1989). A second more likely reason is the lack of transparent, reliable, and higher-frequency data emanating from bond markets. This shortcoming is exacerbated in emerging corporate bond markets. While daily and even hourly data may be available for some stock and some developed corporate bond markets, it remains relatively more difficult to source high frequency bond market information in developing countries or regions. While corporate bond markets in developed economies have made meaningful advancements in improving trading platforms through vehicles like TRACE, historical time series data for emerging market corporate bonds are relatively less extensive.[3] Studies that do focus on corporate bonds tend to focus on corporate spreads rather than total bond returns.

Chapter 4 presented hard currency corporate bond indices to identify the investable opportunity set available to market practitioners and to investigate the relative mean variance efficiency of the underlying constituent portfolios. The intention was to improve the transparency of the hard currency investment universe to allow for the more robust econometric modelling that follows in this chapter and in Chapter 6. The current chapter builds on Chapter 4 by specifically investigating the variance of returns generated by the benchmark market cap-weighted index. It addresses a gap in the literature by providing evidence of the roles of macroeconomic variables and financial fundamentals on the volatility of total bond returns, especially in a developing country and emerging market setting. Specifically, this chapter is concerned with ascertaining the long-term information content of macroeconomic and financial factors on corporate bond market total return volatility. The aim was to understand the volatility of return on hard currency corporate bonds issued by companies with primary or secondary listings on the Johannesburg Stock Exchange (JSE). The objective was to use a GARCH-MIDAS framework to determine how macroeconomic and financial variables potentially influence the long-run volatility of corporate bond returns. A MIDAS methodology within the GARCH setting was applied to explain long-run bond returns using low-frequency macroeconomic variables. This approach allowed for the use of macroeconomic and financial time series in their original form instead of converting the series to conform to a different frequency. Furthermore, using the GARCH-MIDAS methodology allowed for the disentanglement of the long-term component of volatility from the short-run dynamics, where the long-term component is affected by the macroeconomic variables. Based on the literature on return volatility, a number of macroeconomic variables were examined, including term spread, default premium, South African industrial production (SAIP), US industrial production (USIP), and US real exchange rate. The results of the GARCH-MIDAS framework were examined across a number of specifications and compared to the benchmark GARCH (1,1) framework

[3] The FINRA-developed Trade Reporting and Compliance Engine vehicle that facilitates the mandatory reporting of OTC transactions in eligible corporate bonds and fixed income securities. Broker-dealers of FINRA member firms are required to report transactions in these TRACE-eligible securities under SEC-approved rules.

that has been the framework of choice for much of the seminal literature on stock market volatility. To compare the traditional model to the GARCH-MIDAS framework and to investigate the impact of the different macroeconomic variables, a likelihood ratio test was performed. To the best of the author's knowledge, this is the first attempt to quantify this relationship in a developing country setting based on a foreign currency denominated listed bond market index. In addition, this framework allowed for testing the performance of the index in relation to fundamental indices constructed in Chapter 4.

The analysis in this chapter emphasises an in-sample approach. The main findings of this analysis can be summarised as follows: Empirical findings for the market capitalisation (mktcap) index showed that SAIP, default, and the JSE All Share Return (JSEALLR) variables significantly affect bond market return volatility, and the most significant is that stock market returns account for almost one-third of the bond market return volatility. The results also confirm the counter-cyclical behaviour of bond market returns for SAIP, similar to the stock market volatility observed in Schwert (1989) and Conrad and Loch (2015). On the other hand, domestic inflation has limited impact on foreign currency bond market return volatility, which is in line with studies such as that of Conrad and Loch (2015). For foreign currency denominated corporate bonds, long-term volatility was shown to be negatively related to the volatility of USIP across all indices.

The remainder of this chapter is structured as follows: The literature review looks at relevant literature, including a discussion of the links between macroeconomic data and asset markets and an overview of the approach used in this chapter. This is followed by the data and the descriptive statistics. Following this is a section that introduces and explains the methodology, and next the preliminary evidence is discussed. Finally, the key results and findings are presented, and then the limitations and constraints are outlined.

5.2 Literature Review

The motivation for examining the predictive content of macroeconomic factors on bond returns follows from the existing literature on the relationship between macroeconomic indicators and stock market returns. This literature can be traced back to Ross' (1976) arbitrage pricing theory (APT), which is a more generalised version of capital asset pricing theory by Sharpe (1964). Specifically, the APT allows for stock returns to be associated with factors such as macroeconomic variables. Therefore, time series models that introduce macroeconomic and financial variables as factors influencing the variation of returns over time have taken hold in the literature. Interestingly, there is still no consensus on whether stock or bond returns are most important to explain expected returns or variation of returns. Given that there is no definitive consensus in the literature, investigations at country levels are desirable to show the differential contexts in which returns are generated.

An important part of the underlying assumptions of the APT is that risk factors should have an effect on returns and that risk factors should affect expected returns. Furthermore, risk factors cannot be fully predicted as they may contain information that is unexpected to the market (Jones, 2007). Taken together, these assertions establish a basis for a variety of macroeconomic and financial variables to be tested against the assumptions of the APT. Shanken (1982) identifies some of the weaknesses of the APT; for example, the specific risk factors that affect the variation in stock returns cannot be identified or presupposed as the underlying models do not explicitly specify these factors.

5.2.1 Macroeconomic News

A prominent strand of stock market volatility literature hypothesises that macroeconomic data may be informative "about the volatility of either future expected cash flows or future discount rates then can help explain why stock return volatility changes over time" (Schwert, 1989:1116). Macroeconomic data captures both current and expected economic conditions as some variables can be viewed as concurrent indicators while others are either leading or lagging indicators. Independent of the type of economic indicator identified, macroeconomic fundamentals have been shown to be informative in both in-sample and out-of-sample testing in developed market settings.

McQueen and Roley (1993) found a strong relationship between stock prices and macroeconomics news, such as inflation, production, and the unemployment rate. They ascribe researchers' inability to identify significant macroeconomic indicators to the inadequacy of the models being estimated at that time. The majority of research conducted on this relationship assumes a constant coefficient model, which does not take into account the time-varying nature of what some macroeconomic factors may be indicating at different points in the cycle.

An important observation from the early literature on stock market volatility relates to differential impacts of macroeconomic announcements versus economic conditions. Flannery and Protopapadakis (2002) note that prior to 2002, little to no research existed on the impact of macroeconomic announcements on stock market volatility. At about the same time, literature on the role of economics conditions started gaining traction. With the emergence of GARCH models, Hamilton and Susmel (1994) show that macroeconomic conditions significantly impact on equity returns. A contribution worth highlighting, is that of De Goeij and Marquering (2006) who the impact of macroeconomic news announcements on the volatility of bond returns. This is one of the earliest papers to empirically demonstrate the impact of macroeconomic indicators on bond returns, with a focus on scheduled announcements. The authors argue that while firm-specific news is the dominant source of information for equity markets, macroeconomic indicators are the main source of information for bond markets.

5.2.2 Business Cycle Effects

An influential study by Boyd, Hu and Jagannathan (2005) investigates the role of macroeconomic news on stock prices. They show that the stock market response depends on where in the business cycle the economy is. Specifically, they found that the stock market responds positively to news of rising unemployment in expansions but negatively during economic contractions. They show that investors should closely study real sector data, and revise expectations depending on the phase of the business cycles. Belo, Lin and Bazdresch (2014), in the spirit of Boyd, Hy and Jagannathan (2005), show that lower hiring rates and investment are associated with higher stock returns. Conrad and Loch (2015) also combine a series of measures of economic activity to identify macroeconomic variables that may anticipate changes in long-term stock market volatility. Their findings indicate that macroeconomic variables are important predictors of the secular component, or long-term variation, of stock prices. These papers provide notable evidence that economic indicators, especially from the real economy, have a non-trivial influence on the volatility of stock returns.

Relative to equity markets, the literature is not very well established on corporate bond returns, particularly as it relates to examining the volatility of total returns on corporate bonds. The most comprehensive literature on the performance of corporate bonds and macroeconomic variables relates to the credit spreads as either a contributor or detractor to the level of returns. The body of literature examining the volatility of returns is not especially wide (Nieto, Novales & Rubio, 2015); however, reviewing the relevant credit spread literature provide context to the low-frequency macro and financial variables used in this study to examine the volatility of corporate bond returns.

5.2.3 Term Structure of Interest Rates

The term structure of interest rates is an important proxy for macroeconomic growth, and numerous earlier contributions to the literature (Fama & French, 1989; Bernard & Gerlach, 1998; Estrella & Mishkin, 1998) show that economic downturns are often preceded by a flattening or inverting of the yield curve.

Interest rates have been examined extensively in the bond pricing literature. Early studies focusses on disaggregating the level of interest rates from the slope of the yield curve. Longstaff and Schwartz (1995) discovered a negative relationship between the level of interest rates and corporate credit spreads. Alesandrini (1999), Kao (2000), Campbell and Taksler (2001), Brown (2001) and Ericsson and Renault (2006) provide further evidence of the negative relationship between credit spreads and the level of interest rates. This negative relationship has been evidenced for both individual corporate bonds and bond indices. Collin-Dufresne and Goldstein (2001) list US corporate bonds and found that interest rates become an even more significant determinant of credit spreads as credit quality deteriorates. These conclusions are consistent with earlier research by Duffee (1998), who also found a significant negative relationship between short-term interest rate levels and bonds of lower credit quality. Papageorgiou and Skinner (2006) agree with the significance of the negative relationship but argue that it is consistent across both higher and lower quality bonds. Joutz and Maxwell (2002) also found a significant negative relationship in the short term but found evidence of a positive relationship between spreads on lower quality or non-investment grade corporate bonds and the level of interest rates.

Research on the slope of interest rates is relatively inconsistent in establishing a robust relationship with changes in credit spreads. Papageorgiou and Skinner (2006) found a negative relationship between changes in credit spreads and the slope of US Treasuries across both lower and higher quality bonds. Duffee (1998) and Bakshi, Madan and Zhang (2006) largely contradict these findings by asserting that the negative relationship is significantly stronger for higher quality investment grade (IG) bonds than for more speculative issues. This difference is attributed to the hypothesis that higher quality bonds have a stronger correlation to US Treasuries and are therefore more sensitive to interest rates, whereas lower rated bonds behave more like equities. Joutz and Maxwell (2002) studied bond indices instead of individual bonds and argue that the negative relationship between the slope of interest rates and credit spreads is stronger at intermediate and longer maturities. Contrary to the majority of earlier studies, Avromov et al. (2007) found a strong positive relationship between changes in credit spreads and interest rates when using three separate proxies to capture the slope between short-, intermediate- and long-term rates.

5.2.4 Default Risk

Previous studies show that default risk has some explanatory power for corporate bonds returns. Early contributions by Fama and French (1993) demonstrate that both term spreads and defaults are bond specific factors that impact the expected returns from corporate bonds. Elton et al. (2001) studied credit spreads and found that systematic equity market risk is an important determinant of spreads. In addition, they found that corporate credit spreads can also be attributed to potential default loss. This is relatively consistent with a later contribution by Gemmill and Keswani (2011), who also found that default loss is primarily responsible for the spreads on corporate bonds. Higher credit spreads incorporate a relatively higher risk premium that is mainly attributable to bondholder fears of suffering sizeable losses. However, Delianedis and Geske (2001) found that changes in credit spreads are not primarily explained by factors like default and recovery risk but are more affected by market risk factors. Gebhardt, Hvidkjaer, and Swaminathan (2005) present evidence of the relationship between aggregate default risk to bond returns, and found that even after controlling for credit rating and duration, default risk impacts significantly on average bond returns. Tang and Yan (2010) examine the relationships between corporate bond credit spreads and market risk and default risk and found that when using credit default swap (CDS) data, average credit spreads increase with higher growth GDP volatility but decrease with higher GDP growth rates and when investor sentiment is strong. However, the authors also indicate that macroeconomic variables explain a relatively small portion of credit spreads and changes are mostly due to default risk. This is an interesting finding in the context of the finding by Giesecke et al. (2011) that default rates at the aggregate corporate bond level can be predicted by financial and macroeconomic variables. Huang and Huang (2012) used a structural model with a specific default variable to investigate the contribution of credit risk priced into corporate bond spreads. Their findings show that credit risk contributed relatively less to credit spreads in IG bonds but a higher percentage in more speculative non-IG bonds.

5.2.5 Equity Returns

Numerous earlier studies also highlight the negative relationship between equity returns and credit spreads at the individual company level (Ramaswami, 1991; Kwan, 1996) as well as at the portfolio level (Cornell & Gren, 1991; Blume, Keim & Patel, 1991). The literature is also largely supportive of equity returns being used to model the real economy. Avromov et al. (2007) use equity market returns as a proxy for the business cycle and found that this is the second most significant determinant of changes in credit spreads after interest rates. This conclusion supports earlier research by Campbell and Taksler (2003) that found that volatility in equity returns explains approximately a third of the changes in corporate credit spreads. Their findings further indicate that equity has as much explanatory power for variation in bond yields as credit ratings. Bewley, Rees and Berg (2004) used conditional variance volatilities and option pricing to investigate the impact of equity volatility on bond spreads, and found that bond spreads are not significantly affected by implied volatilities in the options market. Conditional variance volatilities at the aggregate equity market index are, however, found to have both stable and significant effects on bond spreads. King and Khang (2005) found that the equity market has a limited impact on bonds after controlling for the default risk.

5.2.6 Asset Return Volatility

The primary literature considered for this chapter relates to the development and application of the GARCH-MIDAS framework to quantify long-term volatility in corporate bond markets. Engle (1982) and Bollerslev (1986) pioneered the earlier seminal research on examining the relationship between stock market volatility based on autoregressive conditional heteroskedasticity (ARCH) and GARCH models. Engle and Lee (1999) contributed to the methodology by introducing an additive GARCH (1,1) model. This allowed short-term volatility to be modelled as a transitory component and a long-term component to be representative of volatility trend. Engle and Rangel (2008) further developed the methodology by introducing a multiplicative component structure through the Spline-GARCH model. This framework accommodates the non-stationarity features of the long-run-to-trend volatility component and allowed for the introduction of a low-frequency component. The most recent iteration to the methodology was contributed by Engle, Ghysels and Sohn (2013), who proposed the MIDAS methodology within the GARCH setting.

Most of the contributions have been on US equity markets and very little application of the methodology have been examined on corporate bond markets. The main contributions and findings are discussed here. Engle and Rangel (2008) use a Spline-GARCH model to examine stock market volatilities across 50 countries using daily data. They propose modelling stock volatility using both macroeconomic and financial variables. Low-frequency volatility of stock returns is then modelled as a function of these variables. They show that it changes over time as well as across countries. Higher volatility is supported by low output growth, high inflation, high volatility of short-term interest rates, and high volatility of production growth as measured by the GDP. The authors suggest that countries with negative or low economic growth are expected to experience higher volatilities compared to countries with more positive economic growth. Countries with relatively higher inflation rates are also shown to have larger expected volatilities than countries with more contained levels of inflation. This is largely confirmed by their conclusions on the significance of market development. They found that emerging markets have higher levels of low-frequency market volatilities, which would potentially be supported by emerging markets that usually have higher rates of inflation compared to more developed markets. The authors also demonstrated that volatility is higher for markets with lower market breadth, measured by a lower number of listed companies or exchanges with lower market capitalisations.

Engle, Ghysels and Sohn (2013) first used a GARCH-MIDAS model to investigate the relationship between daily US stock market volatility and macroeconomic activity. The approach they took to examine the contribution of economic variables to stock market volatility is effectively a regression through MIDAS filtering. By introducing this new type of model that allowed for the separation of the short- and long-term components of variation, they found that producer price inflation and industrial production growth explain a significant proportion of stock market volatility. These two variables explain the long-term component of stock market return volatility. More specifically, the authors found that based on daily data, inflation and industrial production growth comprise between 10% and 35% of one-day ahead volatility prediction.

Girardin and Joyeux (2013) followed the methodology of Engle, Ghysels and Sohn (2013) to examine the relationship between macroeconomic fundamentals on the long-term volatility of the Chinese stock market. They focus on the Chinese Renminbi denominated A-market as well as the foreign currency denominated B-market. Although the authors are interested in economic fundamentals, they also support their approach by including a market trading volume variable to approximate investor speculation. Real economy variables include industrial production, inflation, bank credit, and exchange rates because of B-shares being denominated in US Dollars. They found that the volatility of macroeconomic variables become increasingly influential in the A-market after being included in the World Trade Organisation (WTO), and that market volatility is especially sensitive to inflation. The B-market has more speculative characteristics and is less influenced by low-frequency macroeconomic variables. These are interesting observations given that the A-market was previously only accessible to Chinese domestic investors while the B-market was only traded by foreign investors. Girardin and Joyeux (2013) also cite the disconnect between the Chinese real economy and long-term volatility of the stock market as especially notable. Speculation is posited as the most likely explanation for the stock volatility being relatively detached from the economic fundamentals. The authors argue that modelling asset returns using a fundamentals-based approach is a sensible start to understanding the dynamics and volatility of asset returns as it presents one of many views on what may be driving asset returns. This approach should be viewed as complementary to any other analysis that may be conducted, such as present value modelling and the impact of trading volumes.

Asgharian, Hou and Javed (2013) adopted a GARCH-MIDAS methodology to investigate the effect of macroeconomic variables on US stock market volatility. Their approach differs from that of Engle, Ghysels and Sohn (2013) in that they primarily focus on variance predictability and specifically include macroeconomic variables to examine whether these can contribute to higher predictive power than more traditional volatility models. The authors use a GARCH-MIDAS approach to break down return volatility into a short-term and long-term component, and they model the long-term component of the variance on a realised volatility (RV) of US stock returns. In addition, they also use macroeconomic variables, namely interest rate level, the slope of the yield curve, unemployment rate, industrial production, inflation, exchange rates, and a default term variable. Their results show that the inclusion of low-frequency macroeconomic variables improves the predictive power of the model and is especially evident for the long-term variance component. Interest rate level and the default rate, defined as the yield spread differential between Moody's BAA and AAA corporate bonds, are shown to provide the most meaningful results. In addition, Asgharian, Hou and Javed (2013) demonstrate the robustness of their approach by comparing the results to the more widely used GARCH (1,1) and found the GARCH-MIDAS specification a better fit for their analysis.

Nieto, Novales and Rubio (2015) use the GARCH-MIDAS approach to model the impact of macroeconomic indicators on the Spanish bond market. Theirs was one of the first papers to use this approach to model the relationship between macroeconomic and financial variables fundamentals on the volatility of corporate bond markets. They use daily data from January 1997 to January 2012. The authors found that industrial production, aggregate consumption, employment growth, and financial variables, including the volatility index (VIX), default premium, and slope of the yield curve, are significant determinants of corporate bond volatility for both investment and non-IG credit with regards to the long-run component of volatility. The authors also show the differences in the variables that affect investment versus non-IG bonds. The volatility of the lowest quality CCC-rated, non-IG bonds was found to be relatively more affected by shocks to higher levels of default, aggregate market illiquidity, and inflation than AAA-rated bonds. They also show that low level of the term premium and slow industrial production are have a more pronounced effect on non-IG bonds.

5.3 Data

The analysis in this chapter uses the constructed bond indices presented in Chapter 4 and specifically focuses on the mktcap index because it is the most widely used indexation strategy in global capital markets. For a description of the index methodology, see section 4.4.3 In keeping with research in this area of interest, in this chapter, bond market returns are in weekly frequency and the macroeconomic and financial variables are in monthly frequency. Data was sourced from Eikon Refinitiv. The weekly bond returns are calculated as the differenced natural logarithm of the bond index in line with research on stock and bond market volatilities.

The data were selected to cover the period from January 2008 to December 2019. This period covers the end of the 2008 financial crisis to the end of 2019, just before the COVID-19 pandemic hit the world. The data selection period could not be extended to cover a longer period due to restricting data limitations. Firstly, the South African bond market data relating to foreign currency denominated bonds is somewhat limited or non-existent prior to 2008, making the creation of a reliable index prior to 2008 near impossible. An extension of the data period beyond 2019 was also not possible given the extensive impact of COVID-19 on domestic economies around the world, and ultimately, the significant variation in domestic production that resulted from the pandemic, making any form of forecasting difficult and highly unpredictable.

Many macroeconomic variables tend to be low frequency in nature because of the timing of releases that include monthly and quarterly indicators, and bond returns may be available at daily, weekly, or monthly intervals, depending on the market or country of interest.

An important consideration in the data selection process was data revisions. Conrad and Loch (2015) show that using revised data leads to misleading forecasts as the revised data may differ substantially from first-release or real-time data that market practitioners have access to on which to base decisions. Revised estimates of key economic variables are also released as statistical authorities receive more and updated information, often with a delay between date of receipt and the public reporting date. Research on the use of macroeconomic variables in forecasting (see Stark & Croushore, 2002; Croushore, 2011) confirm that first-release or real-time data is important for business decision-making and setting expectations (Conrad & Loch, 2015). This is further supported through research that shows stock markets respond to the announcements of economic information, such as GDP and inflation, confirming that real-time data is an important determinant of both future and current stock market volatility, and future economic conditions (Boyd, Hu & Jagannathan, 2005; Belo, Lin & Bazdresch, 2014). It should be noted that South African statistical authorities amend and revise macroeconomic variables for up to four subsequent release dates, but these changes are usually not announced and therefore do not materially factor into forecast models as much as first-release data.

A final point of clarification of macroeconomic data is the issue of first-release versus real-time information. Indicators such as GDP growth are released at least 60 days after the end of a given quarter, causing a natural delay of the data that is expected by the market. This data then becomes the most reliable form of real-time data as it is the most recently released version available to the public. In keeping with Conrad and Loch (2015) and the reality faced by market practitioners, for the rest of this chapter, the term first-release data will be used to describe the use of macroeconomic data that is first released to the public but also the most recent available data in the market.

5.3.1 Descriptive Statistics

Table 7 is the summary of the statistics for the weekly bond market returns and monthly macroeconomic variables used during the analysis in this chapter. Weekly bond market returns were not normally distributed and displayed excess kurtosis and skewness. Bond returns and five of the macroeconomic variables displayed kurtosis greater than three, indicating distributions with excess kurtosis or distributions that are leptokurtic. While bond returns displayed negative skewness, it remained within the normal range. Excess skewness was observed for three of the macroeconomic variables. Half of the macroeconomic variables displayed a negative skewness.

South African inflation (SAInf) averaged 6% over the period under examination, which is in line with the long-term average of 6% since 2000. Mean real returns of the JSE averaged 5.5% over the period under consideration, with a high of 7.36% and a minimum of 1.82%. SAIP also displayed a relatively low mean of 0.98% over the period, with a maximum of 1.11% and a minimum of 0.87%, indicative of the country's slow productive growth over time. All series had a positive mean.

Table 7: Descriptive statistics of bond returns and macroeconomic variables

	Bond returns	*SAIP*	*Level*	*Slope*	*Default*	*SAInf*	*JSEALLR*	*USREER*	*USIP*
Mean	0.071	0.98	0.03	0.02	0.01	5.83	5.05	1.04	0.98
Skewness	-0.392	-0.64	0.39	-0.31	2.51	1.99	-0.94	0.19	-1.02
Exc. Kurtosis	6.449	3.78	2.25	2.76	9.91	7.07	4.11	1.54	3.21
Max	3.786	1.11	0.04	0.04	0.03	0.14	7.36	1.18	1.04
Min	-4.579	0.87	0.01	-0.01	0.01	0.03	1.82	0.92	0.85

Table 7 presents the descriptive statistics for the bond returns and the macroeconomic and financial variables used in this analysis.

Table 8 shows the correlation between the low-frequency monthly macroeconomic and financial variables and the RV used in this chapter. The RV was negatively correlated with the level, slope, SAInf, JSEALLR and USIP variables. As expected, SAIP was highly correlated with JSEALLR. Similarly, the financial variables level, slope and default were all negatively correlated with JSEALLR. SAIP displayed a strong correlation of 0.81 with USIP.

Table 8: Correlation between variables

Variables	*RV*	*SAIP*	*Level*	*Slope*	*Default*	*SAInf*	*JSEALLR*	*USREER*	*USIP*
RV	1.00								
SAIP	0.05	1.00							
Level	-0.05	-0.14	1.00						
Slope	-0.11	-0.53	0.54	1.00					
Default	0.19	-0.39	0.22	0.23	1.00				
SAInf	-0.02	0.24	0.39	0.18	0.53	1.00			
JSEALLR	-0.15	0.41	-0.40	-0.47	-0.84	0.59	1.00		
USREER	0.29	0.18	-0.24	-0.60	0.01	-0.15	0.13	1.00	
USIP	-0.02	0.81	-0.37	-0.68	-0.56	-0.12	0.72	0.31	1.00

Note: The tables shows the correlation between monthly observations between the macroeconomic and financial variables, and the realised volatility of the total bond returns (RV). The macroeconomic variables are South African Industrial Production (SAIP), the yield on a three months US Treasury Bill (Level), the yield spread between a ten-year bond and a three-month US Treasury Bill (Slope), the spread between Moody's Baa and Aaa corporate bond yields (Default), the monthly changes in the South African Consumer Price Index (SAInf), the monthly stock return on the Johannesburg Stock Exchange (JSEALLR), the monthly changes in the US Real Exchange Rate (USREER) and the growth rate in US Industrial production (USIP). Data covers the period January 2008 to December 2019.

It is important to note up front that the length of the time series for this analysis was not as long as other studies in this area. Due to the nature of the South African foreign currency denominated bond market, the time series under consideration is at its maximum length, and there was no way to extend this time series further back in time nor to extend it forward.

5.4 Methodology

The purpose of this chapter is to examine the effects of low-frequency macroeconomic and financial variables on the volatility of total bond returns generated by hard currency corporate bonds issued by JSE-listed companies. This was done by examining the constructed mktcap index described in Chapter 4. In this analysis, weekly bond data was combined with monthly macroeconomic and financials indicators to investigate the effect of these indicators on the volatility of corporate bond total returns. For this purpose, a GARCH-MIDAS estimation model was used where the low frequency macroeconomic and financial variables were expected to influence the long-run component of volatility. To satisfy this purpose, the analysis was predicated on the methodology introduced by Engle and Rangel (2008) and Engle, Ghysels and Sohn (2013). The GARCH-MIDAS model introduced by Engle and Rangel (2008) and Engle, Ghysels and Sohn (2013) assume that returns may be written as shown in Equation 34.

$$r_{i,t} - E_{i-1,t}(r_{i.t}) = \sqrt{\tau_t g_{i,t} \varepsilon_{i,t}}$$

34

Where,
$r_{i,t}$ = Log return in week *i* during month *t;*
$E_{i-1,t}(r_{i.t})$ = Conditional expectation given information up to time $(i-1)$. Volatility is further assumed to have two components, namely one short-term and one long-term (secular);
$g_{i,t}$ = Higher-frequency short-run component accounting for weekly fluctuations; and
τ_t = Low-frequency long-term (secular) component.

The benefit of setting up the specification in this manner is that it allows for the same news to have a different impact depending on prevailing economic and market conditions. An important assumption was that macroeconomic and financial variables are assumed to affect the long-term or secular component of volatility but not the short-term. It can be further assumed that $E_{i-1,t}(r_{i.t}) = \mu$, allowing Equation 34 to be rewritten as Equation 35.

$$r_{i,t} = \mu + \sqrt{\tau_t g_{i,t} \varepsilon_{i,t}}$$

35

Where,
$\varepsilon_{i,t} \mid \varphi_{i-1,t} \sim N(0,1)$; and
$\varphi_{i-1,t}$ = Information set up to week $(i-1)$ of period *t*.

According to Engle, Ghysels and Sohn (2013), it can be assumed that the volatility dynamics of the short-run component $g_{i,t}$ is a Bollerslev (1986) weekly GARCH (1,1) that follows a mean-reverting process, expressed as Equation 36.

$$g_{i,t} = (1 - \alpha - \beta) + \alpha \frac{\left(r_{i-1,t} - \mu\right)^2}{\tau_t} + \beta\, g_{t-1,t}$$

36

Where,
$\alpha + \beta < 1.$

Let τ_t be defined as the smoothed RV (MIDAS regression) and given as Equations 37 and 38.

$$log\, \tau_t = m + \theta \sum_{k=1}^{K} \varphi_k(w_1, w_2) RV_{t-k}$$

37

$$RV_t = \sum_{i=1}^{N_t} r_{i,j}^2$$

38

Where,
τ_t, = Long-term component and the RV are fixed within the chosen time span;
$\varphi_k(w_1, w_2)$ = Weighting scheme; and
K = Number of periods over which volatility is smoothed. This is also known as the number of MIDAS lag years where K equal to 12 is equivalent to one MIDAS lag year.

Equations 37 and 38 is the basic logarithmic specification for the long-term component in the logarithmic version of GARCH-MIDAS as it matches the specifications in Asgharian, Hou and Javed (2013) and Engle, Ghysels and Sohn (2013).

This analysis investigated the effects of both the level and volatility of the macroeconomic variables on bond market return volatility (Engle, Ghysels & Sohn, 2013). A GARCH-MIDAS model with an one-sided filter that incorporates macroeconomic variables directly, either through the level macroeconomic variables or the volatility of the macroeconomic variables, for the long-term component is given by Equations 39 and 40.

$$log\ \tau_t = m_l + \theta_l \sum_{k=1}^{K} \varphi_k(w_1, w_2) X_{l,t-k}$$

39

$$log\ \tau_t = m_v + \theta_v \sum_{k=1}^{K} \varphi_k(w_1, w_2) X_{v,t-k}$$

40

Where,
X_{t-k}^{l} = Level of a macroeconomic variables represented by the logged first differences; and
X_{t-k}^{v} = Volatility of the macroeconomic variable.

Following Asgharian, Hou and Javed (2013), the squared first differences was selected as the measure of variance in the macroeconomic variables. The logarithmic set up was chosen to avoid issues that may arise if the macroeconomic and financial variables take on negative values. The total conditional variance can be defined as Equation 41.

$$\sigma_{it}^2 = \tau_t . g_{i,t}$$

41

5.4.1 Weights and Number of Lags in the MIDAS Equation

For model completeness and ease of estimation, the weighting scheme used in Equations 37,38, and 39 is described by a beta lag polynomial (Equation 42).

$$\varphi_k(w) = \frac{\left(k/K\right)^{w_1-1}\left(1-k/K\right)^{w_2-1}}{\sum_{j=1}^{K}\left(j/K\right)^{w_1-1}\left(1-\frac{j}{K}\right)^{w_2-1}} \tag{42}$$

Where,
w_1 = 1. Increasing w_2 gives larger weight to more recent observations. If w_1 is larger than 1, more recent observations are given a lower weight.

The beta weighting function in Equation 42 includes two parameters of w_1 and w_2. Asgharian, Hou and Javed (2013) specifies the following three possibilities of choosing the weights, w_1 and w_2:

a) Allowing both w_1 and w_2 to be determined within the model;
b) Fix w_1 while w_2 is determined within the model; and
c) Fix both w_1 and w_2.

Following Engle, Ghysels and Sohn (2013) and Girardin and Joyeux (2013), the value of w_1 was optimally set to 1 where weights are monotonically decreasing over the lags. As a result, w_1 was set to 1 and only the single w parameter was reported in all the estimation results. This conforms to alternative b) where no prior preferences are exhibited for w_2.

The second step to facilitate model estimation was to decide on the length of lag in the MIDAS equation (K in Equations 37, 38, 39, and 41). The lags were determined by the number of MIDAS years and the time span *t* to be used to calculate τ_t in Equations 37, 38, and 39.

For the purposes of this analysis, the number of MIDAS lag years was set to 3 or K was set to 36 for the three model specifications discussed in section 5.4.2 This was motivated by Conrad and Loch (2015) and Engle, Ghysels and Sohn (2013), who show that robust estimation results can be obtained provided the number of MIDAS lag years is sufficiently long. Therefore, it can be concluded that the estimations costs three years of information to conduct the analysis. While this was not ideal given the short length of the data time series in this analysis (12 years), setting the number of lags to 36 remained optimal to ensure satisfactory dynamics were captured in the long-term component.

5.4.2 Estimation Strategy

Overall, three different specifications were employed. The specifications differed with respect to the characterisation of the long-term variance component, τ_t, to gain a better understanding of the factors influencing the long-term component of the volatility of corporate bond returns. The equation for the short-term variance, g_{it}, remained unchanged. These three specifications was presented to examine how the long-term variance is explained by historical RV as well as by the macroeconomic and financial variables included in the specifications.

The first specification to be estimated applied the monthly RV in the long-term component of the variance. Therefore, there were no macroeconomic or financial variables in this specification. RV was used exclusively in the long-term component of the variance, as defined by the MIDAS equation, τ_t, as defined in Equations 37 and 38. This conforms with prominent papers on this topic (Engle, Ghysels & Sohn, 2013; Asgharian, Hou & Javed, 2013).

The second specification included the level of low frequency macroeconomic or financial variable to the MIDAS equation to examine the effects of these variables on the long-term variance. The form of this specification allowed it to denote basic formation explained by the macroeconomic or financial variable.

The third specification relied on the inclusion of the volatility of the macroeconomic and financial variables to the long-term component of the MIDAS equation. Following Asgharian, Hou and Javed (2013), the squared first difference of each of the macroeconomic or financial variable was included as a measure of the variance. These specification results are presented in section 5.6.1.

The variables used in the empirical analysis are described in the following subsections. The variables were separated into macroeconomic and financial variables for ease of reference and to differentiate the type of information available to market participants. For each variable, a short motivation is provided to support that variable's inclusion in the analysis.

5.4.3 Low Frequency Variables

A key objective of this chapter is to understand the behaviour of corporate bond return volatilities by examining the change in percentage of weekly total bond returns. A primary outcome of interest was the role and influence of economic fundamentals and their volatilities on total bond returns. The variable selection for this chapter was informed by Engle, Ghysels and Sohn (2013), Girardin and Joyeux (2013), Asgharian, Hou and Javed (2013), Conrad and Loch (2015), Conrad and Kleen (2020), and Nieto, Novales and Rubio (2015). The main macroeconomic variables of interest were economic growth, inflation, and exchange rates. Schwert (1989) was one of the first authors in this strand of literature to include economic fundamentals when investigating the role of macroeconomic variables on stock market volatility, specifically focusing on 'real economy' variables. Exchange rates were included because the index composition comprises foreign currency denominated corporate bonds, implying that prevailing exchange rates should contain useful information with respect to foreign currencies. Given that the bond index is constructed of foreign currency denominated bonds, the US real exchange rate was used rather than the South African real exchange rate. The inclusion of exchange rates was important because the bond indices analysed in this thesis were derived from dollar-denominated corporate bonds issued by listed South African companies. Lastly, the inclusion of interest rates was justified as it is representative of financial time series.

Ultimately four macroeconomic and four financial indicators were selected as the low-frequency variables. The following low-frequency macroeconomic were used:

- Real GDP growth, proxied by monthly industrial production;
- Inflation, given by the monthly changes in the seasonally adjusted consumer price index (CPI; SAInf);
- Exchange rate is the US real effective exchange rate (USREER); and
- US Economic growth, proxied by monthly industrial production (USIP).

The following financial variables were used:

- 10-year US Treasury bond yields (level);
- Slope of the yield curve, measured as the yield spread between a 10-year bond and a three-month Treasury bill, US Interest rate (Slope);
- Moody's BAA-AAA corporate bond spread differential (Default); and
- JSE All Share Index USD total returns (JSEALLR).

Each of these indicators is discussed further in the following subsection.

5.4.3.1 South African Industrial Production

Real GDP growth is typically released on a quarterly basis in South Africa. As all the other low-frequency variables are released monthly and industrial production closely tracks and is highly correlated with real gross domestic production, industrial production was used to proxy real GDP. Therefore, industrial production serves as a proxy for real gross domestic production, which is in keeping with international literature.

5.4.3.2 Inflation (SAInf)

The monthly changes in the seasonally adjusted South African headline CPI was used as the primary measure of inflation in the model. The level of inflation was measured as the logged first difference of the index. South African consumer inflation closely tracks producer inflation and is released with more certainty on a monthly basis. Inflation was useful as it closely corresponds to changes in production costs where

South African research shows producers consistently pass on increases in production costs to consumers rather than absorbing those costs.

5.4.3.3 Real Effective Exchange Rate for the United States (USREER)

The real effective exchange rate measures the weighted average of a country's currency relative to an index comprised of a basket of the major currencies of main trading partners. The USREER was used to capture currency effects in the model since the US dollar has historically functioned as the reserve currency of the world, US-dollar denominated bonds comprise the majority of foreign currency issues included in this thesis, and all bond returns were converted to US Dollars.

5.4.3.4 Industrial Production for the United States (USIP)

USIP was included as a measure of global productivity as all the bonds were denominated in foreign currency and not local currency, making it susceptible to influences from the US economy. These impacts can be captured through a measure of USIP, which can also capture growth effects in developed economies around the world.

5.4.3.5 10-year US Treasury Bond Yields (Level)

The nominal yield on 10-year US Treasury bonds was used as a proxy for the global risk-free rate and to measure the level of global interest rates.

5.4.3.6 Term Spread (Slope)

The slope of the yield curve was measured as the spread between the bid for a 10-year US Treasury bond and a 3-month Treasury bill. Within the finance literature, the slope of the yield curve is often used and interpreted as a leading variable for business cycles and is often used a predictor of economic activity within financial markets. This is one of two state variables used in the empirical analysis.

5.4.3.7 Moody's BAA-AAA Corporate Bond Spread Differential (Default)

The default premium was the other state variable used in the analysis. It was calculated as the difference between Moody's BAA and AAA corporate bond yields of the same maturity. The variable measures default risk that other contributions (see Asgharian, Hou and Javed (2013) and Nieto, Novales and Rubio (2015) to the asset pricing literature found to be significant to partly explain corporate bond returns.

5.4.3.8 Johannesburg Stock Exchange All Share Index Returns (JSEALLR)

An important question arising from the finance literature is the nature of the relationship between stock and bond return volatilities. Limited research exists on this topic, especially in a developing country context, and even less in a South African context. To investigate whether any relationship exists, an indicator variable for the JSEALLR index was included in the empirical analysis.

5.5 Preliminary Evidence

The economic rationale for using a GARCH-MIDAS model was to cater for the data challenges and constraints that are commonly encountered in developing countries like South Africa. However, before proceeding with model specifications, the suitability of the GARCH-MIDAS methodology was tested for robustness against estimation specifications that were previously used to address volatility clustering in listed capital markets. More specifically, before adopting the GARCH-MIDAS approach, the underlying data was interrogated through a GARCH (1,1) model. This section therefore assesses the robustness of the GARCH (1,1) model and compares the fit of the model relative to the GARCH-MIDAS specification used.

5.5.1 Pre-checks

To continue with either the GARCH (1,1) or the GARCH-MIDAS approach, pre-checks of the underlying data first needed to be conducted. The following steps were taken to test that the data meets the requirements for the use of GARCH models.

- The data was tested for the presence of a unit root using the augmented Dickey-Fuller (ADF) test. ADF tests were run on all the time series to test for the presence of unit roots and to ensure stationarity of the data. All the time series were found to be stationary, and the ADF tests rejected the null hypothesis of the presence of a unit root in the data.
- The Ljung-Box test was used to test for autocorrelation. The squared residuals were examined for autocorrelation, and if the autocorrelation had disappeared, it may have been concluded that the GARCH effect has been captured to a satisfying degree (Engle, 2001). The results of the Ljung-Box test rejected the presence of serial autocorrelation in the residuals.
- The data was further tested for ARCH effects. The results confirmed the presence of ARCH effects, necessitating the use of a GARCH model as asset returns were not constant over time. The variance of asset returns was not constant over time either, displaying volatility clustering at different time periods. This can be observed in Figure 21, which shows the weekly bond returns over time.

Figure 18 shows the weekly log corporate bond returns for the period 1 January 2008 to 31 December 2019. The graph shows the persistence in volatility and visually confirms that volatility clustering was present in the weekly corporate bond returns. Similar to the stock market volatility shown in Schwert (1989), Figure 18 and Figure 19 illustrate volatility clustering where bond market return volatility was higher during recessions compared to periods of economic expansion. This was observed in the 2009 and 2016 periods.

Figure 19 shows the monthly RV for the period 1 January 2008 to 31 December 2019. As expected, the graph shows the same patterns were observed in the data compared to Figure 21, including the presence of volatility clustering, especially noticeable in 2009 and 2016. The 2009 spike in bond returns and RV can be explained by the spill over of the 2008 Financial Crisis into South African domestic markets. While 2016 also shows a spike in bond returns, it is not associated with a domestic recession. Instead, the slowdown in China affected global capital markets in terms of declines or drawdowns in asset prices, spilling over into South Africa.[4]

These pre-checks confirmed that a GARCH methodology was the most appropriate in the presence of volatility clustering. Based on this, and in the spirit of Nieto, Novales and Rubio (2015), it was also appropriate to use the GARCH (1,1) model as a robustness check for the newer GARCH-MIDAS model. As the model of choice for the empirical analysis remained the more advanced GARCH-MIDAS model, the next subsection examines key econometric model specification criteria from the GARCH (1,1) specification against the GARCH-MIDAS specification to identify the econometrically superior model.

Figure 18: Weekly log returns

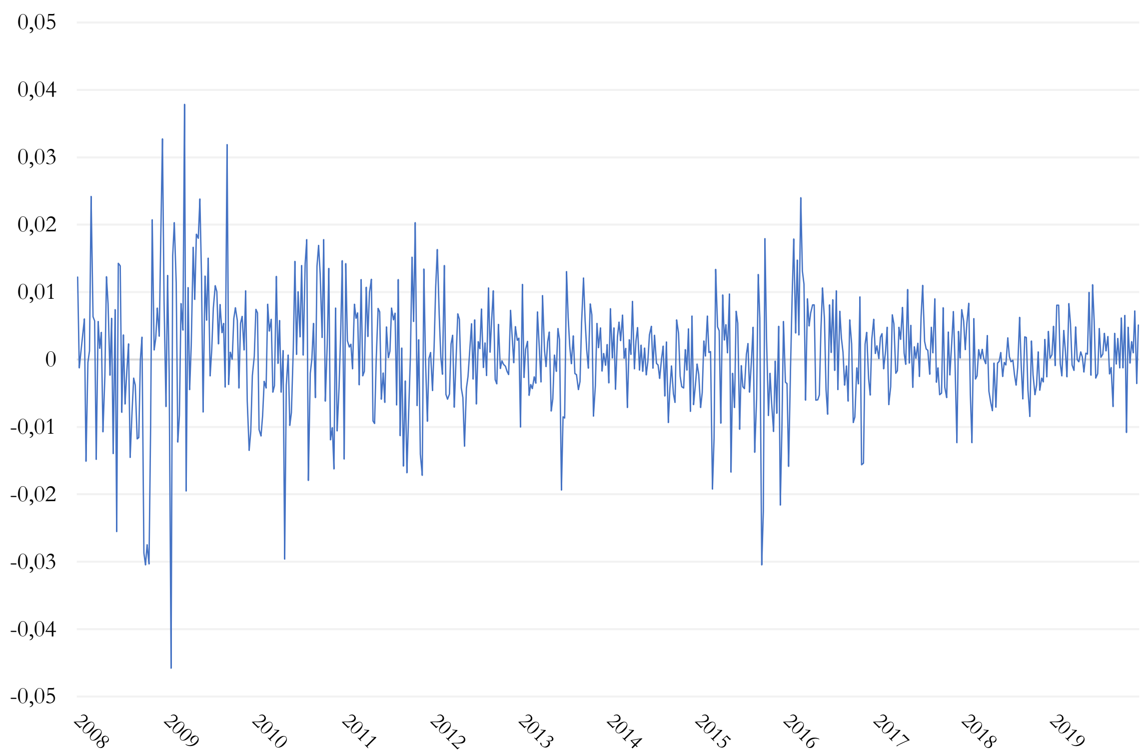


Figure 18 shows weekly log corporate bond returns from 2008 to 2019.

[4] Given that South Africa is a resource-led economy and China accounts a meaningful percentage of basic materials demand, the country tends to be particularly affected during these periods.

Figure 19: Plot of monthly RV

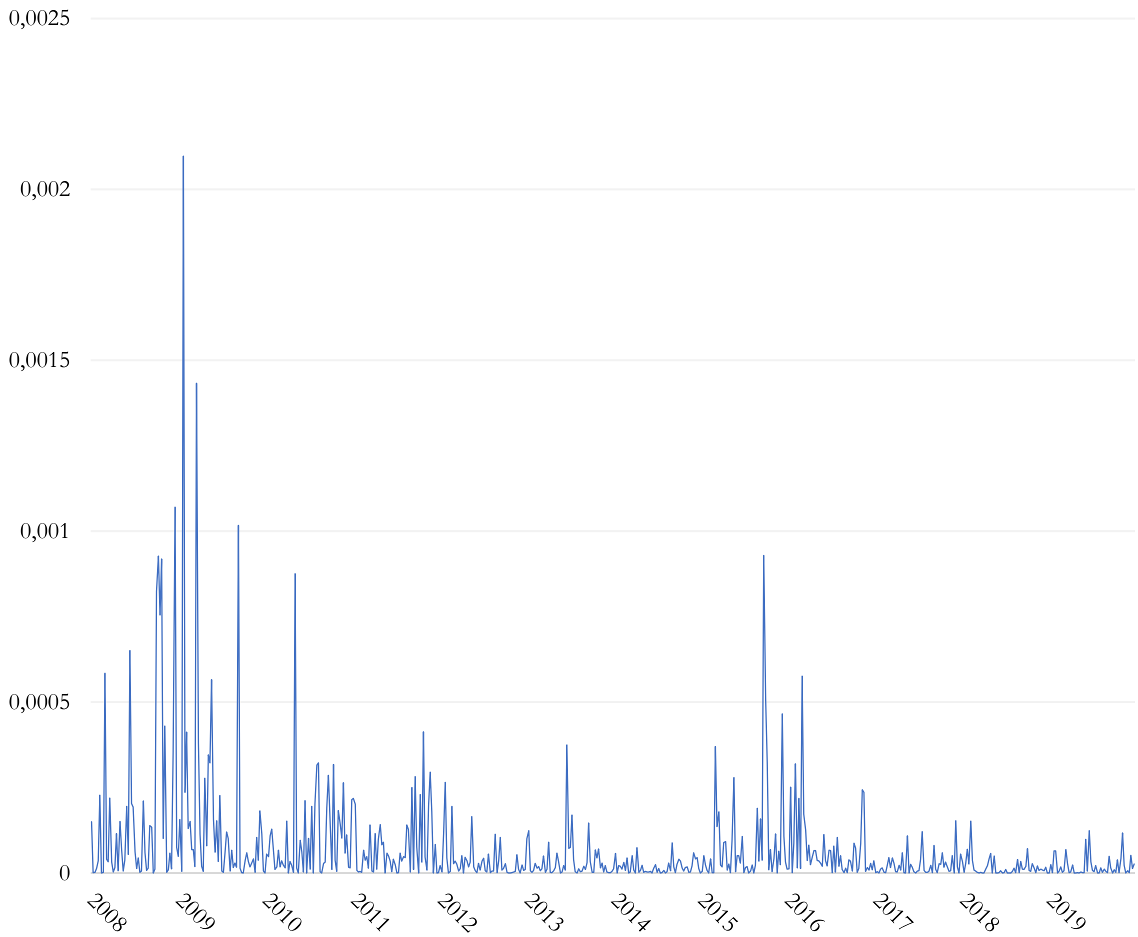


Figure 19 shows the plot of monthly RV from 2008 to 2019. RV is calculated as the squared returns as given by equation 38.

5.5.2 GARCH (1,1)

Prior to the emergence of GARCH-MIDAS models, GARCH (1,1) was the benchmark model used to conduct empirical analysis when financial time series data displayed persistence in volatility or volatility clustering. Section 5.4 showed that the GACRH (1,1) model is embedded in the GARCH-MIDAS framework as the underlying process around which short-run dynamics are observed. Andersen and Bollerslev (1998) provide further evidence for the continued use of GARCH (1,1) in the modelling of financial data with volatility clustering, showing that consistent with earlier literature, the GARCH (1,1) model continues to perform at very high levels. This supports the use of the GARCH (1,1) framework as a good model for evaluating the robustness of the findings in the context of this thesis.

In evaluating the performance of different models, studies typically apply one or two evaluation measures. It is often the case that one model does not dominate all other models across a single chosen measure. A common way to overcome this problem is to choose more than one evaluation measure across which to compare model performance. In this chapter, the models were compared across three criteria to identify the preferred model. The chosen criteria were the log likelihood, the Akaike information criterion (AIC), and the Bayesian information criterion (BIC) because the analysis focused on predominantly in-sample estimation. Better-fit models are those with higher log likelihoods and lower AIC and BIC criteria. The models were compared across two specifications, namely the RV specification and the volatility specifications of the macroeconomic and financial factors, to confirm the pattern of results and identify the optimal model.[5]

Table 9 shows the high-level results for the GARCH (1,1) and GARCH-MIDAS models. Across all three criteria, namely the log likelihood, AIC and BIC, the GARCH-MIDAS model outperformed the GARCH (1,1). The better-fit model, which in the case was GARCH-MIDAS model, is highlighted in grey in the table.

Table 9: Comparison of GARCH (1,1) and GARCH-MIDAS mktcap models (in-sample)

Measure		*Log Likelihood*	*AIC*	*BIC*
Returns	GARCH (1,1)	2103.89	1396.6	1409.90
	GARCH-MIDAS	2821.69	921.35	947.98
IP	GARCH (1,1)	-524.75	1048.66	1046.44
	GARCH-MIDAS	-451.23	914.47	941.10
Level	GARCH (1,1)	-524.79	1048.58	1046.36
	GARCH-MIDAS	-447.83	907.67	934.30
Slope	GARCH (1,1)	-524.84	1048.69	1046.47
	GARCH-MIDAS	-452.55	917.09	943.73
Default	GARCH (1,1)	-524.80	1048.61	1046.39
	GARCH-MIDAS	-450.76	913.51	940.15
SAInf	GARCH (1,1)	-525.47	1049.93	1047.71
	GARCH-MIDAS	-454.37	920.75	947.38
JSEALLR	GARCH (1,1)	-525.36	1049.72	1047.50
	GARCH-MIDAS	-448.62	9009.23	935.87
USREER	GARCH (1,1)	-524.85	1048.69	1046.48
	GARCH-MIDAS	-452.22	916.44	943.08
USIP	GARCH (1,1)	-524.93	1048.85	1046.63
	GARCH-MIDAS	-454.76	921.51	948.15

[5] The level specification was not tested as seminal literature shows that volatility specifications outperform level specifications.

Note: The table shows the log likelihood, AIC, and BIC for each model. For log likelihood, higher values indicate better-fit models. For AIC and BIC, smaller values indicate better-fit models. In each instance above, the GARCH-MIDAS model was preferred to the GARCH (1,1) model based on the three criteria. The better-fit model for each macroeconomic variable is indicated by the grey bar.

Across both the RV and volatility specifications, there was supportive evidence that the GARCH-MIDAS model was the more appropriate model to use to examine the influence of macroeconomic and financial factors on total corporate bond return volatility. Notwithstanding the econometric support for the model, the lack of data integrity in terms of both availability and frequency lend further support to using a GARCH-MIDAS approach in less developed capital markets like South Africa. The rest of the analysis proceeds using the GARCH-MIDAS model.

5.6 Results

The first set of results presented in this section focuses on the GARCH-MIDAS specifications with RV. The discussion focuses on the estimations with the inclusion of the macroeconomic and financial variables described in section 5.4. The single variable GARCH-MIDAS models adopted in this chapter allowed the research to focus on the significance and direction of impact of the macroeconomic variables. For ease of reference, results for both the level variables (logged first differences) and volatilities are described in this section. The final parts of this section discuss variance ratios.

The GARCH-MIDAS model described in section 5.4 was used to fit weekly total bond returns between January 2008 and December 2019. The weights applied in the model are given by the beta-polynomial weighting scheme given by Equation 42. The number of MIDAS lags in the long-run component, given by K, was consistent for each macroeconomic indicator, and equalled to 3 MIDAS years (or 36 months of lags) in each case.

All results presented in this section represent fixed span RV. Comparisons of fixed span RV and rolling window RV yielded consistently similar results across all specifications and variables. Consistent with Engle, Ghysels and Sohn (2013), this shows that there was not much difference in terms of likelihood behaviour between models. Therefore, all empirical results presented have a fixed span RV applied.

The slope parameter θ was the estimated parameter of interest in the model specifications in this chapter because it was the slope parameter of the long-run component and a measure of how the RV and the macroeconomic and financial variables affect the long-run bond market volatility in terms of significance and sign. It is an indicator of past behaviour of the macroeconomic and financial variables on the volatility of total bond returns.

5.6.1 In-sample Estimates of GARCH-MIDAS

5.6.1.1 GARCH-MIDAS with Realised Variance

Table 10 shows the estimates for the first specification using RV only. The parameters of α and β, representing the short-run component, were highly significant at the 1% level. Each α and β were larger than 0 and the sum of α and β was close to 1, which suggests that shocks to the conditional variance will be highly persistent. Overall, this was indicative that the short-term component given by $g_{i,t}$ was significant. The main parameter of interest in Table 10 was θ, representing the influence of the RV on the long-term bond return volatility. Two points are worthy of note. The parameter was very small in size and quite close to zero, but at the same time, was not statistically different from zero. This was unexpected. The results in this specification differed from those of the low-frequency financial and macroeconomic variables, indicating that the various macroeconomic and financial indicators affect long-run bond returns differently that the RV over the specified period under consideration.

Table 10: Parameter estimates of GARCH-MIDAS with RV

μ	a	β	θ	w	m	LLF/BIC
0.042	0.095***	0.861***	0.066	1.892	0.294	455
(0.028)	(0.003)	(0.061)	(0.118)	(5.887)	(0.207)	947

Note: This GARCH-MIDAS specification was estimated with monthly RV and 3 MIDAS lag years. The estimation period covers January 2008 to December 2019. Numbers in parentheses are standard errors. *, ** and *** denote the significance level at 10%, 5% and 1% respectively. Column 7 reports the negative of the log-likelihood value at the optimum and the BIC.

The results for the GARCH-MIDAS estimation are confirmed graphically in the graph showing the comparison of long-term, short-term, and total variance in Appendix A The long-term volatility remained fairly subdued over time, showing little fluctuation when the large spike in total conditional volatility is observed in 2016. Given that the long-term parameter estimate was statistically insignificant, the graph showing the comparison of long-term, short-term, and total variance in Appendix A confirms this lack of statistical relationship as the long-term component remained flat over time. This means that an examination of the impact of macroeconomic and financial variables becomes more important to understand the factors that may drive bond return volatility. This is done in the next section.

5.6.1.2 GARCH-MIDAS: Market Capitalisation Index

The estimates for the GARCH-MIDAS parameters for the mktcap index by level and volatility are presented in Table 11, which are representative of Equations 39 and 40. Each row represents a different macroeconomic or financial variable. The mktcap index represents a hard foreign currency bond return index and is comparable to equity market return indices in its construction and design (see Chapter 4). The reported estimated parameters were given by the set $\Theta = (\mu, \alpha, \beta, \theta, w, m)$, with standard errors in parentheses. The negative of the log-likelihood function and the BIC are also reported in the last column of Table 11. The top half of the table presents the estimation results for the level specifications with the macroeconomic or financial variables, and the bottom half of the table presents the results for the volatility specifications. These correspond to specifications 2 and 3 described in section 5.4.2

Table 11 shows the parameter estimates for the mktcap specifications. A comparison of the point estimates between the level and volatility specifications revealed very similar estimates between the two estimations, with marginally smaller standard errors in the volatility specification. This suggests that the volatility specifications are marginal improvements on the level specification, and better capture the dynamics at play between the macroeconomic and financial variables and total corporate bond returns. Across both the level and volatility specifications, α and β were statistically significant for the macroeconomic and financial variables. In addition, the sum of α and β, representing persistence, was between 0.95 and 0.991, and similar in magnitude to that of Engle, Ghysels and Sohn (2013). The results for the θ parameter are interesting when evaluated by each variable. For the level specification in the top half of the table, the θ parameter was significant for all macroeconomic variables except the JSEALLR. The long-run coefficient was highly significant for the slope and default variables, indicating that these two financial variables plays an important role in bond market return volatilities. The θ estimates tended to have the expected sign where a positive coefficient implies that an increase in that variable increases the volatility of bond returns while a negative coefficient implies an increase in a particular macroeconomic variable results in decreases in bond market return volatility. For example, in the level specification, an increase in SAIP variable, ceteris paribus, led to a decrease in bond return volatility while in the volatility specification an increase in industrial production volatility led to an increase in bond market return volatility. This counter-cyclical business cycle effect is observed in studies on stock market volatility (Conrad & Loch, 2015; Engle, Ghysels & Sohn, 2013) and by the only other bond market study (Nieto, Novales & Rubio, 2014).

The next steps of model estimation involved using macroeconomic volatility, which represents the uncertainty investors may have. These volatilities were used to examine the long-term impact of macroeconomic and financial variables on long-term bond market return volatility. The bottom half of Table 11 shows these estimated volatility parameters. A key feature of the results is that the short-term components, given by α and β, were similar in sign and magnitude to the level specification. Not all coefficients remained statistically significant between the two specifications. However, a notable difference between the results from the levelled variables and the variance estimates was that the sign of θ, the long-term volatility coefficients, changed. For example, SAIP changed sign from negative to positive, for the volatility specification, implying that an increase in SAIP volatility increases bond market return volatility. The SAIP θ coefficient was also substantially larger in the volatility model specification compared to the level model, with improved statistical significance. This result is similar to a key finding by Engle, Ghysels and Sohn (2013) that notes that business cycle uncertainty, given by industrial production volatility, matters for market participants and investors.

The difference in outcomes for the USREER and USIP variables between the two model specifications is another interesting outcome. In the level specification, USREER and USIP both had the expected sign on the long-term slope parament but only USREER was statistically significant at the 10% level.

The GARCH-MIDAS with macroeconomic variables (Appendix A) contains several graphs that help visualise the relationship between total and long-term volatility. The graph showing the GARCH-MIDAS with South Africa inflation (volatility specification; Appendix A) shows the relationship between bond market returns and the volatility of the JSEALLR index. This graph provides evidence of strong co-movement between the bond and equity markets in the long run in the South African context. All other macroeconomic variables, excluding Moody's, display the standard pattern observed in many international papers (Asgharian, Hou & Javed, 2013; Nieto, Novales & Rubio, 2015; Conrad & Loch, 2015).

Table 11: Parameter estimates of GARCH-MIDAS mktcap index

Variables	μ	a	β	θ	w	m	*LLF/BIC*
IP	0.046	0.087***	0.863***	-7.048*	3.896	7.427*	453
	(0.028)	(0.004)	(0.053)	(3.885)	(5.096)	(3.901)	944
Level	0.048*	0.106***	0.863***	-28.932*	50	1.164**	452
	(0.028)	(0.035)	(0.504)	(16.146)	(102.73)	(0.483)	943
Slope	0.045*	0.1***	0.833***	19.302***	1.181	0.033	453
	(0.027)	(0.034)	(0.063)	(7.801)	(1.099)	(0.159)	944
Default	0.039	0.085**	0.88***	66.109**	50.000	-0.166	453
	(0.028)	(0.034)	(0.051)	(26.033)	(120.02)	(0.217)	944
SAInf	0.045	0.071***	0.92***	-29.407*	6.213	2.096	454
	(0.027)	(0.026)	(0.030)	(17.62)	(4.056)	(1.154)	946
JSEALLR	0.045***	0.092***	0.882***	-4.865	5.706	0.507***	453
	(0.028)	(0.035)	(0.047)	(7.026)	(9.426)	(0.147)	945
USREER	0.045	0.105***	0.852***	-1.618*	1.001	2.139**	454
	(0.028)	(0.034)	(0.055)	(0.857)	(0.707)	(0.942)	946
USIP	0.040	0.089***	0.865***	-4.481*	49.976	4.903**	453
	(0.027)	(0.032)	(0.052)	(2.338)	(155.34)	(2.368)	946
Volatility specification							
IP	0.048*	0.075**	0.877***	2413.7***	1.257***	-1.864***	452
	(0.027)	(0.032)	(0.059)	(756.03)	(0.249)	(0.355)	941
Level	0.049*	0.106***	0.869***	14.05*	50.000	0.378***	447
	(0.027)	(0.032)	(0.044)	(7.462)	(43.868)	(0.129)	934
Slope	0.039	0.108***	0.875***	-0.168	50.000	-0.5184	453
	(0.028)	(0.034)	(0.043)	(0.228)	(121.75)	(0.437)	944
Default	0.043	0.091***	0.834***	63.004***	2.061**	0.055	453
	(0.027)	(0.034)	(0.066)	(20.427)	(0.973)	(0.097)	944
SAInf	0.041	0.091***	0.874***	105.21	1.914	-1.389***	454
	(0.028)	(0.032)	(0.047)	(71.432)	(1.711)	(0.426)	947
JSEALLR	0.046*	0.062**	0.932***	120.65***	19.628*	-0.806	448
	(0.027)	(0.025)	(0.028)	(53.816)	(13.132)	(0.263)	935
USREER	0.049*	0.084***	0.880***	2448.7*	20.678	-1.129***	452
	(0.027)	(0.031)	(0.050)	(1351)	(15.857)	(0.281)	944
USIP	0.043	0.103***	0.867***	-3551.4	50.000	-0.649**	455
	(0.028)	(0.034)	(0.048)	(5106.3)	(140.37)	(0.291)	948

Note: This table provide estimates of the GARCH-MIDAS model for the conditional variance of total bond market returns with monthly levels of the low-frequency variables and 3 MIDAS lag years. Weekly data from January 2008 to December 2019 is modelled. The numbers in parentheses are standard errors. *, ** and *** denote the significance level at 10%, 5% and 1%, respectively.

5.6.1.3 GARCH-MIDAS: Fundamental Indices

Tables 20-27 (Appendix A) provide the estimation results for the level and volatility specifications of all five indices broken down by the eight macroeconomic and financial variables. Across all indices and macroeconomic and financial variables, the volatility specifications showed more promising results compared to the level specifications. This is similar to the results for the mktcap index, which overall showed the most promising results of all the indices. This is consistent with evidence from Engle, Ghysels and Sohn (2013).

For the industrial production index (SAIP), the level specification showed that standard negative sign on the θ variable for long-term volatility. The sign changed to positive for all indices when examining the volatility specification. In line with the findings on the mktcap index, an increase in volatility in industrial production was associated with an increase in volatility in bond market returns. This supports international findings of the role of uncertainty in business cycles translating into increased volatility in both equity and bond financial markets (Engle, Ghysels & Sohn, 2013).

An important finding applicable across almost all indices is the role, or lack thereof, of domestic inflation. The results for the level and volatility specifications showed that the level of inflation provided sufficient information to the markets and that the volatility of inflation did not provide additional information to market participants over the long term, as shown by the insignificance of the θ variable in the volatility specifications. While international studies on stock market volatilities found that inflation is significant in the long run (Nieto, Novales & Rubio, 2014), this study found the opposite is true for a developing country setting. Conrad and Loch (2015) similarly found that inflation does not significantly impact stock markets.

For the JSEALLR variable, the results showed that the market capitalisation, book value, and cash flow indices acted similarly while the sales index exhibited different behaviour at the level specification. The θ variable was significant for only the sales and composite indices at the level specification but was significant for all indices at the volatility specifications. This is indicative that across the index types examined in this chapter, the information value of volatility, or more specifically uncertainty, outweighs 'levels' information to the extent that volatility affects market participant behaviour. The volatility specification results showed the overall connectedness and influence between stock market returns and bond market returns.

An interesting outcome was that of the USREER variable. Among the level specifications, the θ variable was significant for the mktcap index only. While the size of the θ coefficient variable varied substantially among all the indices, the mktcap index had the largest θ. The same pattern existed among the volatility specifications where all the fundamental indices had a statistically insignificant θ variable, but the mktcap index displayed both a significant and large θ coefficient.

Overall, the results with macroeconomic and financial variables performed best for the mktcap index relative to the fundamental indices, given by the smaller standard errors.

As previously indicated the data set used for the analysis of corporate bond returns in this study was constrained by both lack and quality of underlying constituent bond data. However, it is potentially valuable to consider the credit worthiness of the underlying constituents at the company specific level. The next section therefore splits the aggregate corporate bond index presented in Chapter 4 into IG and high yield (HY) buckets. This allowed for some comparability with the findings of the seminal corporate bond market contribution by Nieto, Novales and Rubio (2015). This specification was modelled on the volatility of corporate bond returns across these two rating bands.

5.6.1.4 Investment Grade Versus High Yield Bond Returns

Table 12 shows how the volatility of the macroeconomic and financial variables affected the volatility of corporate bond returns across the IG and HY issuer buckets. A few relationships are notable. For the θ parameter, the default variable was significant at the 1% level for both rating buckets. This is consistent with findings at the aggregate level and is the only variable where the IG and HY return volatilities showed similar results. HY issuers showed sensitivity to economic growth when measured by both domestic SAIP and USIP. However, economic variables were less influential and insignificant for IG issuers. It should be noted that the IG set is mostly secondary listings that are less leveraged to the domestic South African economy. These companies generate the majority of their earnings offshore.

An interesting finding was the volatility of HY issuer returns was significantly affected by RV. RV was shown to be insignificant at both the IG and aggregate level. This means that the volatility of current HY returns was affected by historical return volatility. This suggests that bondholders are especially sensitive to past fluctuations in lower quality HY issuers where issuer fundamentals in terms of balance sheet capitalisation and free cash generation are potentially weaker than higher quality IG issuers.

It should be noted that while an attempt was made to capture the impact of ratings on the volatility of corporate bond returns, these results should be interpreted with caution. The lack of granularity in the ratings data suggests that it would be more appropriate to contrast the findings between the above IG and HY segments as opposed to making any inferences with regards to other studies.

Table 12: Parameter estimates of GARCH-MIDAS mktcap index – IG versus HY

Variables	μ	a	β	θ	w	m	LLF/BIC
Investment Grade							
RV	0.043	0.092***	0.864***	0.188	3.357	1.358***	396
	(0.025)	(0.034)	(0.059)	(0.269)	(8.089)	(0.493)	830
SAIP	0.046	0.105***	0.866***	-136.060	50.000	0.868***	395
	(0.025)	(0.034)	(0.048)	(170.840)	(114.58)	(0.267)	830
Level	0.051**	0.107***	0.867***	22.896***	50.000	1.140**	388
	(0.028)	(0.032)	(0.046)	(8.879)	(46.350)	(0.296)	815
Slope	0.040	0.108***	0.878***	-0.17	50.000	0.649	393
	(0.025)	(0.035)	(0.042)	(0.226)	(124.530)	(0.435)	825
Default	0.047*	0.064**	0.890***	168.44***	2.861***	2.137***	391
	(0.024)	(0.027)	(0.052)	(50.965)	(1.018)	(0.323)	821
SAInf	0.042*	0.087***	0.877***	113.730*	1.913	1.676***	395
	(0.025)	(0.029)	(0.046)	(64.622)	(1.588)	(0.384)	829
JSEALLR	0.045*	0.060***	0.935***	141.400***	17.570**	1.069*	388
	(0.023)	(0.022)	(0.025)	(45.391)	(8.083)	(0.600)	813
USREER	0.050**	0.083***	0.883***	2503.000*	24.500	1.372***	393
	(0.024)	(0.029)	(0.048)	(133.400)	(17.600)	(0.275)	825
USIP	0.045*	0.102***	0.870***	-2292.300	49.992	-0.871***	396
	(0.025)	(0.034)	(0.047)	(5026.300)	(237.360)	(3.113)	831
High Yield							
RV	-0.001	0.163***	0.734***	-21.213***	1.985***	-3.278***	407
	(0.004)	(0.050)	(0.059)	(4.267)	(0.545)	(0.280)	776
SAIP	0.007	0.212**	0.692***	-2.24.200***	3.872**	-3.848***	407
	(0.004)	(0.061)	(0.062)	(669.900)	(1.627)	(0.429)	776
Level	0.000	0.156**	0.677***	-30.647	6.406	-4.086***	406
	(0.005)	(0.071)	(0.122)	(31.282)	(7.187)	(0.345)	773
Slope	0.000	0.121	0.652***	0.834	5.314	-4.421***	408
	(0.005)	(0.076)	(0.168)	(1.105)	(12.707)	(0.114)	776
Default	0.000	0.225***	0.719***	-277.710***	5.390*	-2.636***	410
	(0.004)	(0.058)	(0.063)	(97.677)	(2.905)	(0.821)	782
SAInf	0.000	0.136*	0.661***	-17.533	28.373	-4.334***	405
	(0.005)	(0.078)	(0.150)	(19.021)	(72.868)	(0.169)	771
JSEALLR	0.000	0.167***	0.747***	-228.890	5.257	-3.401***	406
	(0.004)	(0.060)	(0.077)	(152.090)	(3.582)	(0.701)	773
USREER	-0.000	0.138*	0.669***	-413.28	50.000	-4.363***	405
	(0.005)	(0.077)	(0.141)	(1144.900)	(232.990)	(0.223)	771
USIP	0.000	0.141**	0.676***	500.070	6.821***	-5.636***	420
	(0.004)	(0.066)	(0.133)	(128.780)	(2.366)	(0.333)	799

Note: This table provides estimates of the GARCH-MIDAS model for the conditional variance of total bond market returns for the IG (top panel) and HY (bottom panel) categories, with monthly levels of the low-frequency variables and 3 MIDAS lag years. Weekly data from January 2008 to December 2019 is modelled. The numbers in parentheses are standard errors. *, ** and *** denote the significance level at 10%, 5% and 1%, respectively.

5.6.1.5 Analysing the Contributions of Macroeconomic and Financial Variables

A natural question arising from the empirical analysis was that of the contribution of the macroeconomic variables to expected volatility. For this reason, as a final step in this analysis, it was important to evaluate the impact of each macroeconomic and financial variable on expected total corporate bond return volatility.

This was done by examining variance ratios, which showed how much a given variable, in terms of the long-term component, contributed to the total variation in a particular GARCH-MIDAS model (Engle, Ghysels & Sohn, 2013). Variance ratios can be viewed as a measure of fit where a high variance ratio implies that a large share of the expected volatility can be explained by the long-term component. Conrad and Loch (2015) highlight that a low variance ratio should not be dismissed as a poor fit of the data as the underlying distribution of the low-frequency data may affect the ratio. The level specifications in this analysis tend to yield lower variance ratios compared to the volatility specifications, which indicates that variables in the level form may not provide sufficient information about a variable, especially in a developing country setting. Rather, variables transformed to provide more nuanced information about its volatility tend to be more informative, especially where long-run analysis is applicable. Variance ratios are calculated using Equation 43 for each model specification with a low-frequency macroeconomic or financial variable.

$$VR\ (X) = \frac{Var(\log(\tau_t^X))}{Var(\log(\tau_t^X \cdot g_{i,t}^X))} \tag{43}$$

Table 13 presents the variance ratios for both the level and variance specifications for the mktcap index. The results were generally consistent with the conclusions in Table 11 and the specifications listed in Appendix A. Similar patterns were observed when examining the contribution of economic and financial sources in the long run. This is indicative that the variation analysis provided useful information on the long-term component and hints at a more defined relationship between stock and bond markets, especially in a developing country context.

Table 13: Variance ratios – Mktcap index

Variables	Variance Ratio *Level*	Variance Ratio *Volatility*
RV	3.07	4.36
IP	12.54	12.87
Level	8.85	15.32
Slope	10.74	9.13
Default	7.95	19.59
SAInf	5.77	5.41
JSEALLR	5.88	32.91
USREER	16.78	4.72
USIP	3.67	0.7

Note: The table shows variance ratios measured in percent. The variance ratios are calculated by the formula 100*Var(log τt)/Var(log τtgt)

It is important not to interpret the percentages of the variables in an especially linear manner. Comparing their relative contribution to variance is a more appropriate way to consider the evidence. JSEALLR, for example, should be interpreted as the most meaningful variable impacting the long-term volatility of corporate bond returns as compared to the USIP, SAInf and RV, which have low explanatory power.

Each macroeconomic and financial variable was run independently in a single GARCH-MIDAS regression against the volatility of corporate bond returns. This was done to isolate the influence of the long-term component of each of these variables against total volatility. In other words, the purpose was to ringfence the long-term component and disentangle its relative influence from the short-term component to explain long-term volatility of corporate bond returns. This allowed for an interpretation of how meaningful the potential long-run is.

The results for the variance ratios were interesting. While the USREER variable contributed over 16% towards the long-run component in the level specification, the JSEALLR variable contributed the most when looking at the volatility specification. The JSEALLR variable's contribution to the level analysis was rather low at 5.88% but jumped to 32.90% for the volatility specification. This is indicative that the volatility of the JSEALLR explained a sizeable amount of the total variation. The level of the JSEALLR suggested a slow-moving and smoother process, yielding a smaller variance ratio compared to the volatility specification. Other important contributors of the volatility specification included the level, slope, default, and SAIP variables.

5.7 Limitations

Ratings data is relatively limited at the bond level for the constituent issuers comprising the corporate bond indices used in this thesis. As highlighted in the previous chapter, the analysis of asset pricing in developing markets can be constrained by both the availability and quality of data. This can be especially pronounced when those regions are still emerging, with relatively new listings that trade in over the counter (OTC) markets where price discovery and liquidity are typically less transparent than in developed market peers. Equity market data tends to be relatively more widely available than corporate bonds, which potentially partly explains why the asset pricing literature, specifically on return volatility, is skewed towards stock markets. The lack of rating data at the bond level was partly mitigated in this chapter by modelling credit ratings at the underlying issuer level, with long-term foreign currency ratings being used to differentiate between IG and non-IG issuers.

The length of time series for the corporate bond indices used in this chapter was relatively short, covering the 12-year period from January 2008 to December 2019. This was an outcome of the hard currency listed corporate bond universe being exceedingly small and narrow prior to the 2008 financial crisis. Because no comparative index exist and indices needed to be constructed, the December 2019 cut-off was used to facilitate adequate time for data collection, cleaning, interpretation, and deduction. The specific constraint in this particular chapter is that the number of MIDAS lag years was set to 3 for the model specifications used in the analysis. While this is consistent with the literature, it was not ideal to lose observations based on the relatively short length of the data time series.

5.8 Conclusion

The objective of this chapter was to investigate the impact of macroeconomic and financial variables to explain the long-term volatility of foreign currency denominated corporate bonds in South Africa. Using a GARCH-MIDAS framework and both the level and volatility of each variable, only three of the eight macroeconomic and financial variables were shown to influence total corporate bond returns. These variables were SAIP, Moody's default, and the JSEALLR index. The level and US real exchange rate were also statistically significant in the long run, albeit at the 10% level of significance. The results were surprisingly stable when compared to studies on stock market volatility. In general, the results suggested that real macroeconomic and financial variables play a strong role in explaining the volatility of total bond returns. This is an encouraging finding because it reinforces the connection between bond markets and the real economy. Interestingly, the main nominal macroeconomic variable of inflation was statistically insignificant to explain total bond return volatility in the long run. This is a similar finding to that of Conrad and Loch (2015), who also found no significant relationship between inflation and the stock market.

The findings in this chapter highlight the role of the macroeconomy as a driver of bond return volatility. Conrad and Loch (2015) found that macroeconomic conditions play a role in explaining long-term stock market volatility. With recent financial crises calling for a better understanding between economic conditions and financial market volatility, both stock and bond markets, this chapter makes an important contribution to anticipating how changes in the macroeconomy affects bond return volatility. The results in this chapter showed that key macroeconomic indicators, such as industrial production, influence total bond returns in the long run, and these results are in line with prominent papers (Asgharian, Hou & Javed, 2013; Conrad & Loch, 2015).

The variance ratio analysis aided the economic interpretation of the study. Based on the marketcap index, the main index studied in this chapter, the JSE All Share equity returns explained and accounted for almost one-third of the bond market's long-term volatility. Similarly, the default variable explained almost 20% of the volatility and the SAIP explained just more than 10%. Together these three variables explained a significant proportion of the long-term volatility of bond returns in South Africa.

The finding that JSEALLR explained almost one-third of long-term volatility is important, especially for an economy like South Africa where the bond and equity markets are very accessible and liquid. The results of this chapter gave rise to the question addressed in Chapter 6, which identifies the JSEALLR index, representative of equity markets, as the most informative variable of long-term bond volatility. The variance ratio analysis showed that stock market volatility explained up to 32.9% of long-term corporate bond return volatility, highlighting that equity markets contain valuable information with respect to bond market performance. This naturally leads to the question of causality: Do bond markets granger cause equity markets or do equity markets granger cause bond markets? This question is investigated in the next chapter.

Chapter 6 | Examining the Co-movement Between Hard Currency Corporate Bonds and Listed Equity in South Africa

6.1 Introduction

The previous chapter showed a relatively strong relationship between corporate bonds and equity returns in the long run as evidenced by the GARCH-MIDAS model specifications for both the volatility and variance ratio analysis. Specifically, the variance analysis showed that the total return volatility of the domestic equity market, the Johannesburg Stock Exchange (JSE) All Share index, had the highest explanatory power for the volatility of the aggregate corporate bond index. The JSE All share index was demonstrated to account for approximately one-third of the variation of corporate bond returns in the long run. This has important implications for market practitioners, including research analysts and fund managers. Understanding the influence of South African listed equities on the volatility a corporate bond opportunity sets, which has historically traded with little transparency, can potentially contribute to more robust investment research, portfolio construction, and risk management processes.

Chapter 5 provided evidence of the macroeconomic and financial factors that affect the volatility of aggregate returns. However, the analysis did not examine the level of aggregate returns, specifically with regards to the interaction between corporate bonds and equity at the aggregate index level and does not reveal the exact behaviour between bond and equity returns, nor does it indicate whether one asset class leads or precedes another. A question that arose from the previous chapter was whether the interaction between bonds and equity displays evidence of any causal or predictive relationship that would further improve the ability of market practitioners to calibrate risk and returns on a cross-asset basis. The purpose of this chapter is to investigate that relationship, and specifically, to consider the co-movement between corporate bond and equity returns through a lead-lag framework.

Bonds and equities both represent claims on a firm's assets. Information that affects expected returns or the variance of returns in either market should impact on and be reflected in both the corporate bond and equity markets. Finance theory suggests that in the absence of market frictions, and assuming both markets are informationally efficient, a contemporaneous relationship between bond and equity returns should theoretically be observed (Tolikas, 2018). If the equity market is more efficient than the bond market, equities reflect information faster than bonds. This implies that equity returns will have predictive power for future bond returns, and in turn, this will establish a lead-lag relationship between the returns of the two asset classes.

The relative efficiency between bonds and equity in pricing market information has attracted meaningful attention in developed markets over the years. Numerous studies demonstrates global corporate bond markets to be relatively less transparent, but motivations for its comparative inefficiency are not especially conclusive. The majority of previously conducted studies focus on corporate debt markets in developed countries while the emerging market literature is not particularly diverse. Despite significant improvements in the transparency of corporate bond markets through regulation and initiatives like the Trade Reporting and Compliance Engine (TRACE), Downing, Underwood and Xing (2009) still assert that the corporate bond market in the US is less informationally efficient than the equity market.

Numerous earlier studies show evidence of returns from listed equities leading listed corporate bond returns, which provides support for the argument that the equity market is relatively more price efficient than the corporate bond market. These studies include Kwan (1996), Gebhardt, Hvidkjaer and Swaminathan (2005), Hong, Lin and Wu (2012) and Downing, Underwood and Xing (2009). Other authors (Hotchkiss & Ronen, 2002; Ronen & Zhou, 2013; Bittlingmayer & Moser, 2014) found contrasting results with evidence that equity markets are not significantly more efficient than corporate bond markets by showing that that equity returns do not systematically lead corporate bond returns. Earlier seminal studies from Blume, Keim and Patel (1991) and Cornell and Green (1991) also assert that despite high yield (HY) bonds being very sensitive to equity price movements, they found no support for either leading or lagging equity returns having a significant effect on current corporate bond returns.

The contrast in findings is largely attributed to the corporate bond market being relatively less transparent than the listed equity market, and Alexander, Edwards and Ferri (2000), Hotchkiss and Ronen (2002), and Downing, Underwood and Xing (2009) all cite bond market opacity as a constraint to better price discovery. With specific regard to HY corporate bonds, all the aforementioned authors argue that conflicting findings are also partly related to the especially complex relationship that show the returns on more speculative bonds to be both comparable and distinctly different to the returns on listed equities.

Another important reason provided by some authors for the inconsistency in establishing a lead-lag relationship between corporate bonds and equity is the periodicity of the time-series data used in studies. Hotchkiss and Ronen (2002) use very short sample periods of both daily and hourly data, and Tsai (2014) also uses short data observations of 5-minute intervals. Both Downing, Underwood and Xing (2009) and Hong, Lin and Wu (2012) use daily data, while one of the earliest seminal contributions by Kwan (1996) uses weekly price points to examine the relationship. A more recent study by Bittlingmayer and Moser (2014) uses monthly data points to examine the long-run relationship between equities and corporate bonds, which follows from the earlier contribution by Campbell and Taksler (2003) that use the same data periodicity.

Bond and equity markets not only have structural differences in terms of liquidity but also by the nature of the investor base. Previous contributions to the literature show that institutional investors are relatively more represented in the bond market than the equity market (Bessembinder et al., 2009; Chen, Wang & Wu, 2011; Ronen & Zhou, 2013). Hong and Warga (2002) found a greater level of sophistication for institutional investors trading bonds in the relatively less transparent over-the-counter (OTC) market. Lower corporate bond market liquidity can also result in a relatively larger percentage of bonds being purchased on a longer term hold-to-maturity basis than could be expected to be observed for listed equities.

Institutional investors are also generally professional investors with greater access to market information who place greater primacy on earnings announcements than non-professional retail investors. Ederington and Yang (2013) found significant evidence of changes in listed bond prices following the dissemination of earnings, and Easton, Monahan, and Vasvari (2009) also found that improved liquidity and trading occurs in the bond market around the time of earnings announcements. These findings theoretically support an argument for relatively more efficient bond markets during interim earnings announcements and suggest that relatively more professional bond markets could lead price discovery ahead of equity markets.

The aim of this chapter is to examine the informational efficiency between hard currency non-Rand denominated corporate bond markets and equities issued by the same firms. The objective was to analyse the co-movement of these assets and determine the aggregate index level through a vector autoregression (VAR) methodology and interrogate the findings for lead-lag effects using a Granger causality test. In addition, the analysis was further segmented by equity listing type (primary or secondary), sector, issuer type, duration exposure, and issuer rating.

To the best of the author's knowledge, this study is the first contribution to the global emerging market literature that attempts to examine the co-movement of listed emerging market corporate bonds and equities in a lead-lag framework.

This chapter contains findings or relevant information from the perspective of a market practitioner, and specifically, a fund or portfolio manager managing multi-asset portfolios. The lead-lag relationship between corporate bond and equity markets shows how efficient one market reflects new information relative to the other and could potentially flag or identify investment risk in one asset market relative to another should either market be demonstrated to be relatively more efficient and exhibit lead-lag effects.

The analysis shown in this chapter found evidence of a lead-lag relationship between corporate bond and equity returns at the aggregate level. Empirical analysis at a stratified level revealed varying patterns that depend on the type of stratification investigated. Equity returns led bond returns for investment grade (IG) bonds, but the same relationship did not hold for HY bonds, where the relationship was found to be bidirectional. With respect to listing, both primary and secondary listings were strongly bidirectional. The findings also showed that equity returns led bond returns for low duration bonds. The issuer-level rating results should be interpreted relatively prudently given that the sample size was not considered fully representative of the underlying fundamentals of the issuer. Without having specific detail about why bonds are either unrated or have had ratings withdrawn in the past, it would be spurious to make inferences about the direction and strength of those relationships without further examination.

The remainder of this chapter is organised as follows: Firstly, the related literature is reviewed; secondly, the methodology is discussed; next, the data and descriptive statistics are discussed; then the following section presents, discusses, and interprets the results; the next section outlines constraints and limitations; and the last section concludes the chapter.

6.2 Literature Review

The hypothesis that listed equity markets are relatively more efficient than corporate bond markets, and specifically, that equities typically lead changes in returns between the two asset classes have been studied and evidenced at both the aggregate industry and firm-specific level. In one of the earlier seminal studies, Kwan (1996) uses weekly firm-level data obtained from Merrill Lynch bond dealers to examine the informational efficiency of securities issued by the same firm over the period 1986-1990. He examines the correlation between US stocks and corporate bond returns by regressing changes in bond yields on contemporaneous, leading, and lagging equity returns of the same firm.[6] Furthermore, he also tests the weekly changes in corporate bonds yields by running pooled time-series regressions against US Treasury bonds of the same maturity. The author shows that lower quality non-IG bonds exhibit pricing behaviour more akin to listed equities than to higher quality IG bonds with AAA credit ratings, which are priced more like risk-free government bonds instead of listed equities or lower-rated corporate bonds. He concludes that bond returns have no predictive power for equity returns but finds that equity returns lead changes in corporate bond yields at the firm-specific level. These findings are primarily attributed to the mean as opposed to the variance of the value of the issuing firm's assets. The author's conclusions are supported and consistent with earlier results by Blume, Keim and Patel (1991) and Cornell and Green (1991).

An important contribution to the literature by Downing, Underwood and Xing (2009) uses even shorter data at both intraday and daily frequencies. The authors use a VAR analysis to study the relationship of high frequency returns between equities and corporate bonds in the US at the firm-specific level. They examine intraday transactional data from National Association of Securities Dealers (NASD) for the two asset classes and demonstrate that despite attempts to improve the transparency of bond pricing, the US equity market is relatively more informationally efficient than the US corporate bond market. The authors also demonstrate that data periodicity is significant in estimating the predictive power of equity markets. Using daily data, they show that US equity markets are more informationally efficient by finding US equity returns leading US corporate bond returns, and most importantly, that this finding is consistent across all bond rating classes from IG to HY convertible bonds with conversion options deep in the money. However, using intraday hourly data, the authors only found evidence of a significant intertemporal relationship between lagged equity returns and bond returns for more speculative, non-convertible HY bonds rated BBB and below. Their conclusion is that the listed corporate bond market is less informationally efficient than the equity market. The authors found evidence of significant cross-sectional dispersion to the extent that bonds tranched differently in the capital structure of a firm but allocated the same credit rating do not necessarily exhibit the same behaviour as the other instruments in the broader or aggregate credit rating category.

[6] The term stock/s is used interchangeably with the term equity.

Hong, Lin and Wu (2012) also use daily returns on transaction-based US index data that aggregates TRACE-based price movements. Their study investigates the predictability of corporate bond returns by focussing on serial dependence and causality tests. At the aggregate industry level, they found evidence of significant serial and cross-serial dependence in corporate bond returns. More specifically, the authors found strong evidence that returns on both HY (non-IG) and IG bonds can be predicted by lagged aggregate equity returns. The leading relationship of equities over bonds is shown to be more significant for HY bonds with limited evidence of bonds returns having any predictive power on equities. Interestingly, the study does find some evidence of bond returns leading equity returns at the aggregate index level when data from the 2008 Financial Crisis is included in the sample.

Alexander, Edwards and Ferri (2000) also use daily data to examine the relationship between HY bond returns and listed equities at the firm-specific level in a pre-TRACE study between 1994 and 1997. They found evidence of an economically weak but significantly positive correlation between HY bonds and excess equity returns.

A more recent study by Tsai (2014) investigates financial market informational efficiency by examining the co-movement between corporate bonds and US equities. The author uses Granger causality tests to specifically consider the lead-lag relationship between the two asset classes and finds evidence of the US equity markets adjusting faster than US corporate bond markets to non-consensus earnings announcement (or earnings surprises) than the US corporate bond market. An important contribution to the literature from this study is that the sample bond data comprised exclusively of actively traded issues by institutional investors. Her findings show that by using intraday observations (spaced 5-minute apart) and by explicitly controlling for these larger institutional bond trades, speculative HY bonds have higher predictive power than IG bonds to explain equity returns.

Campbell and Taksler (2003) use monthly data from credit rating agencies, Standard and Poor (S&P), and Moody to study the lead-lag relationship between bond and equities at both the firm-specific level and aggregate market level in the US. They regress the corporate bond yield spread against the lagged average and standard deviation equity returns of both the bond issuing firm and aggregate equity portfolio. They found significant evidence that US equities lead US corporate bonds at the firm-specific level when using time-series data between 1963 and 1999. Furthermore, their study also found that equity volatility is an important determinant of corporate bond spreads at the firm-specific level. This finding is especially significant for firms with high gearing levels as measured by long-term debt to total assets. Their conclusions are that market volatility at the aggregate index level is less important than idiosyncratic variations in the mean and variance of equity returns at the firm-specific level in leading corporate bond returns.

Norden and Weber (2009) investigate both daily and weekly data on the co-movement between a subset of corporate bonds, equities, and credit default swaps (CDSs) from 58 global companies. Their study was conducted over the period from 2000 to 2002 and found evidence of equity returns leading spread changes in both corporate bonds at firm-specific level. An important contribution from the authors is the finding that the strength of the lead-lag relationship is not statistically dependent on firm size but significantly dependent on the aggregate credit rating for the issuing company.

Longstaff, Mithal and Neis (2005) also use a VAR model to study weekly data of US companies to in attempting to examine the lead-lag relationship between equities and corporate bonds. Their study also includes examining the relationship of these two asset classes with CDS spreads. Their main findings show that both US equity markets have predictive power for the corporate bond market. The authors demonstrate that both US equity and US CDS markets are more informationally efficient that the US corporate bond market.

Gebhardt, Hvidkjaer and Swaminathan (2005) examine momentum between listed US equities and corporate bonds using substantially longer frequency data than many of the earlier contributions. The authors use annual data in a pre-TRACE sample between 1973 and 1996 to evidence momentum spill-over from listed equities to IG corporate bonds. Equity returns over the previous year predicts IG corporate bond returns in the current year at the firm-specific level. Companies generating high equity returns over the previous year are shown to earn high bond returns the next year. This finding is not significant for data frequencies less than 12 months.

6.2.1 Other Developed Market Studies

The vast majority of studies investigating the lead-lag relationship and co-movements of listed corporate bonds and equity, at both the firm-specific and aggregate industry level, have been conducted in the US market. In a recent study of the Canadian market, Cao et al. (2017) use monthly firm-level data to study the relative informational efficiency of equities and bonds issued by Canadian domiciled companies. Their analysis explicitly considers the nature of information affecting simultaneous price adjustments between bonds and equity. Their findings show that information relating to the mean of the firms' value is more significant than its volatility to determine contemporaneous changes in bond and equity values. They found that lagged equity returns are strongly correlated to current changes in corporate bond yields. Their analysis also founds a significant but slightly weaker relationship when between current changes in corporate bond yields and leading as opposed to lagging equity returns. This finding supports the argument for informational efficiency in either direction between corporate bond and equity markets but suggests that information flows from the equity side are slightly stronger in pricing in firm-specific information. However, the authors found evidence that in the period after the 2008 Financial Crisis, the bond market has become more efficient in transmitting firm-specific information, which is accentuated during market dislocations.

6.2.2 Corporate Bond Markets Are at Least as Efficient as Equity Markets

A number of more recent studies evidence the explanatory power of listed corporate bonds over equities at both the firm-specific and aggregate industry level. Contributions to the US literature still dominate the subset of empirical studies examining the co-movement of listed corporate bonds and equities. The advent of better pricing efficiency facilitated by TRACE has improved the availability of reliable data but there is a clear absence of any literature on emerging market economies.

Hotchkiss and Ronen (2002) test the informational efficiency of the US equity and corporate bond markets using both hourly and daily data in 1995. They examine bond transaction price summaries returns on 55 HY bonds traded pre-TRACE on the NASD's fixed income pricing system (FIPS). Their study shows no evidence of equity markets systematically leading corporate bond markets. The authors use a VAR model to demonstrate that lagged equity returns do not have any predictive power for current corporate bond yields. They also employ Granger causality tests that further shows that equity returns do not lead corporate bond returns but are also unable to demonstrate the relationship working in the opposite direction with no evidence of corporate bonds returns leading equity returns. Their research found a positive contemporaneous correlation between the two assets classes. This contemporaneous relationship between equities and corporate bonds at the firm-specific level is, however, found to be non-causal in either direction and primarily attributable to the to their joint reaction to common factors. This is consistent with the later findings of Downing, Underwood and Xing (2009). Neither the equity or corporate bond market is therefore found to be more or less informationally efficient than the other in terms of pricing in corporate earnings news. A comparative analysis of pricing errors show support for bond market quality not being weaker than equities. The authors therefore reject the hypothesis that equities lead bonds in pricing and reflecting earnings news at the firm-specific level.

Zhou (2006) uses NASD daily transaction data to study 111 HY bonds TRACE-eligible securities issued by 77 companies between 2002 and 2004. The author uses a VAR model and conducts Granger causality tests to identify pairwise lead-lag relationships between corporate bonds and equities (and options). The author also found evidence to support the hypothesis that current returns on corporate bonds have explanatory power for future changes in listed equity prices. This finding can also be interpreted as lagged corporate HY bonds leading current equity returns. The conclusion supports the corporate bond market being at least as informationally efficient as the listed equity markets and price discovery being improved by informed investors in both markets disseminating new information at the firm-specific level. The conclusions of Zhou (2006) are consistent with the conclusions of Hotchkiss and Ronen (2002) and Kwan (1996) to the extent that equity returns are found to be positively correlated with contemporaneous corporate bond returns. The authors all found evidence to support the thesis that information that influences individual equity and corporate bond returns at the firm-specific level are predominantly attributable to the mean value instead of the variance of the issuing company's assets.

Mao (2012) analyses equity and bond data from the US to assess the extent to which corporate bonds lead equities over the sample period between 2009 and 2011. The sample includes approximately 1 644 US Dollar-denominated bonds issued by 214 US domiciled companies and includes predominantly senior issues approximately evenly distributed across maturity and credit rating. The author found evidence of significant price discovery in corporate bond markets in aggregate, which is demonstrated to be more efficient or pronounced as credit quality declines. In other words, lower quality bonds, as indicated by assigned credit ratings, have higher explanatory power than higher rated bonds for equity price discovery. These findings at the aggregate market level are supported by robustness checks by the author at the firm-specific level.

Bittlingmayer and Moser (2014) consider the co-movement between US-listed securities by regressing equity returns on lagged bond returns between 2002 and 2008. Their results demonstrate the significance of credit quality in explaining the lead-lag relationship. They show that lagged changes in prices of lower-rated HY bonds have predictive power for current price movements in the listed equity. The authors found that more speculative HY bonds are relatively more efficient in pricing negative news information than equities in their sample. The significance of this relationship is exacerbated in companies with high volatility, abnormal or excess returns, and a relatively high issuance of shorter maturity and higher coupon bonds. Another important contribution from this study is the relevance of data periodicity, which numerous authors presents as a possible explanation for contrasting historical results on the co-movement of listed bonds and equities at both firm-specific and aggregate levels. Bittlingmayer and Moser (2014) use monthly data to support their conclusions of the informational efficiency of the bond market.

Ronen and Zhou (2013), examine the OTC corporate bond market to study the informational efficiency of US equities relative to bonds by specifically considering trading patterns and market liquidity. Their analysis also assesses the nature of institutional investors relative to retail investors by using the aggregate Barclays bond indices that only quotes large institutional-sized trades as a benchmark for the study. The authors show that after adjusting for the timing and size of institutional trades and liquidity patterns, the evidence supports equities leading corporate bonds in the OTC market. However, the use of Granger causality tests supports lagged corporate bond returns in the institutional market having predictive power for listed equity returns in the current period.

6.2.3 Studies with Other Listed Asset Classes

Following the introduction of TRACE, a number of studies also focus on the inter-relationship between CDSs with both listed equity and corporate bonds in the context of an informational efficiency, co-movement, or lead-lag framework. While a more detailed analysis including CDSs falls outside the scope of the current study, it was considered important to highlight the relative price discovery evident in the asset class, especially with regard to how previous contributions to the literature document correlations with listed debt and equity.

Longstaff, Mithal and Neis (2005) were the first authors to specifically consider how CDS markets interact with returns on listed US equity and corporate bonds in a lead-lag analysis framework. They found support for corporate bond markets lagging both the listed equity and CDS markets. However, the relationship between CDS and listed equity is found to be inconclusive to the extent that neither asset class exhibits any significant effect of leading the lagged returns of the other from a pricing discovery or market efficiency perspective. The respective correlations with respect to their co-movements are shown to be particularly weak.

This can be contrasted with Norden and Weber's (2004) findings that changes in CDS spreads in CDS markets are inversely related to listed equity returns in European markets. Furthermore, they show that these changes in CDS spreads lag the listed equity returns. The same authors replicate these findings across an international sample of companies in a later study in which Norden and Weber (2009) evidence a significant leading relationship for listed equity returns over changes in CDS spreads. The authors specifically analyse the intertemporal co-movement and lead-lag relationship and found further evidence of equity markets leading CDS markets at the aggregate index level.

Byström (2005) has similar results. The author uses data at the aggregate index level to examine the relationship between listed equity and CDS markets and explicitly considers the lead-lag relationship between the two markets. The evidence shows that returns in equity markets Granger cause changes in CDS spreads and that equity market volatility is an especially important explanatory variable in understanding the basis of the lead-lag relationship.

Norden and Weber (2009) also show that the co-movement between markets is significantly affected by the underlying credit quality of the sample companies and that the strength of this relationship is increased when credit quality declines. This is relatively consistent with the findings of Forte and Pena (2009) that equity markets lead both CDS and corporate bond markets in North America and Europe. This relationship is also demonstrated as being dependant on the underlying creditworthiness, or financial position, of the sample companies at a specific point in time. The overwhelming conclusion is that the specific relationship between CDS and equity prices, the lag in CDS price discovery relative to equities, has decreased over time.

However, Blanco, Brennan and Marsh (2005) found that the CDS market is relatively more price efficient to the extent that declines in credit quality are priced in ahead of equity markets. The topic of informational efficiency is further examined by the authors, who also consider the relationship between IG corporate bond spreads and CDS prices across 33 companies. The study is particularly relevant in testing price discovery in the corporate bond market, which traded with much less transparency than the CDS market prior to the introduction of TRACE. The authors found evidence of informed trading by participants in the corporate bond market by showing that approximately 80% of the sampled firms exhibit price discovery where the equilibrium condition of no arbitrage holds relative to the CDS market.

Despite improved price discovery on bond markets, Coudert and Gex (2010) still found that corporate bond markets lag CDS markets. The authors also show that the strength of the lead in CDS markets has been increased after the 2008 Financial Crisis. This contribution to the literature on the increased prominence of the CDS market is also supported by Coronado et al. (2012) and Lenciauskaitė (2012). These authors show that in European equity and CDS markets, equities generally lead CDS, but in the period preceding the 2008 Financial Crisis, the relationship was reversed and the CDS market led the equities at the aggregate index level.

Fung et al. (2008) found further support for the pricing efficiency of the CDS markets during pronounced equity market drawdowns. The authors show that the dissemination of information between CDS and equity markets is a function of both market and firm-specific risk. In an attempt to isolate market or systematic risk, their study focusses on equity and CDS indices while also differentiating between IG and speculative HY CDSs in their sample. They demonstrate that price discovery in aggregate CDS markets is more efficient than aggregate equity markets, and that this relationship tends to be more pronounced during market downturns due to the ability of the CDS market to more reliably estimate probabilities of default at the index level. Blanco, Brennan and Marsh (2005) also show that CDSs lead IG corporate bonds in pricing in new information.

6.2.4 Market Transparency

An overview of TRACE is important to contextualise the changes in corporate bond markets that largely facilitated the increase in literature contribution in the US. The quality of trade data after TRACE implementation resulted in a pronounced increase in the number of studies examining the co-movement between bonds and equities, especially those focussing on high frequency trading.

The Financial Industry Regulatory Authority (FINRA) introduced significant reforms in the US corporate bond market in July 2002 with the implementation of TRACE. The regulatory requirements included the timeous reporting of trade transactions by registered dealers in an attempt to improve the dissemination of public information in the relatively opaque corporate bond market. The vast majority of corporate bonds trade in the OTC market, which is effectively a large decentralised network comprised of predominantly institutional investors bidding for securities through a professional intermediary system of a bond dealers negotiating trade prices with sellers. The primary benefit of TRACE is that it requires the public disclosure of both price and volume detail on a post-trade basis, and this information was only available to the actual parties to the trade in an OTC transaction before TRACE.

However, there are still opposing views on whether the increased transparency in corporate bond markets benefits investors. Contributions to the theoretical literature include Pagano and Roell (1996) who conclude that in aggregate, increased transparency results in lower transaction costs for traders, irrespective of nominal trade sizes. Naik, Neuberger and Viswanathan (1999), however, contradict these findings by showing that higher transparency could result in lower intermediary rents, which potentially increase trading costs for investors. The advent of TRACE resulted in a number of empirical studies examining the effect of transparency in the secondary corporate bond market on dealer or intermediary trading. These include contributions from Goldstein, Hotchkiss and Sirri (2006) and Bessembinder, Maxwell and Venkataraman (2006), who consider the effect of increased transparency on bid-offer spreads and found evidence of lower trading costs for actively traded bonds. A later study by Asquith, Covert and Pathak (2013) also found evidence of increased market transparency reducing price dispersion for both IG and HY bonds. The empirical studies citing the positive effects of corporate bond market transparency can be contrasted with conclusions by other authors (Holmstrom, 2015) arguing that bond markets are less informationally efficient and that increased transparency may not necessarily result in an improved market structure.

These contradictory findings in terms of market transparency are of less importance in the context of the current study than the reasons TRACE was initially introduced. The increase in transparency facilitated by TRACE was implemented to enhance the integrity of the corporate bond market, which previously suffered from relatively weak price discovery in OTC trading and was more accessible to institutional investors. Goldstein, Hotchkiss and Sirri (2006) found that improved transparency has either a positive or neutral effect on corporate bond market liquidity. This was the premise of the TRACE reforms, and the regulators emphasised the importance of public dissemination of price and transaction data as a significant advantage to non-professional retail investors (NASD, 2005).

6.3 Methodology

This studied followed a similar approach adopted by Kwan (1996) and Downing, Underwood and Xing (2009) to examine the relationship between corporate bond and equity returns using a lead-lag framework as indicated by the vector autoregressive (VAR) model in Equation 44.

The VAR methodology is set up with two specifications. specification 1, as shown by Equation 44, specifically models bond (equity) returns based on lags of both bonds and equities. The resulting information allows for testing the Granger causality effects and identifying any leads or lags by evaluating the F-statistic from the Granger tests. Following the estimation of the specification 1, based on Equation 44, the analysis proceeds to specification 2, which is based on Equation 46, which is an augmented version of Downing, Underwood and Xing (2009; see Equation 45), and includes the addition of an exchange rate term.

6.3.1 Vector Autoregressive Model

VAR models are commonly used in financial time-series research to examine the relationships between variables that may interact with each other. Developed by Sims (1972), the structure of VAR models enables the explanation of the values of endogenous variables from their past observed values. The lead-lag relation between weekly bond and equity returns of hard currency denominated issued corporate bonds is examined based on the bivariate vector autoregressive (VAR) model in Equation 44 (Tolikas, 2018).

$$y_t = c + \sum_{i=1}^{L} \beta_i R_{B,t-i} + \sum_{i=1}^{L} S_i R_{S,t-i} + \varepsilon_{t,}$$

44

Where,
y_t = $R_{B,t}$ or $R_{S,t}$;
$R_{B,t}$ = Weekly bond returns of the market capitalisation (mktcap) index at time;
t, $R_{S,t}$= Weekly equity returns of the equity market index at time *t;*
c, β_i = Intercept term;
S_i = Coefficient matrices to be estimated;
ε_t = Error term; and
L = Lag length.

The lag length is determined by the Akaike information criterion (AIC), after considering the Schwarz information criterion (SIC) and Hannan-Quinn information criterion (HQ) in addition to the AIC. At the index level, the AIC indicates a maximum lag length of eight for the weekly bond and equity market returns. At the firm level, the AIC suggests a maximum lag length of eight. Therefore, a lag length of eight is implemented in the bivariate VAR system. The conclusions are not sensitive to changes in lag length.

The analysis is then extended to include sensitivity tests on the lead-lag relations. These tests should be viewed as robustness tests on results from Equation 44. Short time series or fewer data points may yield estimation results that are less reliable, necessitating the use of additional robustness checks for the analysis. This is done by extending Equation 44 to include measures that control for interest rate risk and market-related risk, which are standard bond risk-related concepts. This extended version (Downing, Underwood & Xing, 2009) is show in Equation 45.

$$R_{B,t} = \alpha + \sum_{i=1}^{L} \beta_{B,i} R_{B,t-i} + \sum_{i=0}^{L} \beta_{T,i} R_{T,t-i} + \sum_{i=0}^{L} \beta_{JSE,i} R_{JSE,t-i} + \sum_{i=1}^{L} \beta_{S,i} R_{S,t-i} + \varepsilon_t$$

45

Where,
$R_{B,t}$ = Weekly bond return at time t;
$R_{S,t-i}$ = Contemporaneous and lagged weekly equity returns;
$R_{JSE,t-i}$ = Contemporaneous and lagged weekly equity returns of the JSE All Share equity index;
$R_{T,t-i}$ = Contemporaneous and lagged weekly returns representing a default-free security;
α = Intercept term; and
ε_t = Error term.

The coefficients in Equation 45, from left to right, shed light on the bond market's sensitivity to a few important market-related factors. Specifically, the coefficient $\beta_{T,i}$ shows the sensitivity of the weekly bond returns to changes in the rates on default-free securities. The $\beta_{JSE,i}$ coefficient shows the sensitivity of weekly bond returns to the JSE equity returns, and $\beta_{S,i}$ shows the sensitivity of weekly bond returns to the returns of a comparable equity index. Following Cornell and Green (1991) and Hotchkiss and Ronen (2002), it is suggested that the sum of the estimated coefficients is reported rather than the individual coefficients as individual coefficients do not yield the necessary information to draw inferences from the analysis. Instead, inferences should be drawn from the sum of the coefficients in support of or in contrast to the findings from the VAR specification.

Given that the analysis in this chapter was based on a hard currency corporate bond index, the model of Cornell and Green (1991) and Hotchkiss and Ronen (2002) was extended to include an additional term, namely exchange rate risk. This was added to the model as the market cap bond index analysed in this chapter was constructed of foreign currency bonds, which may have exposure to currency risk. This term was included as it represents a key link between the domestic and foreign financial markets where exchange rates should be accounted for. To account for this currency or exchange rate risk, the model included the nominal US Dollar/Rand (USDZAR) exchange rate. Therefore, Equation 45 was augmented by adding the exchange rate term, and the full model is shown in Equation 46.

$$R_{B,t} = \alpha + \sum_{i=1}^{L} \beta_{B,i} R_{B,t-i}$$
$$+ \sum_{i=0}^{L} \beta_{T,i} R_{T,t-i} + \sum_{i=0}^{L} \beta_{S,i} R_{S,t-i} + \sum_{i=0}^{L} \beta_{JSE,i} R_{JSE,t-i} + \sum_{i=0}^{L} \beta_{EX,i} R_{EX,t-i} + \varepsilon_t, \quad (46)$$

Where,
$R_{B,t}$ = Weekly return on the corporate bond index at time t;
$R_{T,t}$ = Contemporaneous and lagged weekly return of a default-free security;
$R_{S,t}$ = Contemporaneous and lagged weekly return of the matching-firm equity index;
$R_{JSE,t}$ = Contemporaneous and lagged weekly return of the JSE;
$R_{EX,t}$ = Contemporaneous and lagged weekly return of exchange rate returns, given by the USDZAR exchange rate;
α = Intercept term;
ε_t = Error term; and
$R_{EX,t-i}$ = Contemporaneous and lagged weekly returns of the nominal USDZAR exchange rate.

6.3.2 Granger Causality

VAR models are commonly used to study the relationships between variables. Granger (1969) introduces a useful measure, the Granger causality, to test whether the lags of one variable impact on the current value of another variable. The Granger causality test is inherently focused on the short-term relationship between two variables as it involves examining whether the lagged values of one variable predict the current value of another variable. Moreover, Granger causality assists in identifying whether one variable is useful in forecasting another variable through a reduction in forecasting error.

Lagged terms of the dependent variables were included in the model to gain an understanding of the dynamics and extent of informational efficiency in South African bond and equity markets. If bond and equity markets simultaneously price in market information, the coefficients of the lagged terms are expected to be statistically equal to zero. This gives rise to a null hypothesis that bond and equity markets are equally efficient. The null hypothesis that equity returns do not Granger cause bond returns is examined by investigating the Granger causality test statistic. At the same time, the relationship between bond and equity returns should be evaluated in both directions, and therefore, the null hypothesis of bond returns do not Granger cause equity returns should also be tested. Effectively, the *F*-statistic of the null hypothesis is that all the estimated lagged coefficients are equal to zero, or $H_0 = [\beta_i] = [S_i] = 0$, for all *i*. Following Downing, Underwood and Xing (2009) to support the findings of the Granger causality tests, the results are further scrutinised based on the sum of the lagged cross-market coefficients. This sum test is useful to reinforce the results from the Granger causality tests when the null is rejected based on a small sample size or insufficient data points.

The significance of identifying Granger causality is that where one variable Granger causes another, it is indicative that this variable precedes another or may assist in forecasting another variable. This could help investors identify or predict patterns and movements in returns. It is also useful in identifying which market is informationally efficient relative to the other.

6.4 Data

6.4.1 Bonds

The main index of evaluation of the bond market is the aggregate market capitalisation index constructed and presented in Chapter 4. This index comprises 499 bonds issued across 28 companies with either primary or secondary listings on the JSE. Weekly US Dollar-denominated total bond returns were evaluated as part of the main empirical analysis.

For the sake of completeness, the weighting methodology applied in the construction of the index is outlined below. This is identical to the methodology explained in section 4.4.3.

Weights were applied to the individual issuing companies based on the market capitalisation at the end of the calendar year. These weights were then applied to the index for the next 12 months from January to December. Specifically, the market capitalisation for each bond in the sample was collected on an annual basis from Datastream and consolidated under the issuer where an aggregate index weighting was calculated. The total market cap for all the companies in the sample was calculated as the cumulative market capitalisation of each individual bond in issue. The company specific weighting was calculated as the arithmetic contribution of that firm to the total market capitalisation of all bonds issued by each of the companies being used to construct the index. The general formula for the approach is shown in Equation 47.

$$Weight\ MV = \frac{MV_{(t-1)}}{\sum \mathrm{MV}_{(t-1)}} \qquad (47)$$

Where,
$MV_{(t-1)}$ = Market value of single company bonds as at prior financial period; and
$\sum \mathrm{MV}_{(t-1)}$ = Total market value of all constituent company bonds as at the last financial period.

Constructing the index using the above approach resulted in an aggregate corporate bond index portfolio with characteristics that is shown in Table 14.

The portfolio comprised 499 bonds issued by 28 companies at the aggregate index level. The key characteristics for inclusion in the market index are provided in section 4.4.3. For the purposes of analysing the data in this chapter, stratifying the bonds by main jurisdiction and domicile of listing (primary or secondary), issuer rating (IG or HY), sector of operation (resources, industrials, financials, real estate), and duration (low or high) at the issuing company level allowed for more meaningful investigation of the lead-lag relationship. The portfolio was also segmented by an inferred individual bond level credit rating band, but this was done more for comparability than for modelling to improve the robustness of results.

Table 14 shows notable differences in the number of bonds in each category. When stratified by domicile, it shows that primary listings on the JSE consisted of 83 bonds issued by 17 companies, and secondary listings amounted to 416 bonds spread across 11 issuers. This suggests that companies with primary domicile outside of South Africa have identified the opportunity to diversify their investor base by accessing a more differentiated capital pool outside the markets they are primarily listed in. Table 14 also shows that the resources and industrials dominated the index by number of bonds in issue. This is relatively consistent with the concentration on the JSE, which is especially resource and industrials heavy. Financials and real estate had a much lower representation in the index. The duration stratification was to allow for an examination of the interaction between bonds, which were relatively more sensitive to interest rate risk, and to understand whether there are any lead or lag effects with the counterpart equities in the aggregate equity index. Duration type was classified relative to the duration of the aggregate index. Underlying issuer portfolios with durations above the aggregate index duration of 5 were classified as high and those below the average were classified as low.

The data was also stratified by issuer type. This was the primary credit rating metric applied on the data with companies being assigned either an IG or HY classification. The issuer rating was based on the long-term foreign currency rating at the company level by either Moody's, Fitch, or S&P. The Moody's equivalent rating was applied to ensure consistency and comparability across the different issuers. IG issuers were rated Baa3 or above. There were 16 IG issuers in the sample, and the balance of 12 was made up of HY issuers with long-term foreign currency credit ratings below the Baa3 band.

The last stratification occurred along credit quality. Given the lack of data available at the bond specific level, these were inferred from the long-term foreign currency issuer ratings. The absence of reliable bond level credit data is indicated under limitations of this study and was largely an outcome of approximately half of the sample being unrated. This stratification attempted a look through based on issuer quality but any results under these more narrower ratings bands should be interpreted relatively prudently. It is interesting to note the breakdown at the issuer level because it shows that Baa1 to Baa3 issuer categories account for 13 of the 28 issuers.

Table 14: Characteristics of market capitalisation bond index

Characteristic	Number of Issuers	Number of Bonds	Average Duration (Years)	Average Term (Years)	Senior Bonds	Amount Outstanding ($mil)	TRACE*
Aggregate index	28	499	5.0	9.8	429	230.3	253
Listing (1)							
Primary Listing	17	83	4,5	7,6	63	21,5	30
Secondary Listing	11	416	5,8	13,3	366	208,7	223
Issuer Rating (2)							
Investment Grade	16	430	4,7	8,8	384	218,3	236
Non-investment grade	12	69	5,5	11,2	45	11,9	17
Sector (3)							
Resources	7	178	4,2	8,2	154	62,7	94
Industrials	10	263	5,7	9,1	233	156,6	155
Financials	5	31	4,6	9,5	26	5,6	2
Real Estate	6	27	5,1	13,2	16	5,3	2
Duration (4)							
Low	17	200	4,0	7	161	63,1	92
High	11	299	6,7	14,3	268	167,1	161
Credit Quality (5)							
A1	1	3	10,9	13,3	3	4	-
A3	1	34	5,8	10,4	32	12,7	18
Baa1	4	26	4,4	9,0	24	7,1	-
Baa2	4	304	4,5	10	270	173,9	178
Baa3	5	65	4,2	7,6	61	22,3	41
Ba1	2	11	4,9	8,5	7	3,5	6
Ba2	2	6	2,7	6,7	4	1	-
Ba3	1	1	4,3	6,0	1	0,384	1
B2	1	16	4,2	10,3	4	1,1	8
Caa2	1	11	8,5	20	10	1,3	1
NR	5	21	6,4	13,1	13	3	-
WD	1	1	2,5	5,0	-	-	-

(1) Listing type is segmented by primary country of domicile and incorporation. Primary listings are domiciled and incorporated in South Africa

(2) Issuer Rating is based on the long-term foreign currency rating of the issuer by either Moody's, Fitch or S&P. The Moody's equivalent rating has been applied across the sample to ensure consistency and comparability.

(3) Sector type is segmented by the issuers primary sector of operation and is allocated across the main JSE index sectors

(4) Duration type is segmented relative to the duration of the aggregate index. Underlying issuer portfolios with duration above the aggregate index portfolio are classified as High, while those below the average are classified as low

(5) Credit quality has been approximated based on the long-term foreign currency rating of the issuer.

6.4.2 Equity

To construct the equity index, the same set of firms used in the market cap index was identified and matched to their corresponding equity issue. These portfolios were market cap-weighted indices where the weights in the bond and equity indices were identical to ensure consistency and comparability between the two indices. If different weights were chosen for the indices, it would have led to inconsistent and non-comparable outcomes. This was important issue as firms may have issued multiple bonds but have only one equity stock in issue. Thus, using the market cap-weighting helped overcome any issue that arose due this difference between corporate bond and equity markets. This approach is consistent to the one used by with Tolikas (2018).

Table 15: Characteristics of market capitalisation equity index

Characteristic	Number of Companies	Amount Outstanding ($mil)	Average P/E Ratio	Average LT Debt / Equity	Average Total Debt / Total Capital	Average Total Debt / Equity	Average Return on Invested Capital
Aggregate index	28	778,8	14,0	57,5	37,7	63,5	7,5
Listing (1)							
Primary Listing	17	194,5	10,6	48,7	36,5	51,6	9,4
Secondary Listing	11	584,2	19,4	70,3	39,4	82,0	4,5
Issuer Rating (2)							
Investment Grade	16	734,8	15,7	60,5	39,9	88,8	8,3
Non-investment grade	12	44,0	11,7	53,1	34,7	29,8	6,5
Sector (3)							
Resources	7	280,3	16,0	54,2	36,4	65,6	3,6
Industrials	10	422,2	16,5	71,1	41,1	46,9	10,2
Financials	5	53,5	8,6	39,4	37,9	98,4	14,6
Real Estate	6	22,7	12,0	56,0	33,2	59,8	1,6
Duration (4)							
Low	17	239,6	11,8	52,8	37,4	54,3	5,8
High	11	539,2	17,6	64,3	38,0	77,9	10,1
Credit Quality (5)							
A1	1	79,3	25,8	37,4	37,5	61,3	6,9
A3	1	169,1	13,3	41,0	30,0	46,9	17,1
Baa1	4	33,6	22,1	61,7	43,7	98,4	7,0
Baa2	4	306,3	23,0	92,0	52,0	144,3	10,9
Baa3	5	140,4	15,7	51,5	32,8	56,7	8,7
Ba1	2	18,0	17,1	54,7	35,5	70,1	8,6
Ba2	2	3,2	4,8	46,4	36,6	64,5	-6,9
Ba3	1	7,3	9,0	61,8	37,2	68,9	15,1
B2	1	1,8	9,6	118,5	56,0	135,2	10,0
Caa2	1	0,1	0,0	0,0	9,7	-13,4	37,6
NR	5	11,6	6,7	50,4	35,4	-12,8	2,2
WD	1	8,2	0,0	17,3	16,2	20,5	-6,3

(1) Listing type is segmented by primary country of domicile and incorporation. Primary listings are domiciled and incorporated in South Africa

(2) Issuer Rating is based on the long-term foreign currency rating of the issuer by either Moody's, Fitch or S&P. The Moody's equivalent rating has been applied across the sample to ensure consistency and comparability.

(3) Sector type is segmented by the issuers primary sector of operation and is allocated across the main JSE index sectors

(4) Duration type is segmented relative to the duration of the aggregate index. Underlying issuer portfolios with duration above the aggregate index portfolio are classified as High, while those below the average are classified as low

(5) Credit quality has been approximated based on the long-term foreign currency rating of the issuer.

Table 15 shows the descriptive statistics for the equity index. Data is sourced from Eikon Refinitiv. The fundamental accounting data used to assess the equity portfolio specifically considers a valuation component through average P/E ratios over the sample period. Various debt ratios have also been included to capture balance sheet risk and consider financial leverage or gearing relative to the bond index shown in Table 14. The matching process ensures all 28 issuers represented in the bond index are represented in the corresponding equity index.

A few observations are worth noting. At a market cap of $778.8 bn, the market cap of the equity index is 3.4 times the size of the bond index. At a market cap of $584.2bn, secondary listings are shown to make up a sizeable portion of the total market cap. Investment grade issuers dominate the index in terms of market cap. The 16 investment grade issuers comprise a market cap of $734.8bn which is approximately 94% of the total aggregate index market cap.

Moving to the sector stratification also shows a size concentration towards Industrials at a market cap of $422.2bn and Resources at $280.3bn.

Other important metrics to highlight are that secondary listings have a much higher average P/E ratio at 19.4 times versus primary listings at 10.6 times. Secondary listings also have higher financial leverage and delivered lower returns on invested capital (ROIC). At the sector level, Resources delivered especially low ROIC but P/E ratios are approximately in line with Industrials at 16 times. Industrials also show substantial financial leverage with the highest long-term debt to equity ratio across the sectors at 71.1%. This should be viewed in conjunction with the sizeable amount of outstanding bonds shown for Industrials in Table 14.

6.4.3 Bond and Equity Returns

Table 16 contains the descriptive statistics for the weekly returns of the corporate bond and equity indices based on market capitalisation construction.

The mean weekly total bond returns of the aggregate index for both bonds and equity are very close to zero, with the equity returns slightly negative. The higher evidenced standard deviation of equity would suggest that it traded with relatively higher volatility than bonds over the sample period. This is largely an expected finding. The equity market for the constituent equities are likely to trade in relatively more liquid markets with better price discovery than the equivalent bond peer set. The correlation between corporate bonds and equity is notably high at 0.497. The correlation coefficient between corporate bonds and 3-month Treasury note is negative, indicating that hard currency non-Rand corporate bonds display a negative relationship with respect to US 10-year Treasuries. A notable observation is that bond returns tend to exhibit smaller weekly returns compared to same-company equity returns.

Before proceeding to the estimation of equation (1) using the VAR methodology, the bond and equity return series are tested for stationarity using the Augmented Dickey-Fuller (ADF) test. The null hypothesis of non-stationarity is rejected for both time series. The Johansen cointegration test is then implemented to check if the time series are cointegrated. The null hypothesis of cointegration is rejected and the analysis proceeds to the estimation of specification (1) and (2). The results for the two specifications are presented in the next section.

Table 16: Descriptive statistics of the weekly returns on the bond and equity indices

	Bonds (B)		Equities (S)			
Characteristic	**Mean (%)**	**St.Dev (%)**	**Mean (%)**	**St.Dev (%)**	$\rho_{B,S}$	$\rho_{B,T}$
Aggregate index	0.001	0.008	-0.000	0.046	0.497	-0.011
Listing						
Primary Listing	0.002	0.123	-0.006	0.497	0.495	-0.056
Secondary Listing	0.069	0.787	-0.026	4.306	0.478	-0.004
Issuer Rating						
Investment Grade	0.074	0.688	0.014	3.813	0.471	-0.007
High yield	-0.002	0.234	-0.032	1.096	0.511	-0.021
Sector						
Resources	0.035	0.530	-0.067	3.868	0.516	-0.038
Industrials	0.043	0.361	0.053	1.172	0.376	0.008
Financials	-0.002	0.031	0.005	0.108	0.344	-0.011
Real Estate	-0.003	0.081	-0.012	0.206	0.282	0.092
Duration						
Low	0.026	0.403	-0.035	2.208	0.618	-0.037
High	0.045	0.532	0.030	2.879	0.357	0.010
Credit Quality						
A1	0.003	0.019	0.009	0.071	0.266	0.018
A3	0.015	0.252	-0.002	2.402	0.341	-0.034
Baa1	0.000	0.027	0.006	0.082	0.305	0.031
Baa2	0.043	0.395	0.04	1.625	0.424	0.040
Baa3	0.019	0.216	0.001	1.105	0.583	-0.061
Ba1	0.003	0.025	0.005	0.091	0.401	0.009
Ba2	0.000	0.133	-0.012	0.767	0.551	-0.053
Ba3	0.001	0.003	0.003	0.008	0.932	0.109
B2	0.000	0.078	-0.004	0.278	0.193	-0.067
Caa2	-0.007	0.017	-0.001	0.042	0.084	-0.061
NR	-0.001	0.101	-0.015	0.271	0.440	0.078
WD	0.000	0.000	-0.000	0.008	0.140	-0.077

Table 16 displays the descriptive statistics for the constructed market-cap weighted corporate bond and equity indices. Mean represents the average weekly returns for the bond and equity indices. St.Dev represents the standard deviation of the weekly returns for each index. The $\rho_{B,S}$ is the contemporaneous correlation between the weekly bond and equity returns. The $\rho_{B,T}$ is the contemporaneous correlation between the weekly bond and Treasury-note returns.

6.5 Results

6.5.1 Examining the Lead-Lag Between Corporate Bond and Equity Returns

The results for the main analysis are presented in Table 17. The VAR model was estimated using ordinary least squares (OLS) and lag length was set to 8 based on the AIC. The results were stratified by main listing exchange, issuer rating, duration, credit quality, and issuer sector to allow for a more granular investigation of differences along key metrics. The first part of the results shows the coefficients of the lagged terms. The second last column in Table 17 shows the sum of the coefficients and the corresponding p-value, which tested whether the sum of the coefficients was equal to zero. This built-in robustness check provided support for the results of the Granger causality test, especially in samples where numbers were low or time series short (Downing, Underwood & Xing, 2009). The last column of Table 17 shows the results of the Granger causality test, specifically the F-statistic and the corresponding p-value for the null hypothesis, which shows that all coefficients were equal to zero. The results are insensitive to the number of lags used.

The use of both the F-statistic and p-value are worth noting. Following Downing, Underwood and Xing (2009), two methods were used to test for evidence of a lead-lag relationship between corporate bond and equity returns. The first test was a standard Granger causality test, which yields an F-statistic for the null hypothesis when the lagged coefficients are equal to zero. The second test, which is deemed to be weaker than the Granger causality test, was the sum test which evaluates an F-statistic that the sum of the lagged coefficients is equal to zero. Downing, Underwood and Xing (2009) propose the use of this complementary test to the Granger causality test as small sample sizes or short data series may lead to inconclusive Granger test results. Therefore, using the two tests together provided stronger evidence to identify the lead-lag relationships than using only the Granger causality test on its own would have. Overall, the sum test was not a necessary requirement to confirm the presence of Granger causality but improved the robustness of the model.

The interpretation of the results was premised on testing the null hypothesis that equity (bond) returns do not lead bond (equity) returns at the 1% level of significance. This is consistent with Tolikas (2018) approach, but given the limited sample size, the results presented here used the 1% level of significance as opposed to the 5% level that his results are presented on. A further motivation was its value and usefulness to a market practitioner. Given the nature of market practitioners' work in managing portfolios of assets and determining when and how to respond to market information, a more conservative level of significance was used. The results in Table 17 are first presented for the bond indices, followed by the equity indices within each category.

The results presented in Table 17 show an interesting relationship between corporate bond and equity markets in South Africa. The results are presented at both the broader aggregate index level and the underlying segments consisting of listing type, issuer type, duration type, and issuer credit rating.

Evaluating the results for the aggregate bond index shows evidence of unidirectional Granger causality from equity to corporate bond markets. This means that the bond index returns were predictable with their associated lagged equity returns. Specifically, the first lag of equity returns (0.051) was statistically significant, with lags 2 (0.017) and 6 (0.017) very weakly significant, which contributes to the Granger causality and sum tests rejecting the null hypothesis that equity (bond) returns do not lead bond (equity) returns at the 1% level of significance. This means there is evidence of Granger causality for equity returns leading bond returns at the aggregate level.[7] Put differently, the results confirm that equity returns were statistically relevant in explaining corporate bond returns. Consistent with the literature, the findings suggest that equity markets were relatively more informationally efficient than corporate bond markets and exhibited leading effects when compared to corporate bond markets.

When stratified at the listing type level, the results show a bidirectional Granger causality relationship between bonds and equity. The null hypothesis of the Granger causality test was rejected at the 1% level of significance across the full listing breakdown, indicating that with weekly bond and equity returns there was insufficient evidence to advocate for dominant market efficiency between bond and equity markets. The jurisdiction of the listing of the underlying issuer did not provide any lead or lag effects. Put differently, there was no evidence of primary listed bonds leading primary listed equities, or vice versa. This means that based on the listing distinction, bidirectional Granger causality was observed, indicating that equity and bond markets were equally informationally efficient when evaluated through a listing breakdown. The result for secondary listings, while slightly surprising given that that these are larger listed companies relative to the primary equity peer set, also showed a bidirectional relationship with bonds. The literature is not especially well developed in segmenting primary versus secondary listings, and therefore, further interpretation of this result was difficult to calibrate without speculating on reasons.

The sector results showed a fair amount of dispersion with evidence of some leading effects while others were largely insignificant. The Granger test confirmed for both the resources and industrials sectors equity leading bonds at the 1% level of significance. In addition, the sum test confirmed the Granger result but at a 5% level of significance. Importantly, resources and industrials comprised the largest sectors within the aggregate index, illustrating the importance of these sectors' respective contributions to the market.

The financials sector had an independent relationship with no evidence of a lead-lag relationship as the results for the Granger test could not be rejected at the 1% level of significance. The sum test for the bond index of the financials sector rejected the null hypothesis that the lagged coefficient add to zero; this is a contradictory result to the Granger test. Overall, the results for financials showed that neither market was informationally efficient The real estate sector provided strong evidence of a bidirectional Granger causality relationship that was supported by the results of the Granger and sum tests.

[7] Note that the null hypothesis is evaluated against a p-value of 0.01 and not the standard 0.05 as results should provide strong evidence to a market practitioner of how to proceed based on the information before them.

Breaking out the results to consider issuer rating showed findings that were comparable to the aggregate index level. IG bonds tended to display similar attributes to the broader aggregate equity index. The results from the Granger causality test suggested that IG equity led IG bonds at the 1% level of significance. This finding was confirmed by the results of the sum test, albeit at the 5% level of significance. The HY segment showed evidence of a bidirectional relationship between HY bonds and HY equity, suggesting that both markets were equally informationally efficient. Both the Granger test and the sum test provided statistically strong evidence for this finding.

The analysis of the duration breakdown revealed interesting information. The results for the low duration category showed that equity led bonds based on the result of the Granger test at the 1% level of significance. The results for the high duration category showed a strong bidirectional Granger causality relationship. The results showed a strong rejection of the null hypothesis of the sum test for the equity equation. There was no evidence of a lead or lag in either market.

These results are not necessarily intuitive. Higher duration bonds are typically exposed to more interest rate risk so the expectation could be that they would be relatively more responsive to news than lower duration bonds. That being said, without analysing valuations of the underlying companies at the firm-specific level, it would not be accurate to suggest that the results are at odds with economic or company specific fundamentals. The period under review from 2008 to 2019 was characterised by relatively high global equity prices and low interest rates. The interest rate sensitivity of high duration equities could have been relatively similar to that of high duration bonds.

Breaking out the credit quality bucket showed mixed results. For bonds with IG issuers, only one category, Baa3, showed evidence of equity leading bonds. This category was especially resources heavy and dominated by Anglo American, and therefore, the result was expected given the earlier resources sector evidence of equities leading bonds. The A3 and Baa2 issuer rating categories showed evidence of bidirectional Granger causality and equal informational efficiency between equity and bond markets. The result for Baa2 was somewhat surprising given the findings that resources and industrials displayed statistically significant results for equities leading bonds. The expectation was that the Baa2 credit rating band would display similar results given that the underlying issuers are the two largest industrial companies, namely AB Inbev and British American Tobacco as well as global diversified miner Glencore. That being said, it potentially highlights the weakness that has consistently been stated throughout the thesis that without granular rating data at the bond specific level it is difficult to make inferences about narrow rating band results. All other issuer rating bands displayed independent results with no evidence of Granger causality.

However, there are some important relationships worth noting. The results for the Caa2 credit rated bond are not surprising because the issuer in this category is African Bank. The effective default of this issuer in 2014 was the first listed credit event in the history of South Africa's financial markets. The issuer underwent a negotiated settlement to restructure coupon and repayment terms to bondholders. The Granger causality test strongly rejected the null hypothesis of no Granger causality.

Table 17: Weekly bond returns of the bond indices and the corresponding equity indices

	Lagged bond returns								Lagged equity returns										
	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	*s1*	*s2*	*s3*	*s4*	*s5*	*s6*	*s7*	*s8*	*N*	*Sum*	*Granger*
Aggregate																			
Aggregate Bond index	-0.026	0.001	-0.035	0.128	0.004	-0.034	0.037	-0.006	0.051	0.017	0.011	0.003	-0.013	0.017	0.002	-0.012	618	0.145	2.430
	(-0.548)	(0.023)	(-0.739)	(2.631)	(0.097)	(-0.708)	(0.772)	(-0.132)	(5.754)	(1.901)	(1.182)	(0.344)	(-1.433)	(1.961)	(0.245)	(-1.475)		(0.222)	(0.013)
Aggregate Equity index	0.423	-0.487	0.431	0.615	0.263	0.527	0.344	0.107	-0.128	0.032	-0.076	0.022	-0.071	0.064	-0.118	-0.147	618	1.801	5.632
	(1.579)	(-1.817)	(1.608)	(2.291)	(0.981)	(1.971)	(1.289)	(0.429)	(-2.654)	(0.635)	(-1.501)	(0.441)	(-1.415)	(1.284)	(-2.367)	(-3.055)		(0.005)	(0.000)
Listing																			
Primary Listing																			
Bond	-0.005	-0.084	0.028	0.143	0.039	-0.110	-0.042	-0.041	0.041	0.028	0.009	-0.018	-0.004	0.005	0.024	0.017	618	0.032	3.045
	(-0.119)	(-1.758)	(0.599)	(3.002)	(0.832)	(-2.319)	(-0.893)	(-0.875)	(3.519)	(2.331)	(0.796)	(-1.506)	(-0.366)	(0.501)	(2.059)	(1.446)		(0.767)	(0.002)
Equity	0.193	-0.115	-0.134	0.086	0.384	-0.588	-0.401	0.107	-0.091	0.038	0.008	-0.042	-0.071	0.142	0.091	-0.066	618	-0.475	3.336
	(1.000)	(-0.596)	(-0.698)	(0.447)	(2.002)	(-3.068)	(-2.082)	(0.571)	(-1.911)	(0.784)	(-0.175)	(-0.887)	(-1.476)	(2.985)	(1.899)	(-1.402)		(0.285)	(0.001)
Secondary Listing																			
Bond	-0.027	0.006	-0.021	0.109	-0.018	-0.014	0.055	-0.021	0.047	0.016	0.009	0.006	-0.011	0.017	0.002	-0.013	618	0.143	2.711
	(-0.581)	(0.128)	(-0.441)	(2.287)	(-0.384)	(-0.306)	(1.158)	(-0.471)	(5.439)	(1.770)	(1.074)	(0.754)	(-1.232)	(1.964)	(0.246)	(-1.496)		(0.219)	(0.006)
Equity	0.376	-0.459	0.506	0.534	0.173	0.636	0.461	-0.004	-0.131	0.021	-0.091	0.041	-0.044	0.056	-0.139	-0.141	618	1.795	5.174
	(1.449)	(-1.772)	(1.951)	(2.056)	(0.666)	(2.459)	(1.783)	(-0.017)	(-2.766)	(0.425)	(-1.836)	(0.837)	(-0.901)	(1.147)	(-2.868)	(-2.973)		(0.004)	(0.000)
Issuer Rating																			
Investment Grade																			
Bond	-0.035	-0.007	-0.025	0.146	-0.018	-0.041	0.064	-0.021	0.042	0.017	0.007	0.003	-0.006	0.019	0.003	-0.011	618	0.139	2.181
	(-0.744)	(-0.148)	(-0.536)	(3.091)	(-0.388)	(-0.879)	(1.374)	(-0.487)	(5.066)	(1.942)	(0.899)	(0.368)	(-0.699)	(2.228)	(0.448)	(-1.311)		(0.226)	(0.027)
Equity	0.233	-0.482	0.426	0.719	0.229	0.265	0.362	0.129	-0.122	0.007	-0.074	-0.006	-0.069	0.076	-0.093	-0.105	618	1.379	4.446
	(0.887)	(-1.834)	(1.621)	(2.730)	(0.867)	(1.006)	(1.380)	(0.005)	(-2.601)	(0.143)	(-1.504)	(-0.133)	(-1.425)	(1.561)	(-1.919)	(-2.234)		(0.031)	(0.000)
Non-investment grade																			
Bond	0.140	0.039	-0.066	0.075	0.185	-0.000	-0.042	0.108	0.058	0.004	0.020	0.002	-0.052	-0.002	0.001	-0.011	618	0.460	5.881
	(2.853)	(0.792)	(-1.361)	(1.543)	(3.839)	(-0.004)	(-0.869)	(2.388)	(5.643)	(0.404)	(1.880)	(0.239)	(-4.926)	(-0.211)	(0.134)	(-1.110)		(0.000)	(0.000)
Equity	0.884	-0.209	0.213	0.316	0.521	0.649	-0.061	0.635	-0.115	0.085	-0.105	0.105	-0.116	0.033	-0.112	-0.282	618	2.439	7.363
	(3.902)	(-0.917)	(0.950)	(1.412)	(2.333)	(2.914)	(-0.273)	(3.047)	(-2.410)	(1.702)	(-2.118)	(2.130)	(-2.356)	(0.671)	(-2.292)	(-6.007)		(0.000)	(0.000)

Sector																			
Resources																			
Bond	0.006	0.017	-0.016	0.139	-0.033	-0.011	-0.003	-0.043	0.038	0.013	0.006	0.004	-0.011	0.010	0.004	0.001	618	0.124	2.253
	(0.124)	(0.354)	(-0.325)	(2.791)	(-0.666)	(-0.235)	(-0.007)	(-0.953)	(5.725)	(1.951)	(0.967)	(0.695)	(-1.670)	(1.448)	(0.668)	(0.283)		(0.290)	(0.022)
Equity	0.333	-0.701	0.853	0.251	0.258	0.922	0.377	-0.014	-0.121	0.054	-0.093	0.074	-0.029	0.057	-0.134	-0.135	618	1.953	5.049
	(0.902)	(-1.04)	(2.321)	(0.681)	(0.705)	(2.531)	(1.038)	(-0.042)	(-2.426)	(1.037)	(-1.794)	(1.443)	(-0.564)	(1.132)	(-2.631)	(-2.789)		(0.024)	(0.000)
Industrials																			
Bond	-0.042	-0.030	-0.046	0.127	0.077	0.009	0.054	-0.014	0.058	0.015	0.023	-0.000	-0.010	0.012	-0.006	-0.025	618	0.200	1.760
	(-0.968)	(-0.698)	(-1.053)	(2.887)	(1.751)	(0.205)	(1.233)	(-0.332)	(4.377)	(1.119)	(1.694)	(-0.037)	(-0.781)	(0.902)	(-0.484)	(-1.856)		(0.056)	(0.082)
Equity	-0.124	0.148	0.180	0.255	0.252	0.209	0.083	0.223	0.008	0.036	0.004	0.048	-0.113	0.014	0.026	-0.148	618	0.810	3.399
	(-0.864)	(-1.028)	(1.250)	(1.765)	(1.746)	(1.445)	(0.575)	(1.566)	(0.201)	(0.821)	(0.101)	(1.098)	(-2.563)	(0.336)	(0.594)	(-3.331)		(0.018)	(0.008)
Financials																			
Bond	0.122	0.097	0.025	0.090	-0.006	0.143	-0.003	0.089	0.025	0.024	0.006	-0.003	0.011	-0.006	-0.008	-0.018	514	0.591	1.462
	(2.570)	(2.032)	(0.532)	(1.881)	(-0.141)	(2.975)	(-0.071)	(1.894)	(1.887)	(1.839)	(0.469)	(-0.238)	(0.806)	(-0.461)	(-0.634)	(-1.394)		(0.000)	(0.168)
Equity	0.154	0.267	-0.388	0.177	-0.167	0.067	-0.020	-0.273	-0.038	-0.003	-0.052	0.012	0.080	0.059	-0.058	0.096	514	-0.087	1.183
	(0.896)	(1.542)	(-2.248)	(1.019)	(-0.964)	(0.386)	(-0.117)	(-1.608)	(-0.797)	(-0.082)	(-1.083)	(0.252)	(1.683)	(1.524)	(-1.229)	(2.033)		(0.759)	(0.307)
Real Estate																			
Bond	0.006	-0.064	0.123	-0.059	0.080	0.141	0.103	0.002	0.084	0.043	0.0177	-0.003	-0.011	-0.039	-0.020	-0.052	618	0.351	8.142
	(0.166)	(-1.522)	(2.922)	(-1.393)	(1.871)	(3.293)	(2.374)	(0.006)	(4.942)	(2.469)	(1.000)	(-0.224)	(-0.676)	(-2.285)	(-1.212)	(-3.143)		(0.000)	(0.000)
Equity	0.377	-0.241	0.084	0.373	0.227	0.449	0.194	-0.037	-0.131	0.0884	-0.007	0.055	-0.017	-0.073	-0.087	-0.074	618	1.175	5.844
	(3.651)	(-2.314)	(0.812)	(3.560)	(2.147)	(4.248)	(1.824)	(-0.355)	(-3.109)	(1.925)	(-0.164)	(1.294)	(-0.412)	(-1.738)	(-2.099)	(-1.837)		(0.000)	(0.000)
Duration																			
Low																			
Bond	-0.051	-0.036	-0.036	0.155	-0.059	-0.055	0.018	-0.024	0.050	0.013	0.006	0.009	0.001	0.032	0.009	0.013	618	0.044	2.131
	(-0.979)	(-0.698)	(-0.691)	(2.944)	(-1.139)	(-1.047)	(0.348)	(-0.502)	(5.394)	(1.405)	(0.674)	(0.950)	(0.113)	(3.374)	(0.959)	(1.429)		(0.709)	(0.031)
Equity	-0.150	-0.829	0.266	0.798	-0.191	0.203	0.247	0.062	0.013	0.092	-0.014	0.036	-0.039	0.111	-0.069	-0.056	618	0.482	5.274
	(-0.505)	(-2.802)	(0.897)	(2.681)	(-0.643)	(0.684)	(0.835)	(0.224)	(0.248)	(1.713)	(-0.271)	(0.681)	(-0.732)	(2.062)	(-1.281)	(-1.064)		(0.474)	(0.000)
High																			
Bond	-0.053	-0.018	-0.044	0.099	0.033	0.010	0.044	-0.003	0.050	0.029	0.017	0.008	-0.021	0.002	-0.003	-0.028	618	0.120	2.933
	(-1.205)	(-0.421)	(-1.005)	(2.224)	(0.747)	(-0.226)	(0.996)	(-0.088)	(6.010)	(3.281)	(1.982)	(0.961)	(-2.387)	(0.254)	(-0.441)	(-3.439)		(0.296)	(0.003)
Equity	0.420	-0.394	0.384	0.525	0.422	0.596	0.374	-0.032	-0.211	0.005	-0.070	0.027	-0.068	0.062	-0.127	-0.194	618	1.719	7.809
	(1.781)	(-1.661)	(1.623)	(2.220)	(1.785)	(2.535)	(1.599)	(-0.144)	(-4.788)	(0.108)	(-1.483)	(0.586)	(-1.455)	(1.337)	(-2.752)	(-4.414)		(0.004)	(0.000)

Credit Quality																			
A1																			
Bond	0.144	0.084	-0.283	0.249	-0.538	0.028	0.175	-0.195	-0.091	0.098	0.067	-0.061	0.119	0.371	-0.020	0.097	44	-0.088	1.596
	(0.653)	(0.455)	(-1.406)	(1.410)	(-3.155)	(0.164)	(1.014)	(-0.891)	(-1.589)	(2.196)	(1.523)	(-1.164)	(2.444)	(0.853)	(-0.427)	(2.072)		(0.838)	(0.172)
Equity	0.557	-1.146	0.630	1.249	-0.680	0.198	-1.570	-0.827	-0.266	0.156	-0.257	-0.144	0.325	-0.220	0.138	0.068	44	-2.186	1.918
	(0.621)	(-1.534)	(0.773)	(1.746)	(0.984)	(-0.281)	(-2.237)	(-0.931)	(-1.143)	(0.863)	(-1.443)	(-0680)	(1.649)	(-1.248)	(0.715)	(0.361)		(0.213)	(0.098)
A3																			
Bond	0.003	0.078	-0.025	0.049	0.027	-0.002	-0.107	0.002	0.038	0.020	0.007	0.002	-0.016	-0.003	-0.000	-0.003	618	0.071	3.479
	(0.072)	(1.704)	(-0.555)	(1.091)	(0.614)	(-0.052)	(-2.436)	(0.061)	(8.036)	(3.846)	(1.475)	(0.501)	(-3.262)	(-0.647)	(-0.142)	(-0.734)		(0.526)	(0.000)
Equity	0.275	-0.039	1.433	-0.430	0.848	1.353	-0.073	-0.376	-0.229	0.013	-0.137	0.040	-0.027	0.724	-0.113	-0.184	618	2.425	10.020
	(0.624)	(-0.090)	(3.326)	(0.993)	(1.969)	(3.181)	(-0.174)	(-0.968)	(-5.077)	(0.271)	(-2.707)	(0.812)	(-0.550)	(1.504)	(-2.363)	(-4.233)		(0.024)	(0.000)
Baa1																			
Bond	-0.054	-0.005	-0.051	0.025	-0.080	0.007	-0.038	0.044	0.011	0.001	0.024	0.004	0.000	0.012	0.014	0.024	461	-0.058	0.933
	(-1.089)	(-0.118)	(-1.030)	(0.516)	(-1.592)	(0.154)	(-0.785)	(0.905)	(0.724)	(0.101)	(1.490)	(0.297)	(0.044)	-0.747	(0.864)	(1.514)		(0.678)	(0.488)
Equity	-0.084	0.038	0.231	-0.284	0.034	-0.005	-0.186	0.093	-0.011	0.072	-0.113	0.066	0.046	-0.111	0.027	0.032	461	-0.146	0.823
	(-0.547)	(0.252)	(1.512)	(-1.852)	(0.221)	(-0.000)	(-1.228)	(0.618)	(-0.208)	(1.443)	(-2.271)	(1.308)	(0.930)	(-2.245)	(0.553)	(0.656)		(0.733)	(0.582)
Baa2																			
Bond	-0.016	-0.023	-0.041	0.173	0.030	0.001	0.111	-0.037	0.032	0.017	0.016	0.001	0.004	0.028	-0.008	-0.009	566	0.281	2.824
	(-0.348)	(-0.496)	(-0.879)	(3.740)	(0.685)	(0.034)	(2.512)	(-0.855)	(3.017)	(1.567)	(1.501)	(0.133)	(0.431)	(2.669)	(-0.827)	(-0.844)		(0.007)	(0.004)
Equity	-0.089	-0.518	0.327	0.617	0.045	0.221	0.311	0.101	-0.032	0.064	-0.030	0.071	-0.087	0.076	-0.018	-0.118	566	0.941	2.623
	(-0.441)	(-2.556)	(1.611)	(3.063)	(0.236)	(1.144)	(1.607)	(0.530)	(-0.699)	(1.355)	(-0.652)	(1.520)	(-1.868)	(1.624)	(-0.395)	(-2.554)		(0.039)	(0.008)
Baa3																			
Bond	-0.132	0.016	-0.005	0.062	-0.091	-0.034	0.001	-0.610	0.047	0.013	0.003	0.009	0.016	0.022	0.007	0.027	566	-0.096	0.886
	(-2.491)	(0.313)	(-0.112)	(1.168)	(-1.718)	(-0.658)	(0.038)	(-1.222)	(4.704)	(1.312)	(0.320)	(0.903)	(1.643)	(2.154)	(0.726)	(2.796)		(0.447)	(0.527)
Equity	-0.236	-0.412	-0.240	0.308	-0.132	0.307	0.025	-0.255	0.036	0.011	0.028	0.005	0.020	0.036	-0.034	0.075	566	-0.457	4.368
	(-0.840)	(-1.466)	(-0.855)	(1.095)	(-0.472)	(1.110)	(0.094)	(-0.962)	(0.673)	(0.210)	(0.520)	(0.095)	(0.385)	(0.667)	(-0.647)	(1.429)		(0.495)	(0.000)
Ba1																			
Bond	0.042	0.014	-0.078	0.057	-0.144	0.119	-0.052	-0.062	0.043	0.020	0.026	0.018	0.012	0.018	0.015	0.011	514	0.064	2.260
	(0.858)	(0.305)	(-1.610)	(1.169)	(-2.967)	(2.450)	(-1.074)	(-1.297)	(3.298)	(1.565)	(2.015)	(1.416)	(0.968)	(1.374)	(1.156)	(0.883)		(0.564)	(0.022)
Equity	0.150	0.300	-0.454	0.163	-0.199	0.350	0.164	-0.361	-0.018	-0.091	-0.011	0.017	0.032	0.004	-0.070	0.087	514	0.062	2.233
	(0.816)	(1.633)	(-2.489)	(0.893)	(-1.096)	(1.915)	(0.898)	(-2.020)	(-0.372)	(-1.844)	(-0.232)	(0.350)	(0.658)	(0.081)	(-1.441)	(1.782)		(0.882)	(0.023)
Ba2																			
Bond	0.139	0.081	-0.002	-0.038	0.035	0.192	-0.194	0.067	0.049	-0.007	0.005	0.039	-0.048	-0.011	0.017	0.000	618	0.329	10.537
	(2.780)	(1.629)	(-0.055)	(-0.768)	(0.729)	(4.059)	(-0.957)	(1.431)	(5.320)	(-0.740)	(0.637)	(4.122)	(-4.997)	(-1.214)	(1.965)	(0.041)		(0.007)	(0.000)
Equity	0.817	0.452	1.344	-0.385	0.570	1.650	-0.525	0.158	-0.084	-0.002	-0.338	0.246	-0.036	-0.147	-0.087	-0.160	618	3.473	8.017
	(3.024)	(1.680)	(5.062)	(-1.443)	(2.158)	(6.460)	(-1.989)	(0.623)	(-1.692)	(-0.046)	(-6.750)	(4.785)	(-0.701)	(-2.997)	(-1.788)	(-3.345)		(0.000)	(0.000)

Ba3																			
Bond	0.293	0.549	-0.379	0.119	1.335	0.159	-0.843	-0.207	-0.094	-0.180	0.151	-0.000	-0.057	-0.039	0.256	0.017	44	0.562	0.853
	(0.514)	(0.946)	(-0.549)	(0.177)	(1.950)	(0.222)	(-1.321)	(-0.327)	(-0.374)	(-0.719)	(0.533)	(-0.001)	(-2.094)	(-0.134)	(0.981)	(0.069)		(0.548)	(0.565)
Equity	0.532	1.349	-0.982	0.893	2.370	-0.165	-2.224	-0.871	-0.191	-0.535	0.393	-0.263	-1.053	0.081	0.660	0.220	44	0.216	0.940
	(0.413)	(1.028)	(-0.628)	(0.586)	(1.530)	(-0.102)	(-1.541)	(-0.607)	(-0.336)	(-0.943)	(0.613)	(-0.431)	(-1.693)	(0.121)	(1.116)	(0.385)		(0.918)	(0.500)
B2																			
Bond	0.113	-0.121	0.137	0.170	0.049	-0.203	0.061	-0.157	0.070	0.003	0.13	0.006	-0.008	-0.046	0.021	0.043	618	0.152	8.924
	(2.750)	(-2.946)	(3.402)	(4.174)	(1.216)	(-5.022)	(1.482)	(-3.915)	(6.055)	(0.258)	(1.166)	(0.554)	(-0.735)	(-4.214)	(1.866)	(3.927)		(0.085)	(0.000)
Equity	0.572	0.078	-0.148	0.094	0.500	-0.685	-0.130	0.070	-0.125	0.157	-0.044	-0.086	-0.008	0.146	0.093	-0.107	618	0.377	11.136
	(3.870)	(0.524)	(-1.015)	(0.638)	(3.392)	(-4.703)	(-0.875)	(0.485)	(-2.996)	(3.624)	(-1.043)	(-2.084)	(-0.212)	(3.665)	(2.271)	(-2.699)		(0.237)	(0.000)
Caa2																			
Bond	0.098	0.195	0.169	0.009	0.101	0.047	0.015	0.173	-0.032	0.048	0.011	-0.023	0.021	-0.032	-0.043	-0.036	409	0.724	0.803
	(1.974)	(3.926)	(3.347)	(0.193)	(1.994)	(0.939)	(0.319)	(3.552)	(-1.880)	(2.790)	(0.649)	(-1.373)	(1.231)	(-1.846)	(-2.463)	(-2.083)		(0.000)	(0.599)
Equity	0.069	0.079	-0.053	0.003	0.001	-0.178	-0.220	0.004	-0.040	0.107	0.022	-0.076	0.059	0.060	0.013	-0.035	409	-0.181	3.833
	(0.476)	(0.543)	(-0.357)	(0.021)	(0.007)	(-1.207)	(-1.531)	(0.034)	(-0.795)	(2.113)	(0.432)	(-1.491)	(1.163)	(1.173)	(0.261)	(-0.678)		(0.424)	(0.000)
NR																			
Bond	0.002	-0.085	0.078	-0.052	0.110	0.079	0.081	0.044	0.048	0.044	0.016	-0.024	-0.008	-0.024	-0.016	-0.049	618	0.246	2.002
	(0.062)	(-1.876)	(1.738)	(-1.158)	(2.428)	(1.757)	(1.790)	(0.988)	(2.850)	(2.525)	(0.918)	(-1.389)	(-0.464)	(-1.398)	(-0.940)	(-2.879)		(0.018)	(0.043)
Equity	0.257	-0.102	0.117	0.047	0.291	0.241	0.083	-0.013	-0.164	0.054	0.050	-0.056	-0.037	-0.018	-0.025	-0.070	618	0.656	3.085
	(2.146)	(-0.849)	(0.972)	(0.398)	(2.428)	(2.006)	(0.692)	(-0.116)	(-3.623)	(1.156)	(1.083)	(-1.212)	(-0.794)	(-0.397)	(-0.540)	(-1.559)		(0.017)	(0.002)
WD																			
Bond	-0.327	0.023	0.118	-0.018	0.004	0.111	-0.036	-0.055	0.001	0.021	0.002	0.012	0.001	0.001	0.015	-0.002	305	-0.124	0.776
	(-5.549)	(0.384)	(1.969)	(-0.301)	(0.080)	(1.881)	(-0.633)	(-1.000)	(0.264)	(3.534)	(0.457)	(2.044)	(0.249)	(0.247)	(2.487)	(-0.343)		(0.494)	(0.623)
Equity	-0.301	-0.447	0.375	0.052	0.050	0.027	-0.577	0.702	0.006	-0.091	-0.020	0.110	0.044	0.063	0.015	-0.018	305	-0.008	2.842
	(-0.534)	(-0.771)	(0.652)	(0.091)	(0.087)	(0.049)	(-1.037)	(1.317)	(0.111)	(-1.554)	(-0.348)	(1.840)	(0.736)	(1.052)	(0.259)	(-0.306)		(0.996)	(0.004)

Table 4 presents the estimates of the bivariate VAR model. β_i and s_i are the estimated coefficients. The t-statistics of the coefficient estimates are given in parentheses. N is the number of data points.

6.5.2 Determinants of Predictability

The results above provide relatively consistent evidence that equity market returns lead corporate bond market returns at the aggregate level. However, there is substantial variation within the stratified categories for which this relation holds at individual category levels. To further examine the results from the lead-lag analysis in the previous section, the methodology of Downing, Underwood and Xing (2009) is followed to investigate the determinants of predictability of corporate bond returns in order to identify which factors the hard currency corporate bond market may be most sensitive to. The Downing, Underwood and Xing (2009) approach is modified to include the exchange rate, as this thesis is primarily concerned with the performance and determinants of a hard currency corporate bond index. Similar to the motivation by Girardin and Joyeux (2013), exchange rate returns are included as the bond returns are denominated in US dollars. As this analysis extends and supports the work in the previous section, it should be viewed as another robustness check of the results reported in Table 17.

A number of hypotheses on the behaviour of corporate bonds may be tested by examining the sensitivity of contemporaneous bond returns to lagged bond returns, matched equity returns, market returns, interest rate movements and exchange rate movements. Based on past literature, it is expected that changes in Treasury rates drive changes in bonds issued by safer issuers. It is also expected that equity returns will closely drive lower rated bonds (Tolikas, 2018). To the best of the author's knowledge, this chapter is the first contribution to the literature to include the effects of the exchange rate on hard-currency corporate bond returns. The expectation is that the exchange rate, defined as rand per dollar, will display a negative sign with respect to bond returns if the rand depreciates, illustrated by a rise in the defined exchange rate.

Table 17 shows the estimation results based on equation (3). Following Hotchkiss and Ronen (1999) and Tolikas (2018), the sum of coefficients is reported rather than individual coefficients as the interpretation of individual lagged coefficients is not appropriate in this context.

Table 18: The relationship between corporate bond returns, equity returns, treasury rates, market returns and exchange rates

Characteristic	$\sum_{i=1}^{L} \beta_{B,i}$	$\sum_{i=0}^{L} \beta_{T,i}$	$\sum_{i=0}^{L} \beta_{S,i}$	$\sum_{i=0}^{L} \beta_{JSE,i}$	$\sum_{i=0}^{L} \beta_{EX,i}$	Adj. R^2
Aggregate index	-0.158 (0.185)	-0.051 (0.004)	0.198 (0.000)	0.000 (0.478)	-0.123 (0.020)	0.493
Issuer Rating						
Investment Grade	-0.083 (0.471)	-0.370 (0.012)	0.215 (0.000)	-0.027 (0.559)	-0.735 (0.069)	0.448
High yield	-0.007 (0.946)	-0.105 (0.022)	0.157 (0.000)	0.060 (0.000)	-0.325 (0.004)	0.507
Duration						
Low	-0.245 (0.033)	-2.593 (0.001)	0.227 (0.000)	0.037 (0.085)	-5.035 (0.021)	0.521
High	-0.039 (0.741)	-2.694 (0.021)	0.109 (0.012)	0.069 (0.099)	-8.827 (0.003)	0.444
Listing						
Primary Listing	-0.030 (0.793)	-0.083 (0.765)	0.198 (0.000)	0.008 (0.313)	-1.391 (0.054)	0.358
Secondary Listing	-0.133 (0.260)	-4.866 (0.004)	0.204 (0.000)	0.027 (0.674)	-9.677 (0.045)	0.471
Sector						
Resources	-0.181 (0.110)	-4.881 (0.000)	0.182 (0.000)	0.024 (0.467)	-4.510 (0.126)	0.504
Industrials	-0.019 (0.865)	0.135 (0.868)	0.170 (0.000)	0.021 (0.304)	-7.493 (0.000)	0.363
Financials	0.571 (0.000)	0.015 (0.856)	0.114 (0.024)	0.003 (0.207)	0.057 (0.832)	0.244
Real Estate	0.032 (0.780)	-0.148 (0.457)	0.102 (0.076)	0.027 (0.000)	-0.939 (0.044)	0.266
Credit Quality						
A1	-	-	-	-	-	-
A3	-0.141 (0.222)	-2.565 (0.000)	0.123 (0.000)	0.016 (0.318)	-2.033 (0.109)	0.474
Baa1	-0.227 (0.125)	0.168 (0.044)	0.091 (0.078)	0.005 (0.030)	-0.479 (0.024)	0.197
Baa2	0.033 (0.766)	-1.519 (0.086)	0.145 (0.000)	0.044 (0.119)	-8.921 (0.000)	0.429
Baa3	-0.230 (0.061)	-1.106 (0.024)	0.187 (0.000)	0.043 (0.009)	-3.372 (0.016)	0.430
Ba1	-0.135 (0.290)	-0.042 (0.529)	0.220 (0.000)	0.002 (0.235)	-0.428 (0.037)	0.239
Ba2	-0.171 (0.160)	-0.678 (0.007)	0.209 (0.000)	0.017 (0.019)	-0.562 (0.346)	0.541
Ba3	-	-	-	-	-	-
B2	0.025 (0.800)	-0.122 (0.496)	0.170 (0.002)	0.004 (0.460)	-0.551 (0.209)	0.308
Caa2	0.838 (0.000)	-0.020 (0.688)	-0.062 (0.226)	0.000 (0.732)	-0.116 (0.406)	0.362
NR	-0.114 (0.345)	-0.082 (0.724)	0.140 (0.011)	0.029 (0.000)	-1.824 (0.001)	0.306
WD	-0.254 (0.196)	0.005 (0.144)	0.075 (0.001)	0.000 (0.015)	0.007 (0.423)	0.180

Table 18 presents the estimates for the regression specification given by equation (3). The sum of the estimated coefficients is presented with the corresponding p-values (in parentheses) of the null hypothesis that the sum of the estimated coefficients is statistically equal to zero.

The results show that the most meaningful contributors to corporate bond returns are US treasuries, matching equity and USDZAR exchange rate. The local currency JSE variable, representative of market returns, is shown to not provide much explanatory power which at face value would contradict the findings in Chapter 5.

The first result worth noting is that of US treasury rates. The negative sign on the coefficients indicates that an increase in interest rates is associated with a decrease in aggregate corporate bonds returns. This is relatively consistent across the different stratifications. A notable exception is bonds in the financials sector. Banks would tend to benefit from rising interest rates, given higher net interest margins, so this is not a result which is largely outside expectations. Both the secondary listings and resources sector show the highest sensitivity to the interest rate variable. Table 15 shows that the resource sector index constituents used in this study have relatively high levels of debt and have historically generated poor returns on investment capital (ROIC). Higher interest rates would therefore increase debt repayment costs and potentially make re-financing upcoming bond maturities substantially more challenging. Given the fundamentals of the sector, this sensitivity is within expectations.

In line with results from Downing, Underwood and Xing (2009), this analysis also finds evidence that better-rated issuers exhibit sensitivity to movements in Treasury rates, while lower-rated issuers do not exhibit the same sensitivity, given by more coefficients that are statistically insignificant. This result is expected and reinforces the idea that higher-rate issuers of bonds are sensitive to movements in Treasury rates while lower-rated issuer bonds behave more similarly to equity.

The results for the matching equity index are in line with expectations and support the results shown in Table 17 of a lead-lag relationship at the aggregate level. The VAR analysis is a superior analysis for interpreting the effects across the different stratifications as it allows for an evaluation of the dynamic multivariate relationship to be described. However, the specification shown in Table 18 provides supportive evidence of the predictive relationship between corporate bond and equity returns. It is worth highlighting that the results for the matched equity index show significance at the 5% level of significance, with only two coefficients significant at the 10% level and another one coefficient that is not statistically significant.

Before interpreting the exchange rate variable it is worth discussing the results for the JSE variable which is shown to have little to no explanatory power in the model. As previously indicated, this result may seem surprising given the relative importance of the JSE variable in Chapter 5 where it was found to explain approximately a third of the variance in corporate bond returns. There are two reasons to explain the difference. First, the previous chapter examined the determinants of the long term variance of corporate bond returns while this chapter considers the level of those returns. The second, and most important point is that the JSE variable used in the previous chapter was constructed as total returns in hard currency, US dollars, while the variable here is modelled as local currency, South African rand total returns. This is done to model the spot exchange rate variable separately to better understand and quantify the effect of currency risk on bond returns. Given that secondary listings dominate the index by market cap, it is not surprising that the JSE variable in local currency is statistically insignificant in explaining the level of US dollar denominated corporate bond returns. These are multinational companies whose revenue streams are less leveraged to both the South African real economy and financial markets. The effect of the exchange rate however does show interesting results in the context of this study.

The exchange rate variable specified as spot USD/ZAR is statistically significant for most stratifications included in the analysis. The interpretation of this variable could be oriented from two perspectives.

The first is that of a South African investor holding US dollar-denominated bonds. For this investor, a depreciation of the rand relative to the US dollar (dollar appreciation) is a net positive outcome as the rand depreciation (dollar appreciation) benefits the rand-based investor once the dollar-based investment is converted back to rand-based equivalents. Put differently, rand depreciation would benefit investors currently holding US dollar-denominated bonds since they initiated their holding at a more favourable exchange rate. New investors, however, would be forced to initiate positions at a higher exchange rate. This framework can be extended to any foreign investors whose local currency has depreciated relative to the US dollar. That foreign investor will need to pay a higher US dollar price, *ceteris paribus*, to allocate capital to the bonds after the US dollar has strengthened. US dollar strength is therefore net negative for new foreign investors whose local currencies have depreciated, but net positive for existing investors holding US dollar-based assets. Given that currency pairs are considered, the opposite is true for a US dollar-based investor.

This leads to the second perspective. Consider the US dollar-based investor who is holding these dollar-based bonds in their portfolio. A dollar appreciation (rand depreciation) brings a net negative outcome for the same change in the currency-pair. Put differently, the dollar-based investor experiences the change in bond returns negatively as the investment is dollar-based. Given that the dependent variable in the analysis is bond returns based in US dollars, the negative sign on the exchange rate variable is expected and in line with the argument for the dollar-based investor. While slightly fewer sub-categories are statistically significant compared to the matching equity index results, the size of the sum of the coefficients are largest for the exchange rate variable, emphasising the sensitivity of hard-currency bond returns to movements in exchange rates. This is indicative of the importance and impact that exchange rates play when considering foreign-currency corporate bond returns, both from the perspective of the dollar-based investor as well as the rand-based investor.

The expectation is that dollar strength detracts from the returns of dollar-based investments. An important input that is outside the scope of this analysis is the absolute and relative valuation of the US dollar relative to the rand or any other foreign currency. Capital markets are forward looking. If investors expect the dollar to continue to strengthen or appreciate relative to their local currency, then it could be assumed that those investors would seek to initiate investment positions before any increase in exchange rate. However, this ignores valuation. If the dollar is considered to be relatively expensive versus its fair value, then continued dollar strength would most likely deter foreign investors from allocating any capital.

The results presented in Table 18 show that, the USD/ZAR exchange rate is statistically significant for at the aggregate corporate bond index level. Other notable relationships are shown for sector stratification, where at the 1% level of significance, Industrials are evidenced to be meaningfully affect by changes in the USDZAR exchange rate. Significant results can also be seen for both the Secondary Listings and High Duration stratifications, where currency sensitivity is shown to be very high. In terms of the magnitude of change given a change in any of the modelled variable, the results for the USDZAR exchange rate are the most significant. The negative sign is also expected based on the explanation provided above of foreign versus US investors. This is consistent with Wong and Li (2010). Rand depreciation (or increases in the USDZAR exchange rate) is negatively related to total returns on US dollar-denominated bonds. Markets are forward looking, and new foreign investors are unlikely to allocate capital with persistent dollar strength. Another potential explanation is that at the firm specific level, a strengthening dollar reduces the foreign earnings of multinational companies, which, *ceteris paribus*, will negatively affect debt serviceability on outstanding bonds. Considering that Industrials were shown to highly leveraged in Table 2, this would at face value appear to be a plausible explanation.

6.6 Limitations

It is important to interpret these results within the constraints and limitations of the study. As previously indicated, the most obvious constraint is the availability and granularity credit rating data at the bond specific level. For purposes of comparability with the previous literature contributions examining lead lag effects in cross asset markets, an attempt has been made to mitigate this constraint by modelling credit risk at the constituent company level and apply that issuer foreign currency rating across the bonds outstanding in the constituent bond portfolio. While this does allow for relatively meaningful observation and testing at the broader investment grade versus high yield issuer type, it does not necessarily capture the underlying credit, default and liquidity risk in the underlying constituent bond portfolios. Put differently, the approach is useful for aggregating general credit quality at the issuer level, but may not capture the investment risk of the bonds that a specific issuer has outstanding.

The time series considered is relatively short. Analysis of lead-lag causality and market informational efficiency usually require longer time series data to produce reliable inferences and conclusions. That being said, the data used in this analysis represents a 12-year period which is longer than Kwan (1996), Downing, Underwood and Xing (2009) and Tolikas (2018). However, their sample sizes were bigger than the sample analysed in this study. It should further be noted that the sample size used in this thesis comprises the whole universe of fixed rate hard currency bond in issue by companies with JSE listings. The smaller sample size is therefore more an outcome of the relatively young, emerging market nature of the full investable universe, as opposed to omitting any bonds for the data.

6.7 Conclusion

In this chapter, the correlation between the returns on equities and the total returns on bonds issued by the same firm is examined. The weekly returns of the market capitalisation index (*marketcap* index) and a comparative equity market index is used to examine the informational efficiency of foreign-currency denominated bonds relative to equity in a developing country setting. This contribution to the literature is timely as it is one of the first studies to examine a foreign-currency corporate bond index and relate it to an equivalent equity index in a developing country. This will improve our knowledge of information flows between asset markets.

This chapter finds that the informational efficiency of the foreign currency denominated equity market is superior to that of the corresponding corporate bond market at the aggregate index level. The results of the Granger causality tests, interpreted at the 1% level of significance, show that past equity returns have predictive power for current bond returns, but that past bonds returns do not predict current equity returns.

The general results presented in this chapter are most consistent with Downing, Underwood, and Xing (2009) who find that equities leading bonds is consistent for both investment and non-investment grade issuers. The results would seemingly contradict Hotchkiss and Ronen (2002), who find no evidence of equity markets systematically leading corporate bond markets. Both of these previous contributions, however, are done at the firm specific level while findings here are presented at the aggregate index level.

Hong et (2012) does find some evidence of bond returns leading equity returns at the aggregate index level when data from the 2008 financial crisis is included in the sample. Given that the sample period in this chapter included the market shock in 2008, there is no evidence to support that conclusion. For the entire 12-year period, this thesis finds no evidence of bonds leading equities. This is consistent at the aggregate level as well as at the presented at the listing, issuer, credit rating and duration segments. Furthermore, there is also evidence for any period making up the 12-year time series of bonds leading equities or equities lagging bonds. Put differently, using weekly data, and up to 8 lags, historical bond returns have displayed no evidence of predicting current equity returns.

The assertions that high yield bonds may have some predictive power for equity markets as presented by Zhou (2006), Mao (2012), Bittlingmayer and Moser (2014) is also not supported by the results in this chapter. However, it is conceded that given the lack of granular ratings data at the bond specific level, that findings presented here are not necessarily conclusive enough to draw inferences from.

The conclusions of Ronen and Zhou (2013) are especially interesting in the context of this chapter. They found evidence of equities leading corporate bonds in the OTC market and with specific regards to institutional investors. Give that almost half the bonds in the sample used in this study are traded by professional investors in OTC markets where trading information is not disseminated in line with TRACE, their study most closely approximates the structure of the corporate bond market examined here.

This chapter adds to the literature on hard currency corporate bonds by being the first to identify the superior informational efficiency of comparable equities in an African and emerging market context. Findings are especially relevant for market practitioners given that the underlying issuers, especially those in the Resources and Industrials sector are sizeable positions in JSE All-Share and Top 40 indices and would have exposure in client equity and multi-asset portfolios with JSE linked benchmarks. Bonds and equity do not operate independently at the firm specific level with companies have the option to raise capital either through debt or shares issuance. Understanding the co-movement and predictive power of both bonds and equities can potentially improve the risk management framework used across client investment portfolios. Systematically monitoring changes in equity returns could therefore identify future return enhancement opportunities when equity markets are strong, and flag the need for potential risk mitigation strategies for corporate bond exposure when equity are relatively weak. This does not suggest trading bonds pro-cyclically. The findings in this chapter suggest that given the greater evidenced informational efficiency at the aggregate level, in investment grade issuers and in the Resources and Industrials sectors, that risk management process can be augmented by considering that the respective bond market may not have priced in any new information. While this chapter finds no evidence of bonds leading equities, the results are relatively compelling at the 1% level of significance that past equity returns may provide high explanatory power for less efficient bonds.

Chapter 7 | Conclusion

7.1 Key Findings

The stated intention of this thesis was to construct a JSE foreign currency corporate bond index and identify the determinants of both the level and variance of returns at the aggregate index level. This has been examined through three substantive chapter, each of which followed a delineated approach to investigate key aims and objectives.

The first substantive chapter constructed both traditional market and fundamental indices to evaluate the performance of hard currency corporate bonds. The fundamental indices are shown to be more mean-variance efficient, deliver superior average, annualised and cumulative returns, and take on lower levels of total, systematic and downside risk. The sales index was evidenced to deliver the highest levels of outperformance against the market cap reference portfolio. Portfolio attribution at the sector level also showed that only the sales index delivered a positive allocation effect over the full sample period. However, that outperformance is underpinned by a strong overweight Resources position relative to the benchmark, and is shown to be relatively lumpy over the 12-year period between January 2008 and December 2019.

Despite generating significant alpha over the period, the sales outperformance started to narrow towards the end of the sample period. All fundamental portfolios are however shown to deliver statistically significant excess return, but that outperformance is predominantly supported by security selection with no evidence of asset allocation adding any value over the benchmark. The findings in this chapter are mostly consistent with previous contributions to the literature including the seminal equity contribution by Arnott, Hsu and Moore (2005) who also found that the sales index delivers superior mean variance returns.

While risk-adjusted analysis and portfolio sector attribution are useful in quantifying historical performance, a more forward-looking or predictive framework is required to evaluate both the volatility and level of corporate bond returns. The second substantive chapter used a GARCH-MIDAS methodology to examine the importance of both macroeconomic and financial variables in accounting for the variation in long-term corporate bond returns. The equity market literature on long-term return volatility supports the importance of RV as a predictor of future volatility (see Asgharian, Hou and Javed, 2013 and Engle, Ghysels and Sohn, 2013). However, the findings in this analysis do not lead to the same conclusions. Instead, the results of this analysis confirm that in the context of a foreign-currency denominated corporate bond market, RV is not a statistically significant predictor of long-term bond returns. This analysis confirms the contribution of macroeconomic and financial volatility over level-specifications in explaining long-term variation in bond returns. This is consistent with findings from Nieto, Novales and Rubio (2015) who also examine the bond market and Conrad and Loch (2015) and Engle, Ghysels and Sohn (2013) who examine equity markets. The most encouraging finding is the importance of JSEALLR as a predictor of long-term corporate bond return volatility. To the best of the author's knowledge, this is the first contribution to the emerging market literature to show the importance of stock market returns for predicting the long-term volatility of corporate bond returns. The volatility of US dollar JSE returns is shown to explain around 30% of volatility in weekly corporate bond returns. The significance of the finding extends to market practitioners such as fund managers who have the ability to allocate capital to both equities and bonds. Fixed income managers allocating to hard-currency bonds could use the long-term volatility of dollar-based JSE returns to potentially flag any stress in corresponding bond markets. Supplementing existing investment process with screening that flags long-term trends in the equity market could potentially both identify opportunities in bond and fixed income mandates, or act as an early warning signal of market stress. In addition to JSE total return, the parameter estimates for South African industrial production and the default variable are also statistically significant in explaining long-term corporate bond market volatility. This finding is less surprising and in keeping with international literature, including Asgharian, Hou and Javed (2013), Nieto, Novales and Rubio (2015) and Engle, Ghysels and Sohn (2013).

The final substantive chapter in this thesis constructed matching corporate bond and equity portfolios to examine the informational efficiency of both asset classes. A VAR and Granger causality analysis examining the co-movement between bonds and equity showed that equities lead corporate bonds at both the aggregate and IG issuer level. This is consistent with Downing, Underwood, and Xing (2009) who show that equities leading bonds is consistent for both IG and HY issuers. At the sector level, Resources and Industrial equity are also shown to be more informationally efficient than bonds in those sectors. The unidirectional granger causality displayed by these categories provide further evidence for the findings at the aggregate index level of relatively more informationally efficient equity markets compared to bond markets.

Segmenting the data by listing type shows both primary listing and secondary listings exhibiting bi-directional granger causality. The same findings apply to non-investment grade bonds which show no leading effect over equities as some other contributions including Zhou (2006), Mao (2012), Bittlingmayer and Moser (2014) have presented. This result was slightly outside expectations given the international, and US evidence, in particular. It is however conceded that price discovery on US HY issuers, with a more defined peer set, and wider market breadth, is not necessarily comparable to the trading on the hard currency HY index studies here. In the absence of TRACE or other liquidity data, any interpretation would amount to speculation. Other segments showing bi-directional granger causality are real estate as well as high duration bonds and equity. These results show that across these sub-categories, both the corporate bond and equity markets may be assumed to be equally informationally efficient.

An important final observation to note is that at the aggregate level, and across all the categorical breakdowns, no evidence is found for bonds leading equity. While 9 sub-category indices are found to display bi-directional Granger causality, and 5 are found to exhibit independence, that is neither granger causality nor bi-directional granger causality, no category displays granger causality in the form of bond returns leading equity returns.

The USD/ZAR exchange rate variable showed results that initially seemed counterintuitive. However, interpreting these results from the perspective of a rand-based or foreign investor would support the negative sign of the coefficients. An increase in the USDZAR exchange rate, or dollar appreciation relative to the rand, is shown to contribute to a decline in the level of US-Dollar denominated returns. While dollar appreciation would benefit existing rand-based investors following a strengthening of the currency, all other things being equal, new rand-based investors would be forced to pay a higher dollar price to initiate a position in those bonds. Because markets are forward looking and largely pricing in future expected returns, a risk to new investors is that they will experience a drawdown on both the currency (from dollar weakness) and the underlying asset (falling dollar price). There are some nuances to this which make the analysis challenging. Currency valuation is largely outside the scope of this thesis, but it would be reasonable to expect the magnitude of the bond drawdown to be partially dependant on investors' expectations around the fundamental or technical valuation of the dollar relative to the rand.

The exchange rate finding has important implications for market practitioners. In light of the increased allowance permitted under Reg 28 for fund managers to allocate up to 45% more capital offshore, the evidence here would suggest that portfolio managers should define clear parameters in term of managing offshore bond exposure. Reviewing existing investment process to ensure offshore bond positions are supported by appropriate mandate specific limits would be a responsible way to manage client portfolios.

7.2 Avenues for Future Research

The first chapter of this thesis highlighted several limitations of this study. While the findings contained in this thesis are encouraging and satisfy the stated intention, aims and objectives, the results open up areas for further research in a number of ways.

In Chapter 4 the market cap index was constructed to provide a benchmark for analysis as one currently does not exist. However, the time series created is relatively short given the stated data limitations. Financial markets have been especially turbulent since the end of 2019 and many economies experienced significant differences in government intervention to contain the fallout from the pandemic. It remains critically important to understand the impact of unexpected events, at local or global level, on domestic bond and equity markets. Extending the time series to include the subsequent pandemic era would contribute to the literature, both domestically and internationally and allow for analysis that could include important variation in economic continuity. By extending the time period of analysis across the traditional market cap and fundamental indices the research would provide important information about the impact of structural breaks in financial markets, especially a developing market setting like South Africa. This type of analysis is currently very limited in a South African context considering data transparency issues.

By generating the extended time series that captures periods of economic uncertainty, applying the analyses of Chapters 5 and 6 would provide informational content beyond the contribution of this thesis. The extended time series would allow for improved precision in future forecasting ability due to the nature of economic uncertainty experienced since 2020.

The results in this thesis emphasise the importance of the equity market to the bond market in South Africa in both the short and long-term. This is confirmed by the results in Chapter 5 from both the volatility specifications and the variance ratio analysis. In addition, the analysis in Chapter 6 confirmed the strong relationship between listed equity and bond markets. Extending the methodologies applied Chapter 5 to an examination anchoring on equity markets will provide market practitioners and fund managers with even more nuanced information that may contribute to improved decision-making processes at an industry and a manager-specific level. This type of information would be especially useful for use in evaluating the forecasting ability within the two key asset classes. This would further provide a read-through from equity to bond markets, allowing for improved understanding of how the two asset classes interact when coupled with the research presented in this thesis to create consolidated evidence from both sides.

It is especially useful to conduct these studies at a country-specific level given that individual economies are likely to show different sensitivities to real economy and financial variables depending on the structure and composition of their capital markets. That being said, consolidating this type of research across emerging market peer sets would also allow for common factors affecting those groups of constituent companies to be assessed. Furthermore, undertaking the research on emerging-market peer sets will allow for a better understanding of the idiosyncrasies of economies to be identified.

In addition to further study on bond and equity markets, the methodology adopted in this thesis can be applied to the analysis of sovereign or government hard-currency issuance with a specific focus on African and South American economies whose currencies are especially leveraged to commodities.

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Appendix A

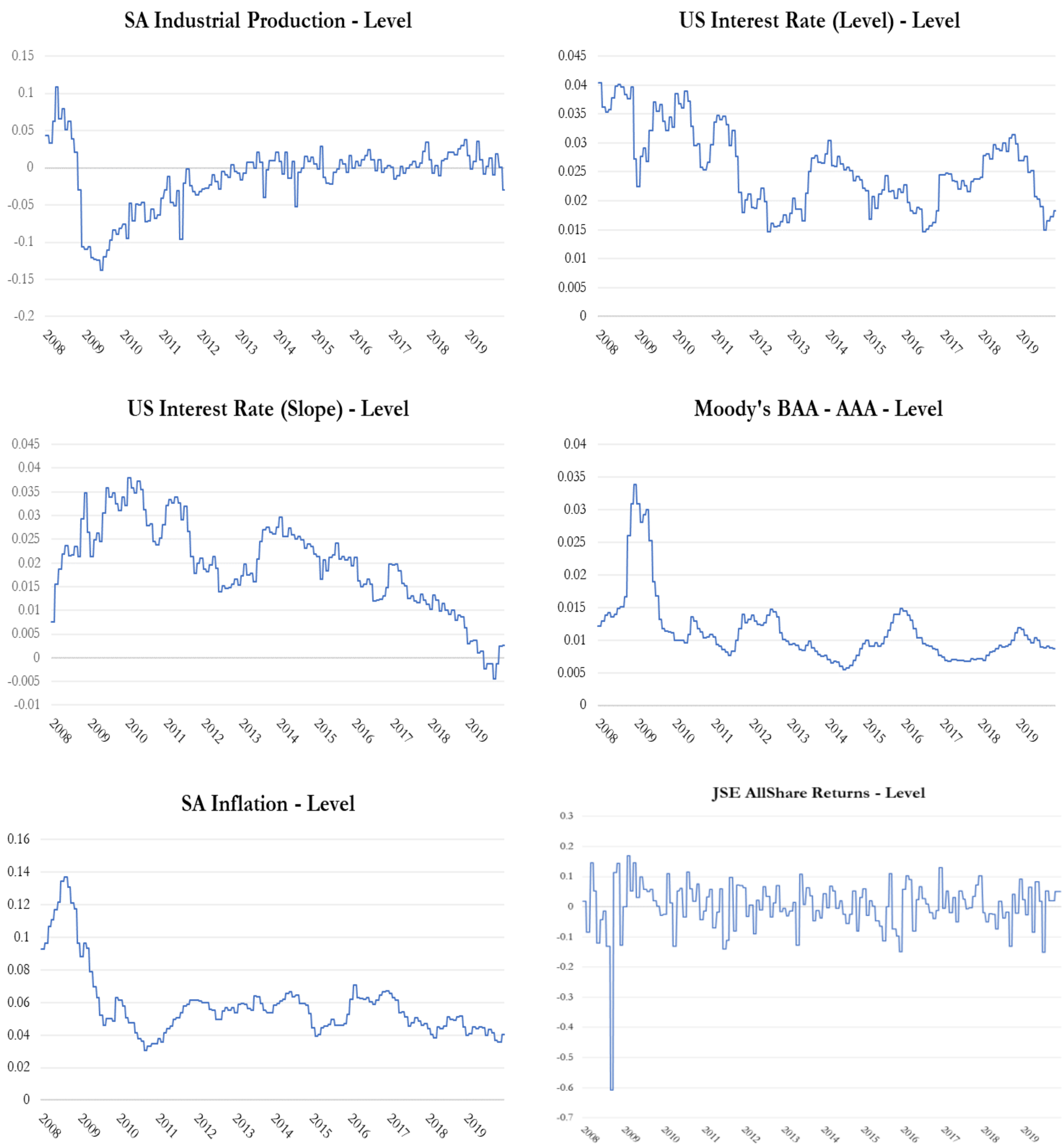
Table 19: Augmented Dickey-Fuller (ADF) tests

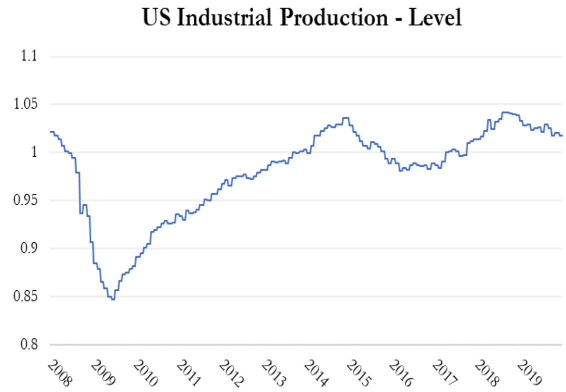
	Augmented Dickey-Fuller (Level)	Augmented Dickey-Fuller (Volatility)
Market Capitalisation		-7.582***
Sales		-7.344***
Book Value		-7.069***
Cash Flow		-7.346***
Composite		-7.254***
SAIP	-4.965**	-7.380***
Level	-7.390***	-6.799***
Slope	-10.448***	-10.448***
Default	-5.472***	-6.619***
SAInf	-4.513**	-6.869***
JSEALLR	-3.892**	-6.286***
USREER	-5.127***	-5.904***
USIP	-4.090**	-6.822***

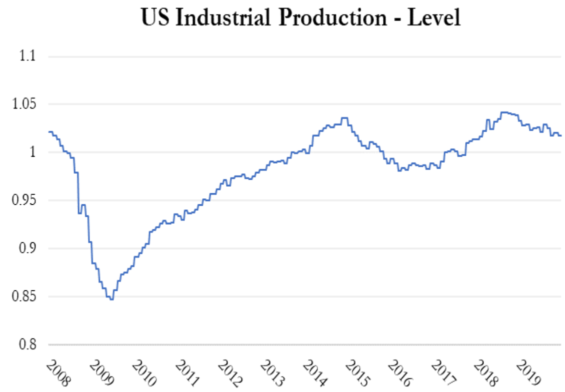
Note: The table shows the ADF test statistics for all the variables used the analysis in this chapter. *, ** and *** denotes rejection of the null hypothesis of the presense of a unit root at the 10%, 5% and 1% level of significance respectively.

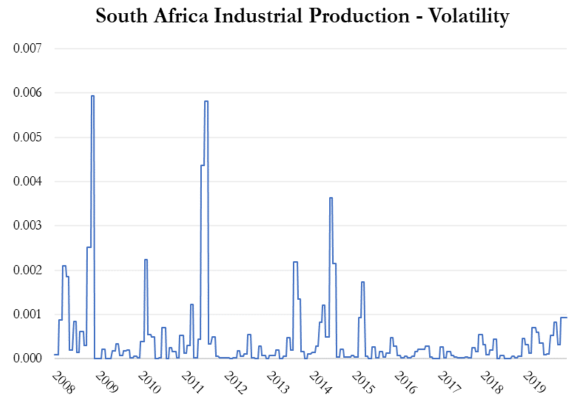
Plot of the economic variables: The levels and volatility of the macroeconomic variables. The data covers the period 1 January 2008 to 31 December 2019.

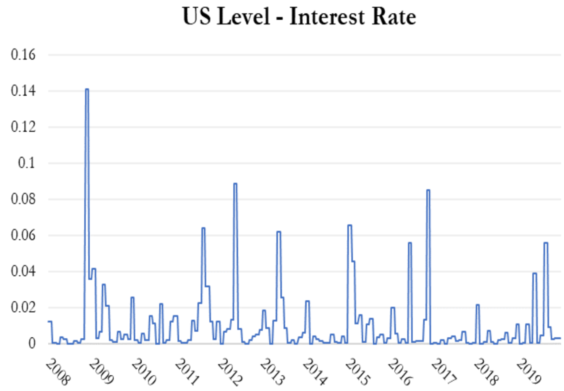
Figure 20: Plot of macroeconomic and financial variables (level and volatility)

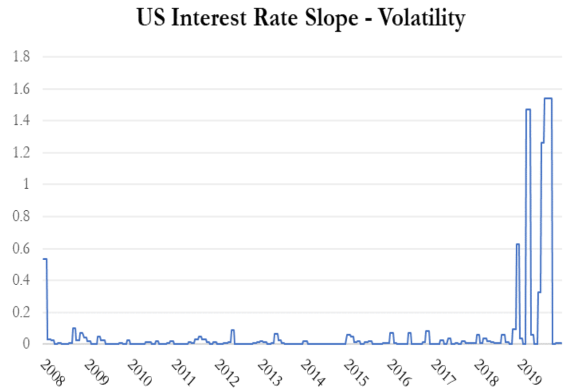


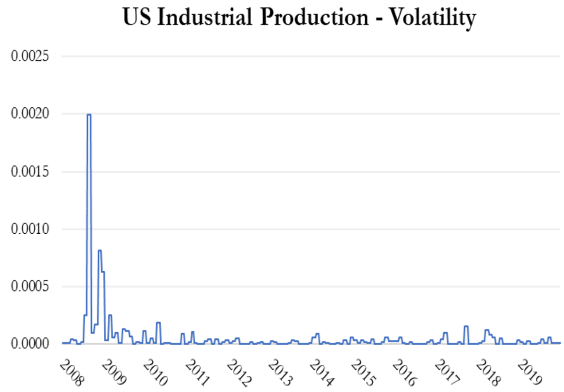

US Industrial Production - Level
1.1
1.05
1
0.95
0.9
0.85
0.8
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019


US Industrial Production - Level
1.1
1.05
1
0.95
0.9
0.85
0.8
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019


South Africa Industrial Production - Volatility
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019

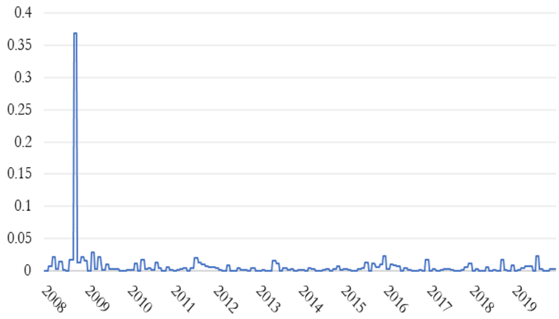

US Level - Interest Rate
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019


US Interest Rate Slope - Volatility
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019

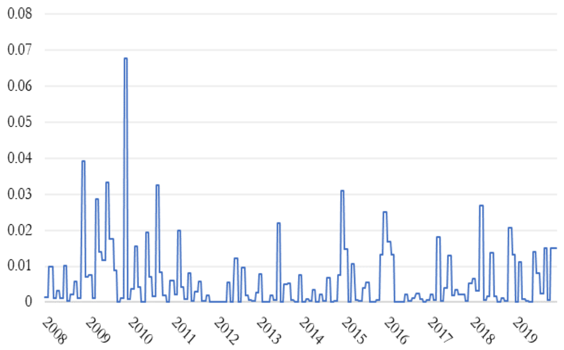

US Industrial Production - Volatility
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019

US Real Effective Exchange Rate - Level

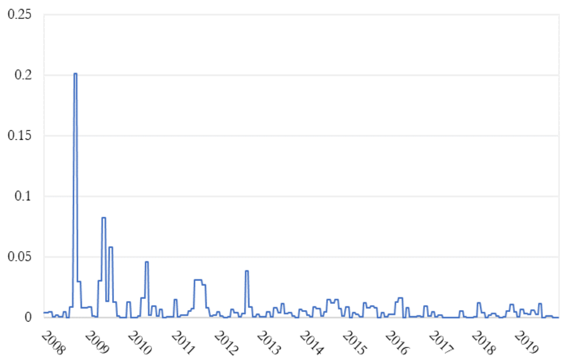
Johannesburg Stock Exchange All Share Return Index - Volatility



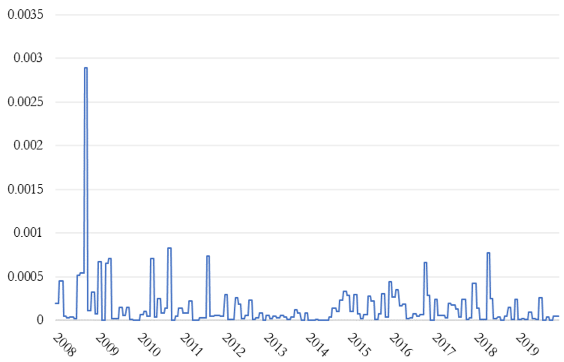
South Africa Inflation - Volatility



Moody's BAA - AAA - Volatility



US Real Effective Exchange Rate - Volatility



Comparison of long-term, short-term and total variance: The long-term, short-term and total variance estimated by the GARCH-MIDAS model.

Figure 21: GARCH-MIDAS with RV

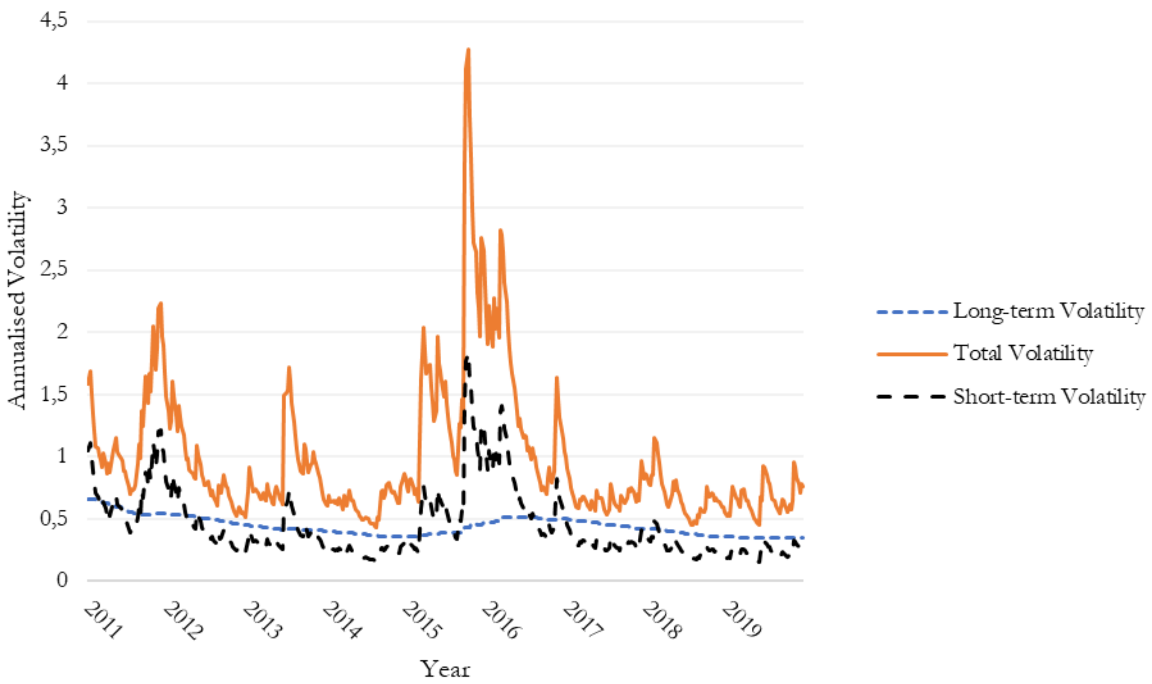


Table 20: Parameter estimates of GARCH-MIDAS - SAIP

Level Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.046	0.087***	0.863***	-7.048*	3.896	7.427*	453
	(0.028)	(0.004)	(0.053)	(3.885)	(5.096)	(3.901)	944
Sales	0.064**	0.128***	0.805***	-4.559	4.111	0.374***	440
	(0.026)	(0.031)	(0.052)	(3.822)	(7.919)	(0.063)	919
Book Value	0.055*	0.081***	0.868***	-2.341	4.517	0.363***	436
	(0.028)	(0.031)	(0.049)	(3.386)	(15.539)	(0.059)	910
Cash Flow	0.062**	0.064**	0.862***	-3.441	3.529	0.319***	421
	(0.027)	(0.030)	(0.076)	(2.717)	(7.485)	(0.047)	879
Composite	0.060**	0.080***	0.866***	-3.362	3.976	0.339***	427
	(0.027)	(0.031)	(0.055)	(3.299)	(8.989)	(0.055)	893

Volatility Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.048*	0.075**	0.877***	2413.7***	1.257***	-1.864***	452
	(0.027)	(0.032)	(0.059)	(756.03)	(0.249)	(0.355)	941
Sales	0.066**	0.131***	0.774***	2135***	1.237***	-1.807***	437
	(0.026)	(0.036)	(0.069)	(675.05)	(0.348)	(0.323)	912
Book Value	0.055**	0.077***	0.879***	316.32	6.052	-1.074***	436
	(0.027)	(0.029)	(0.047)	(396.07)	(8.889)	(0.201)	910
Cash Flow	0.070***	0.138**	0.449	1995.1***	1.115***	-1.905***	417
	(0.025)	(0.066)	(0.330)	(464.59)	(0.223	(4.995)	871
Composite	0.064**	0.065**	0.883***	1869.4***	1.247***	-1.792***	425
	(0.027)	(0.031)	(0.063)	(706.82)	(0.353)	(0.324)	888

Note: This table provides estimates of the GARCH-MIDAS model for the level and volatility specifications for the conditional variance of corporate bond returns. The weighting scheme is the "Beta" function and K = 36 (3 MIDAS years). Weekly bond market return data from January 2008 to December 2019 is used.

Table 21: Parameter estimates of GARCH-MIDAS - Level

Level Specification

	μ	*a*	*β*	*θ*	*w*	*m*	*LLF/BIC*
Market Capitalisation	0.048*	0.106***	0.863***	-28.932*	50	1.164**	452
	(0.028)	(0.035)	(0.504)	(16.146)	(102.73)	(0.483)	943
Sales	0.066**	0.137***	0.809***	-22.49	50	0.959***	440
	(0.026)	(0.034)	(0.055)	(13.677)	(134.06)	(0.367)	917
Book Value	0.057**	0.084***	0.87***	-17.302	50	0.798***	434
	(0.027)	(0.032)	(0.052)	(11.043)	(136)	(0.288)	907
Cash Flow	0.063**	0.071**	0.884***	-16.235*	49.99	0.739***	420
	(0.027)	(0.031)	(0.056)	(9.135)	(126.6)	(0.243)	877
Composite	0.062**	0.088***	0.867***	-17.782	50	0.796***	427
	(0.027)	(0.033)	(0.056)	(10.82)	(137.3)	(0.288)	892

Volatility Specification

	μ	*a*	*β*	*θ*	*w*	*m*	*LLF/BIC*
Market Capitalisation	0.049*	0.106***	0.869***	14.05*	50	0.378***	447
	(0.027)	(0.032)	(0.044)	(7.462)	(43.868)	(0.129)	934
Sales	0.069***	0.129***	0.831***	25.12**	50	-1.134***	433
	(0.025)	(0.029)	(0.046)	(9.945	(47.815)	(0.271)	904
Book Value	0.059**	0.083***	0.882***	21.583**	50	-1.180***	429
	(0.026)	(0.029)	(0.044)	(8.579)	(49.556)	(0.021)	896
Cash Flow	0.065**	0.056***	0.918***	22.844***	50	-1.295***	413
	(0.025)	(0.024)	(0.043)	(7.971)	(41.488)	(0.229	864
Composite	0.066	0.080	0.889	23.229	50	-1.245	420
	(0.025)	(0.028)	(0.044)	(8.553)	(44.572)	(0.243)	878

Note: This table provides estimates of the GARCH-MIDAS model for the level and volatility specifications for the conditional variance of corporate bond returns. The weighting scheme is the "Beta" function and K = 36 (3 MIDAS years). Weekly bond market return data from January 2008 to December 2019 is used.

Table 22: Parameter estimates of GARCH-MIDAS - Slope

Level Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.045*	0.1***	0.833***	19.302***	1.181	0.033	453
	(0.027)	(0.034)	(0.063)	(7.801)	(1.099)	(0.159)	944
Sales	0.063**	0.142***	0.761***	18.589***	1.104	0.024	439
	(0.026)	(0.036)	(0.067)	(7.210)	(0.970)	(0.146)	916
Book Value	0.055**	0.078**	0.861***	12.345*	1.183	0.125	435
	(0.027)	(0.031)	(0.057)	(7.290)	(1.462)	(0.153)	908
Cash Flow	0.065**	0.129**	0.492*	14.515***	1.171	0.047	419
	(0.025)	(0.063)	(0.270)	(4.261)	(0.846)	(0.089)	876
Composite	0.061**	0.091***	0.820***	14.494**	1.147	0.066	427
	(0.026)	(0.035)	(0.076)	(6.167)	(1.076)	(0.129)	892

Volatility Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.039	0.108***	0.875***	-0.168	50	-0.5184	453
	(0.028)	(0.034)	(0.043)	(0.228)	(121.75)	(0.437)	944
Sales	0.061**	0.123***	0.844***	-0.167	50	-0.829***	439
	(0.026)	(0.027)	(0.039)	(0.249)	(133.26)	(0.292)	916
Book Value	0.051*	0.088***	0.871***	-0.132	50	-0.946***	435
	(0.027)	(0.030)	(0.044)	(0.221)	(149.85)	(0.198)	908
Cash Flow	0.057**	0.071**	0.891***	-0.134	50	-1.042***	421
	(0.027)	(0.028)	(0.051)	(0.219)	(148.24)	(0.188)	879
Composite	0.056**	0.087***	0.878***	-0.146	50	-0.982***	427
	(0.027)	(0.030)	(0.044)	(0.226)	(138.54)	(0.227)	891

Note: This table provides estimates of the GARCH-MIDAS model for the level and volatility specifications for the conditional variance of corporate bond returns. The weighting scheme is the "Beta" function and K = 36 (3 MIDAS years). Weekly bond market return data from January 2008 to December 2019 is used.

Table 23: Parameter estimates of GARCH-MIDAS - Default

Level Specification

	μ	a	β	θ	w	m	*LLF/BIC*
Market Capitalisation	0.039	0.085**	0.88***	66.109**	50	-0.166	453
	(0.028)	(0.034)	(0.051)	(26.033)	(120.02)	(0.217)	944
Sales	0.061**	0.111**	0.836***	50.782**	50	-0.064	439
	(0.026)	(0.032)	(0.053)	(25.643)	(149.74)	(0.229)	917
Book Value	0.052*	0.078**	0.872***	27.372	49.999	0.126	435
	(0.028)	(0.032)	(0.053)	(20.402)	(235.7)	(0.185)	909
Cash Flow	0.061**	0.137**	0.602***	39.414**	50	-0.019	421
	(0.026)	(0.065)	(0.211)	(17.452)	(143.53)	(0.153)	880
Composite	0.057**	0.077**	0.873***	36.869*	50	0.022	427
	(0.027)	(0.035)	(0.058)	(21.431)	(171.71)	(0.192)	894

Volatility Specification

	μ	a	β	θ	w	m	*LLF/BIC*
Market Capitalisation	0.043	0.091***	0.834***	63.004***	2.061**	0.055	453
	(0.027)	(0.034)	(0.066)	(20.427)	(0.973)	(0.097)	944
Sales	0.063**	0.135***	0.772***	129.22**	3.297*	-1.663	439
	(0.026)	(0.035)	(0.065)	(55.644)	(1.794)	(0.352)	916
Book Value	0.055**	0.073**	0.876***	76.708*	3.259	-1.415***	435
	(0.027)	(0.030)	(0.054)	(44.605)	(2.841)	(0.271)	908
Cash Flow	0.065**	0.132**	0.428	131.24***	2.834***	-1.841***	417
	(0.025)	(0.060)	(0.286)	(37.16)	(1.039)	(0.224)	872
Composite	0.061**	0.073**	0.864***	110.76**	3.105**	-1.667***	429
	(0.026)	(0.031)	(0.065)	(51.535)	(1.763)	(0.324)	891

Note: This table provides estimates of the GARCH-MIDAS model for the level and volatility specifications for the conditional variance of corporate bond returns. The weighting scheme is the "Beta" function and K = 36 (3 MIDAS years). Weekly bond market return data from January 2008 to December 2019 is used.

Table 24: Parameter estimates of GARCH-MIDAS - SAInf

Level Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.045	0.071***	0.92***	-29.407*	6.213	2.096	454
	(0.027)	(0.026)	(0.030)	(17.62)	(4.056)	(1.154)	946
Sales	0.064**	0.131***	0.824***	-0.577	44.75	0.431***	441
	(0.026)	(0.030)	(0.047)	(0.985)	(134.09	(0.102)	920
Book Value	0.055**	0.089***	0.863***	-3.365	2.215	0.377***	436
	(0.027)	(0.031)	(0.047)	(4.501)	(2.745)	(0.067)	909
Cash Flow	0.060**	0.071**	0.880***	-2.543	1.706	0.345***	422
	(0.027)	(0.030)	(0.057)	(3.552)	(1.842)	(0.055)	882
Composite	0.060**	0.088***	0.868***	-2.739	2.057	0.365***	428
	(0.027)	(0.031)	(0.048)	(4.407)	(2.935)	(0.071)	894

Volatility Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.041	0.091***	0.874***	105.21	1.914	-1.389***	454
	(0.028)	(0.032)	(0.047)	(71.432)	(1.711)	(0.426)	947
Sales	0.063**	0.117***	0.842***	24.15	19.149	-0.980***	440
	(0.026)	(0.026)	(0.042)	(27.752)	(49.24)	(0.251)	920
Book Value	0.053*	0.081***	0.868***	49.704	3.956	-1.126***	436
	(0.027	(0.030)	(0.048)	(71.215)	(6.437)	(0.383)	910
Cash Flow	0.057**	0.056**	0.887***	95.032***	1.916**	-1.576***	421
	(0.027)	(0.027)	(0.064)	(55.451)	(1.314)	(0.293)	880
Composite	0.058**	0.079***	0.877***	61.275	4.078	-1.313***	428
	(0.027)	(0.029)	(0.048)	(72.259)	(5.426)	(0.392)	895

Note: This table provides estimates of the GARCH-MIDAS model for the level and volatility specifications for the conditional variance of corporate bond returns. The weighting scheme is the "Beta" function and K = 36 (3 MIDAS years). Weekly bond market return data from January 2008 to December 2019 is used.

Table 25: Parameter estimates of GARCH-MIDAS - JSEALLR

Level Specification

	μ	α	β	θ	w	m	*LLF/BIC*
Market Capitalisation	0.051***	0.092***	0.882***	-4.865	5.706	0.507***	453
	(0.028)	(0.035)	(0.047)	(7.026)	(9.426)	(0.147)	945
Sales	0.067**	0.115***	0.846***	-16.926***	1.459***	0.507***	439
	(0.026)	(0.032)	(0.045)	(6.252)	(0.277)	(0.131)	916
Book Value	0.062**	0.076**	0.881***	-3.915	5.818	0.398***	434
	(0.028)	(0.033)	(0.053)	(4.339)	(8.064)	(0.073)	907
Cash Flow	0.067**	0.065**	0.884***	-3.049	6.561	0.361***	420
	(0.027)	(0.029)	(0.061)	(3.961)	(10.199)	(0.057)	879
Composite	0.062**	0.086***	0.872***	-15.382***	1.355***	0.451***	426
	(0.026)	(0.033)	(0.051)	(4.767)	(0.216)	(0.098)	890

Volatility Specification

	μ	α	β	θ	w	m	*LLF/BIC*
Market Capitalisation	0.046*	0.062**	0.932***	120.65***	19.628*	-0.806	448
	(0.027)	(0.025)	(0.028)	(53.816)	(13.132)	(0.263)	935
Sales	0.066***	0.054**	0.933***	146.68***	18.353**	-1.485***	433
	(0.025)	(0.021)	(0.030)	(41.751)	(7.716)	(0.359)	906
Book Value	0.058**	0.051**	0.921***	103.32***	23.535**	-1.394***	430
	(0.027)	(0.024)	(0.041)	(34.039)	(11.345)	(0.205)	898
Cash Flow	0.062**	0.126**	0.591***	118.51***	20.646**	-1.5391***	416
	(0.025)	(0.059)	(0.222)	(41.057)	(10.29)	(0.169)	870
Composite	0.061**	0.046**	0.933***	115.3***	20.245**	-1.471***	421
	(0.026)	(0.207)	(0.035)	(38.351)	(9.852)	(0.252)	882

Note: This table provides estimates of the GARCH-MIDAS model for the level and volatility specifications for the conditional variance of corporate bond returns. The weighting scheme is the "Beta" function and K = 36 (3 MIDAS years). Weekly bond market return data from January 2008 to December 2019 is used.

Table 26: Parameter estimates of GARCH-MIDAS - USREER

Level Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.045*	0.107***	0.866***	69.916*	1.536**	0.474*	453
	(0.027)	(0.034)	(0.046)	(36.232)	(0.643)	(0.159)	946
Sales	0.066**	0.125***	0.831***	45.614	1.909	0.399***	439
	(0.026)	(0.032)	(0.046)	(28.861)	(1.345)	(0.108)	917
Book Value	0.064**	0.079**	0.883***	12.468	12.278	0.382***	434
	(0.028)	(0.032)	(0.049)	(9.230)	(11.586)	(0.077)	907
Cash Flow	0.066**	0.064**	0.894***	7.757	12.949	0.347***	421
	(0.027)	(0.029)	(0.054)	(7.120)	(18.089)	(0.061)	880
Composite	0.067**	0.081**	0.881***	11.29	9.716	0.366***	427
	(0.027)	(0.032)	(0.051)	(9.908)	(12.297)	(0.078)	893

Volatility Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.049*	0.084***	0.880***	2448.7*	20.678	-1.129***	452
	(0.027)	(0.031)	(0.050)	(1351)	(15.857)	(0.281)	944
Sales	0.069***	0.103***	0.856***	1709	30.76	-1.103***	439
	(0.026)	(0.026)	(0.043)	(1305.6)	(33.366)	(0.275)	917
Book Value	0.058**	0.074**	0.873***	1643.1	19.334	-1.171***	435
	(0.027)	(0.030)	(0.052)	(1317.6)	(22.433)	(0.221)	909
Cash Flow	0.065**	0.058**	0.893***	1490.5	45.197	-1.233***	420
	(0.026)	(0.028)	(0.062)	(932.11)	(47.91)	(0.182)	878
Composite	0.064**	0.071**	0.886***	1716.6	28.216	-1.215***	427
	(0.026)	(0.029)	(0.0520	(1129.1)	(27.257)	(0.224)	892

Note: This table provides estimates of the GARCH-MIDAS model for the level and volatility specifications for the conditional variance of corporate bond returns. The weighting scheme is the "Beta" function and K = 36 (3 MIDAS years). Weekly bond market return data from January 2008 to December 2019 is used.

Table 27: Parameter estimates of GARCH-MIDAS - USIP

Level Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.045	0.103***	0.865***	-21.064	50	0.495***	453
	(0.027)	(0.033)	(0.049)	(15.278)	(74.046)	(0.134)	944
Sales	0.062**	0.123***	0.827***	-54.154	5.131	0.492***	439
	(0.026)	(0.031)	(0.048)	(46.934)	(5.918)	(0.121)	918
Book Value	0.051*	0.085***	0.856***	-60.908	2.676	0.467***	434
	(0.027)	(0.031)	(0.055)	(39.702)	(1.372)	(0.090)	907
Cash Flow	0.059**	0.077**	0.858***	-31.344	7.096	0.388***	420
	(0.026)	(0.033)	(0.072)	(27.708)	(8.439)	(0.069)	879
Composite	0.057**	0.086***	0.862***	-43.835	4.958	0.428***	427
	(0.027)	(0.032)	(0.056)	(37.403)	(5.523)	(0.091)	892

Volatility Specification

	μ	a	β	θ	w	m	LLF/BIC
Market Capitalisation	0.043	0.103***	0.867***	-3551.4	50	-0.649**	455
	(0.028)	(0.034)	(0.048)	(5106.3)	(140.37)	(0.291)	948
Sales	0.063**	0.127***	0.827***	-2794.6	50	-0.793***	441
	(0.026)	(0.029)	(0.045)	(5535.6)	(177.54)	(0.250)	920
Book Value	0.054*	0.085***	0.867***	1719.6	15.557	-0.982***	436
	(0.027)	(0.031)	(0.047)	(6444.7)	(92.106)	(0.242)	911
Cash Flow	0.059**	0.069**	0.885***	-9632.7	6.341	-0.815**	421
	(0.027)	(0.030)	(0.055)	(15021)	(13.126)	(0.369)	882
Composite	0.059**	0.085***	0.871***	-1477.7	50	-0.948***	428
	(0.027)	(0.031)	(0.049)	(4752.7)	(298.72)	(0.214)	896

Note: This table provides estimates of the GARCH-MIDAS model for the level and volatility specifications for the conditional variance of corporate bond returns. The weighting scheme is the "Beta" function and K = 36 (3 MIDAS years). Weekly bond market return data from January 2008 to December 2019 is used.

Table 28: Variance ratios – Sales index

Variables	Variance Ratio *Level*	Variance Ratio *Volatility*
RV	6.77	1.85
IP	3.76	9.08
Level	4.75	14.96
Slope	7.77	5.02
Default	5	10.45
SAInf	0.57	0.66
JSEALLR	5.6	19.62
USREER	6.95	2.81
USIP	4.78	3.8

Note: The table shows variance ratios measured in percent. The variance ratios are calculated by the formula 100*Var(log $\tau_{t)}$/Var(log $\tau_t g_t$)

Table 29: Variance ratios – Book value index

Variables	Variance Ratio *Level*	Variance Ratio *Volatility*
RV	1.19	4.07
IP	1.19	1.01
Level	3.09	8.73
Slope	2.33	1.98
Default	1.83	3.06
SAInf	0.84	0.74
JSEALLR	1.44	9.28
USREER	2.12	1.39
USIP	4.45	0.87

Note: The table shows variance ratios measured in percent. The variance ratios are calculated by the formula 100*Var(log $\tau_{t)}$/Var(log $\tau_t g_t$)

Table 30: Variance ratios – Cash flow index

Variables	Variance Ratio *Level*	Variance Ratio *Volatility*
RV	2.01	2.52
IP	2.73	5.61
Level	2.73	8.39
Slope	3.18	1.70
Default	3.72	8.61
SAInf	0.4	2.69
JSEALLR	1.00	9.96
USREER	0.86	2.24
USIP	1.86	1.31

Note: The table shows variance ratios measured in percent. The variance ratios are calculated by the formula 100*Var(log τ_t)/Var(log $\tau_t g_t$)

Table 31: Variance ratios – Composite index

Variables	Variance Ratio *Level*	Variance Ratio *Volatility*
RV	1.13	3.53
IP	2.51	5.95
Level	3.26	9.67
Slope	3.16	2.45
Default	3.27	6.18
SAInf	0.53	1.07
JSEALLR	4.39	10.21
USREER	1.46	2.09
USIP	3.15	0.86

Note: The table shows variance ratios measured in percent. The variance ratios are calculated by the formula 100*Var(log τ_t)/Var(log $\tau_t g_t$)

GARCH-MIDAS with macroeconomic variables: The figures illustrate the long-term, short-term and total variance estimated by the GARCH-MIDAS model.

Figure 22: GARCH-MIDAS with SAIP – Level specification

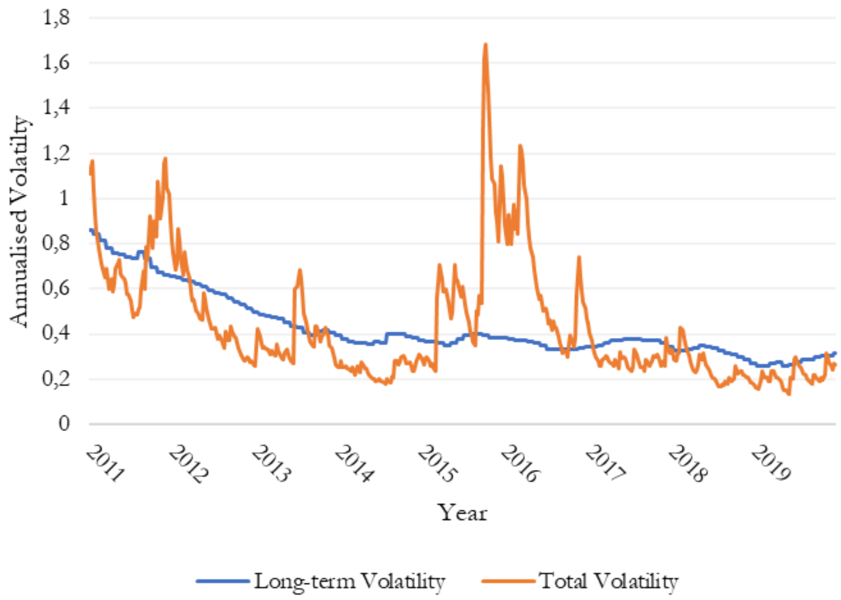


Figure 23: GARCH-MIDAS with Level – Level specification

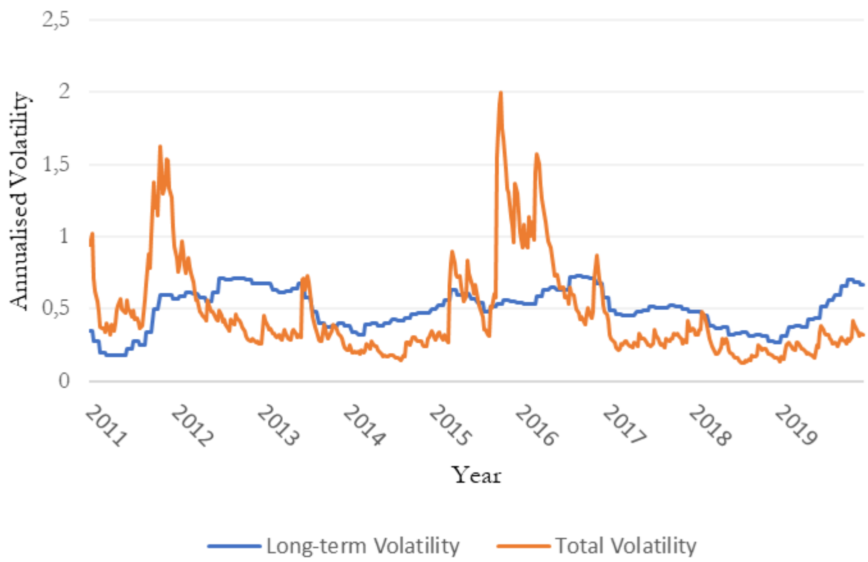


Figure 24: GARCH-MIDAS with Slope – Level specification

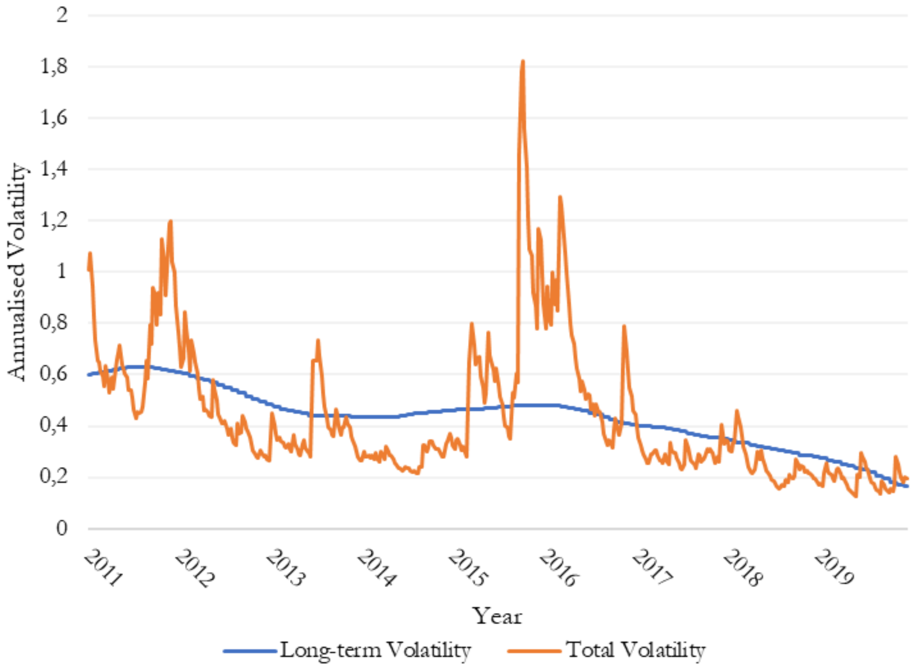


Figure 25: GARCH-MIDAS with Default – Level specification

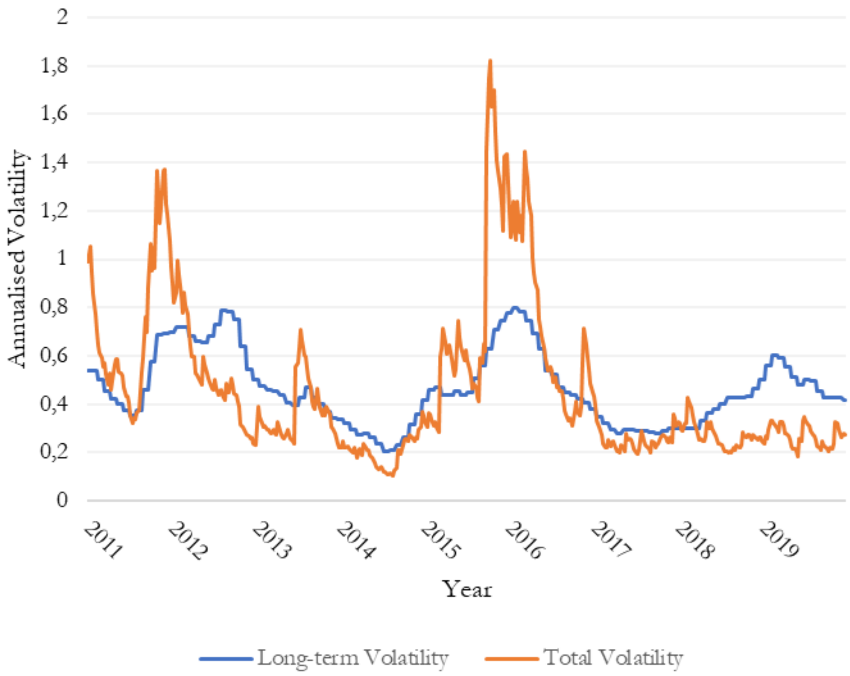


Figure 26: GARCH-MIDAS with SAInf – Level specification

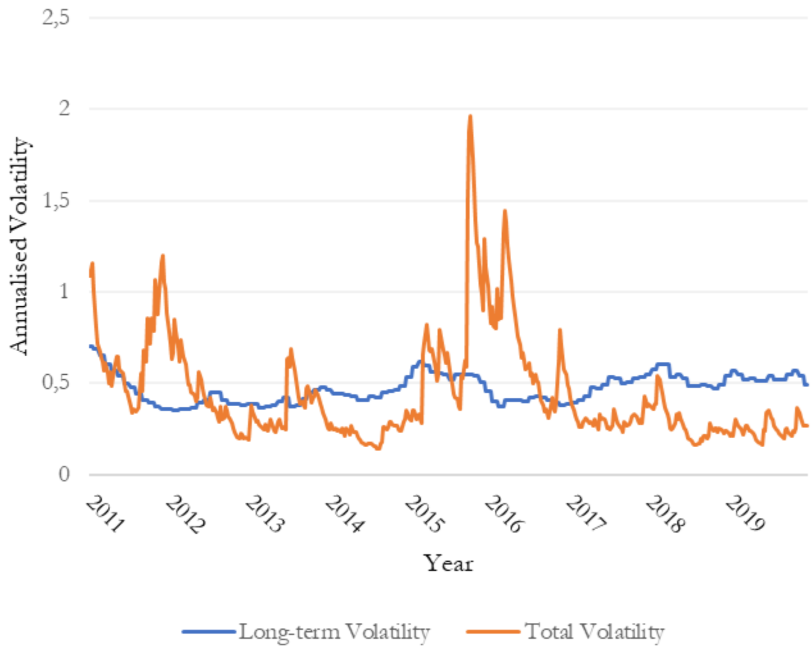


Figure 27: GARCH-MIDAS with JSEALLR – Level specification

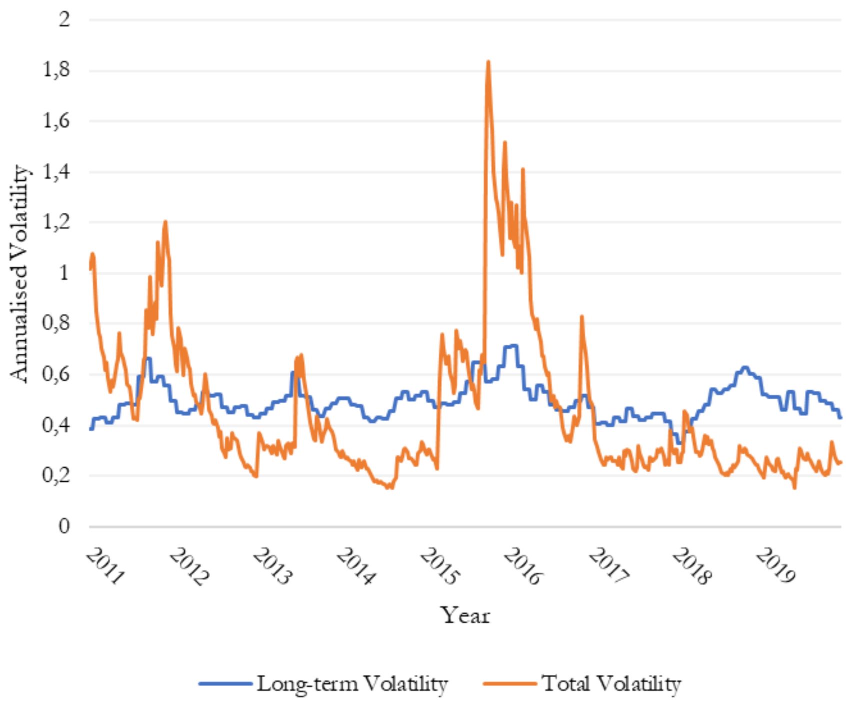


Figure 28: GARCH-MIDAS with USREER – Level specification

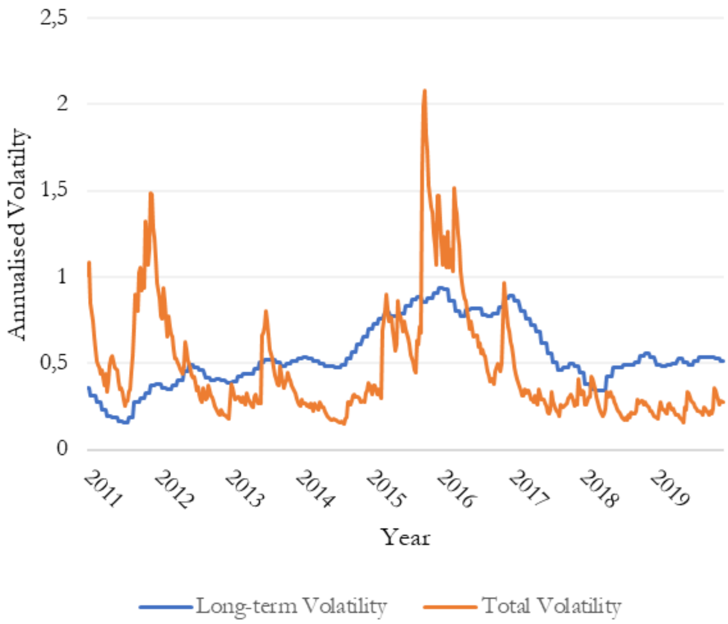


Figure 29: GARCH-MIDAS with USIP – Level specification

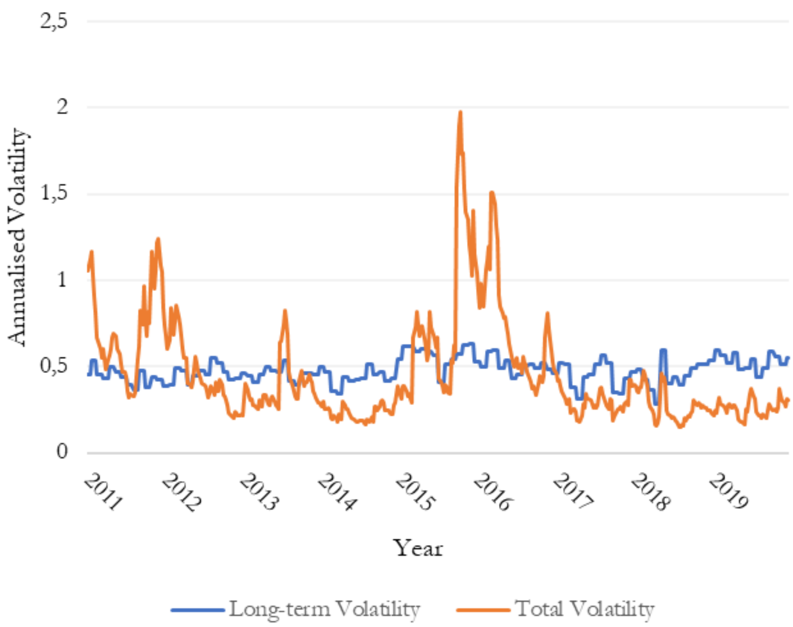


Figure 30: GARCH-MIDAS with SAIP – Volatility specification

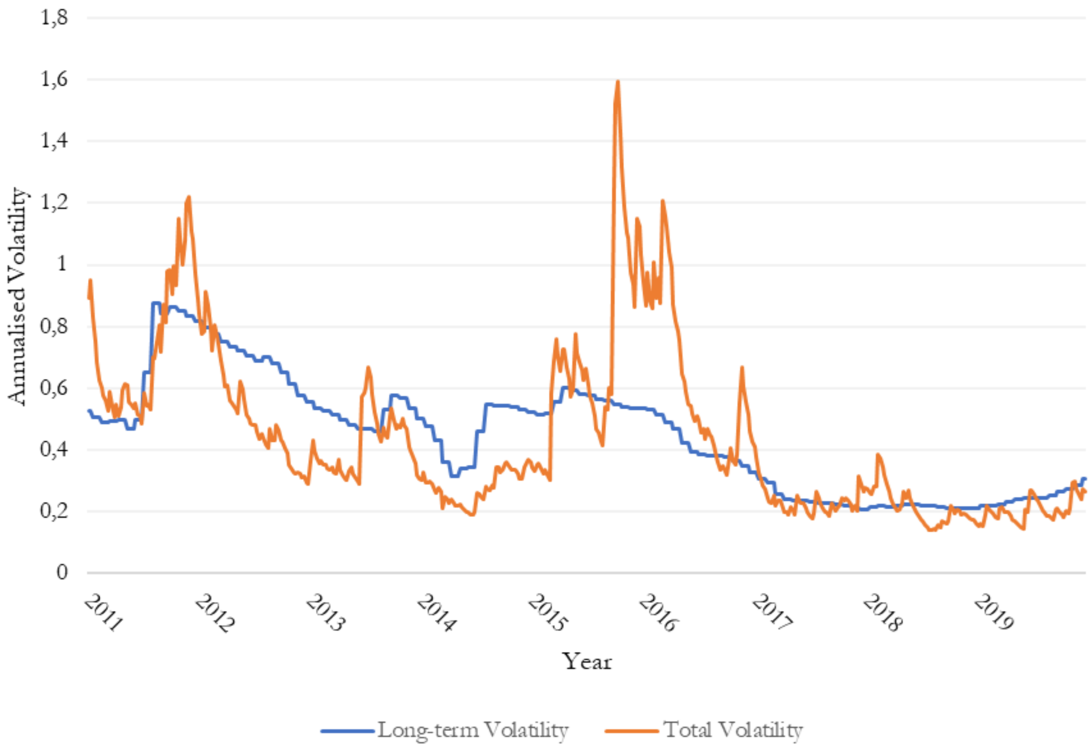


Figure 31: GARCH-MIDAS with Level – Volatility specification

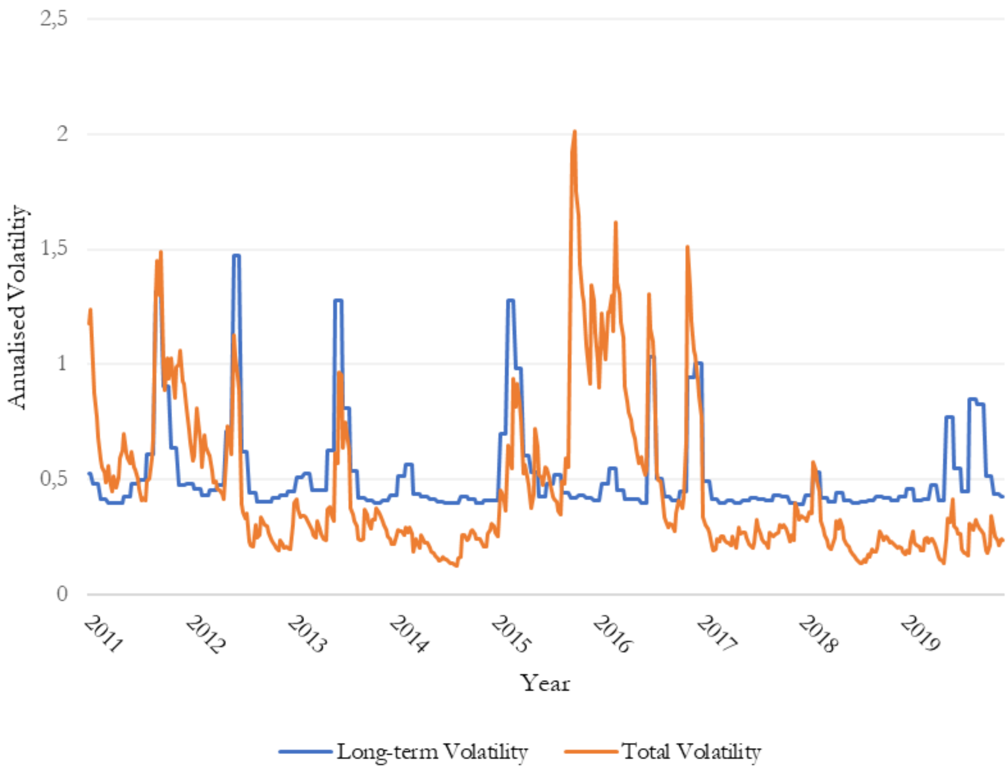


Figure 32: GARCH-MIDAS with Slope – Volatility specification

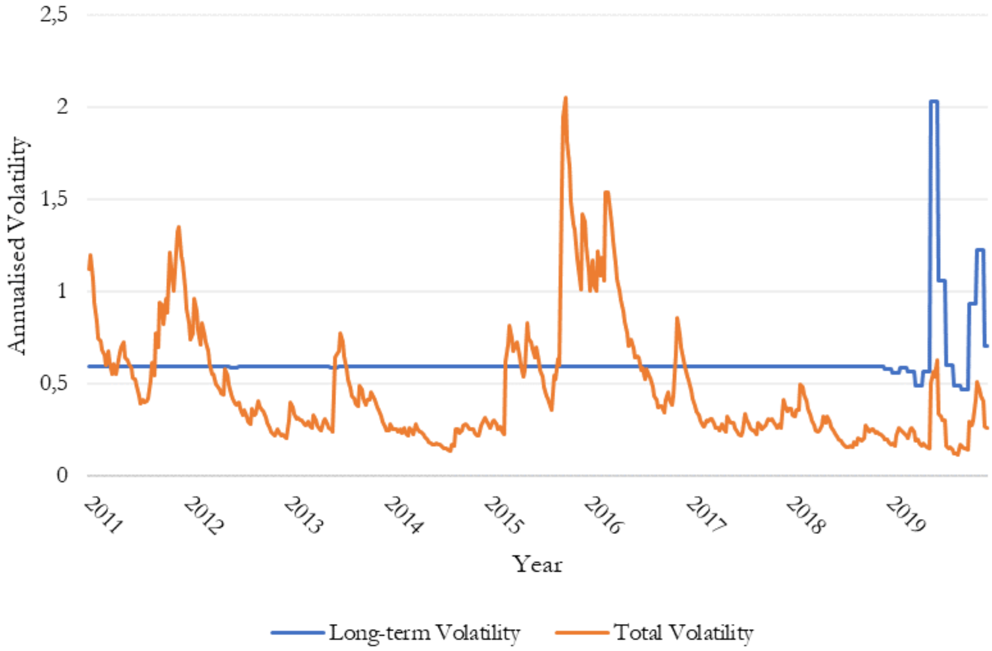


Figure 33: GARCH-MIDAS with Default – Volatility specification

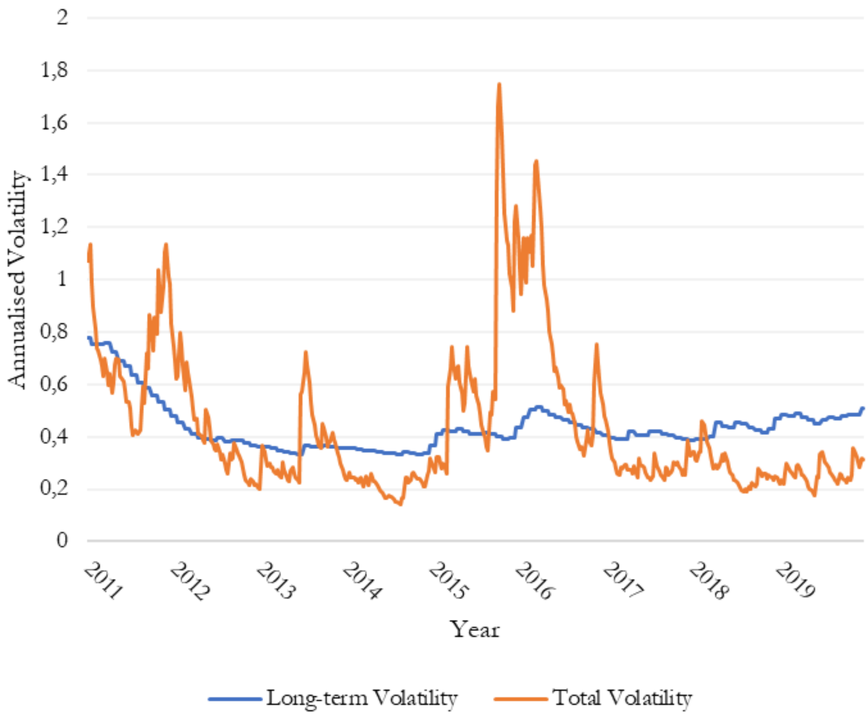


Figure 34: GARCH-MIDAS with SAInf – Volatility specification

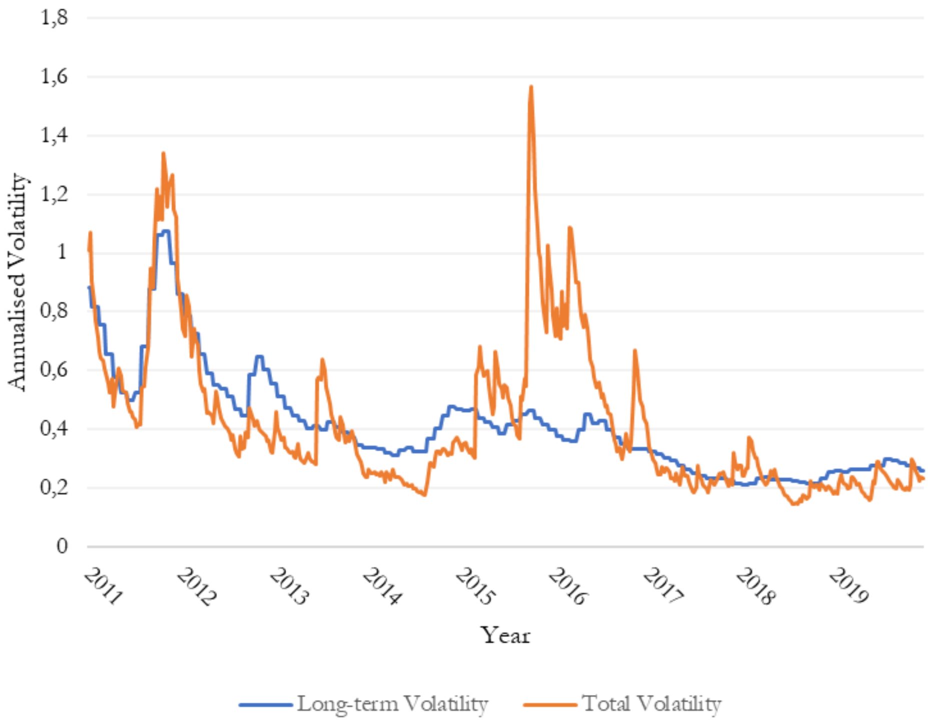


Figure 35: GARCH-MIDAS with USREER -Volatility specification

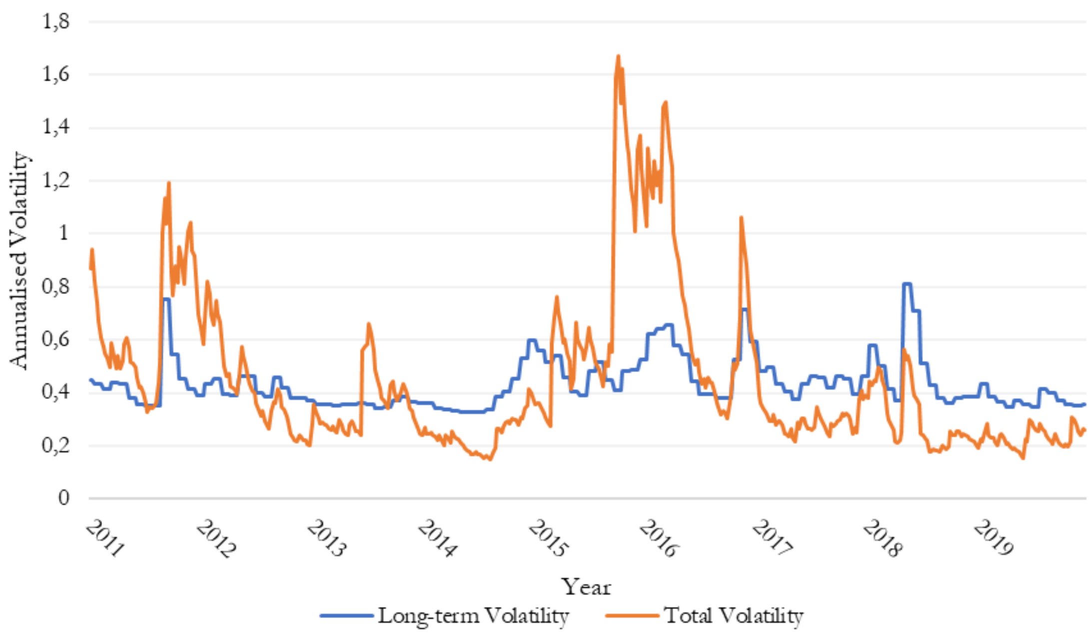


Figure 36: GARCH-MIDAS with USIP – Volatility specification

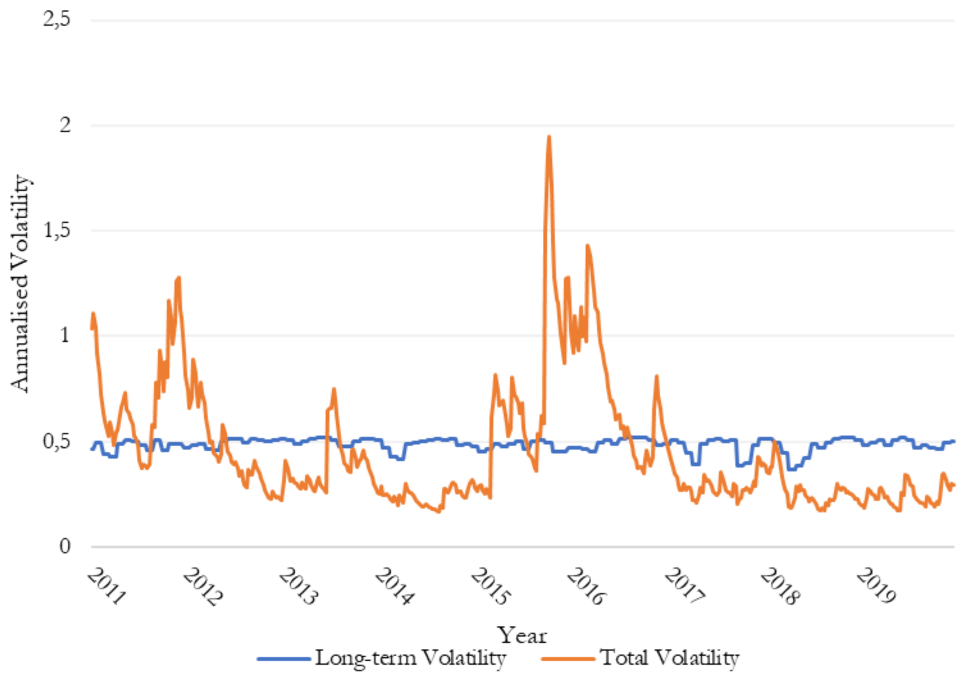


Table 32: Tests for stationarity

	Augmented Dickey-Fuller	Phillips-Perron
Bond returns	-22.015***	-22.454***
Equity returns	-27.694***	-27.568***
US Treasuries returns	-27.834***	-27.748***
Johannesburg Stock Exchange (JSE) returns	-27.542***	-27.655***
Exchange rate returns	-26.033***	-26.047***

Note: The table shows the test statistics for all the variables used the analysis in this chapter. *, ** and *** denotes rejection of the null hypothesis of the presense of a unit root at the 10%, 5% and 1% level of significance respectively.