

AN INVESTIGATION OF EMPIRICAL PROPERTIES OF SOUTH AFRICAN BONDS

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ABSTRACT

This study investigates empirical properties of South African bonds over the period 2000 to 2016. In particular, it investigates i) mean reversion in bond returns; ii) the correlation between bond returns and the inflation rate; and, iii) the correlation between bond returns and equity returns. An understanding of bond return dynamics would allow bond investors to assess which bond properties work in their favour. Thus this study seeks to guide bond investors, and to add to the knowledge of the bond market concerning bond return dynamics in an emerging market economy.

The study employs a quantitative research methodology, using a non-experimental research design. The investigation is carried out at the macroeconomic level using the JSE All Bond Indices as the bond investment proxy, the FTSE/JSE All Share Total Return Index as the equity investment proxy, and the Consumer Price Index as the proxy used to measure the inflation rate. The sample autocorrelation function is used to test for mean reversion and the Kendall Tau-b correlation test is used for the correlation investigations.

This study does not find statistically significant evidence of long term mean reversion but finds statistically significant evidence of short-term mean reverting behaviour in the period 2013-2016. Furthermore, this study reveals that short-term serial correlations vary and are sensitive to political developments in the economy. The correlation analysis between bond returns and the inflation rate and bond returns and stock returns did not return statistically significant correlation values. However, further analysis provided evidence against the use of bonds as an inflation hedge and of diversification benefits to be reaped from combining bonds and stocks together in a portfolio.

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CHAPTER 1: INTRODUCTION

This study seeks to analyse empirical properties of bond returns in South Africa over the period 2000 to 2016. In particular, we investigate the following three properties: i) mean reversion in bond returns; ii) the correlation between bond returns and inflation; and iii) the correlation between bond returns and equity returns. Mean reversion refers to the tendency of a series of observations to revert to a mean value. Thus, sharp movements in one direction are followed by subsequent corrective movements in the opposite direction. Mean reverting behaviour reduces wealth volatility over time, and is thus attractive to risk-averse investors. The correlation between two variables measures the degree of association between the two. Investigating the correlation between bond returns and inflation is essential in assessing the use of bonds as an inflation hedge. Investigating the correlation between bond returns and equity returns informs investors on the diversification benefits, if any, to be reaped by combining the two assets together in a portfolio. Altogether, this research is essential in guiding investors on how best to exploit a bond investment. Investors need to understand which properties of bonds work in their favour, and which do not.

Extant literature has addressed bond return dynamics in developed markets (see Firer & McLeod, 1999; Jostova et al., 2013; Koniarski & Sebastian, 2015; Nayak, 2010; Stewart, Piroos & Heisler, 2011). We shift the focus of this research to emerging markets. Emerging bond markets differ from developed bond markets in areas such as size, liquidity and market composition, amongst others (Radier et. al., 2016). For this reason we cannot assume that findings based on developed markets will hold for emerging market economies as well. We focus on the South African bond market because this is one of the most developed emerging bond markets, and also one of the most relevant emerging bond markets in terms of size and

liquidity (Van Wyk, Botha & Goodspeed, 2015). The South African bond market is the largest bond market in Africa (JSE, 2013). In March 2015, outstanding nominal value in South Africa's debt market was R2 trillion (US\$154bn), almost half the country's GDP in 2015 (Department of National Treasury South Africa, 2015; The World Bank, 2017).

The literature on mean reversion in bond returns is thin. The few studies that have addressed this include Nayak (2010) and Stewart, Piros and Heisler (2011), which focused on US corporate bonds and US Treasury notes respectively. This study seeks to contribute to the literature by addressing mean reverting behaviour in an emerging debt market. Contrary to Stewart, Piros and Heisler (2011), but consistent with Nayak (2010), this study finds evidence of long-term mean-reverting behaviour in South African bond returns over the period 2000 to 2016. In addition, consistent with Nayak (2010), this study finds that the mean reverting evidence observed appears to be more pronounced for longer maturity bonds.

Furthermore, this study seeks to address short-term mean reversion. Stewart, Piros and Heisler (2011) describe short-term mean reverting behaviour over the period 1926 to 2008 with one autocorrelation coefficient. Correlations are not static over time, and one autocorrelation coefficient cannot capture the serial correlation between returns for all short-term horizons over 82 years. This study adds to the literature on mean reversion by exploring changes in the short-term serial correlation coefficient over the study's focus period. We split the overall sample period into sub periods of three years and five years, and find that the serial correlation coefficient changes in size and direction across these sub-periods. The short-term serial correlations appear to be sensitive to political developments in the economy. Moreover, unlike the findings for long-term mean reversion, this study finds that short-term mean reverting behaviour observed is not more pronounced for longer maturity bonds.

The correlation between bond returns and inflation has received relatively more attention in the literature, however, studies have focused on developed economies (See Barr & Campbell, 1997; Koniarski & Sebastian, 2015; Stewart, Piros & Heisler, 2011;). This study seeks to add to the literature by investigating this correlation in an emerging debt market. This study finds that over the period 2000 to 2016, nominal bond returns exhibit a low negative correlation with inflation. This is consistent with Koniarski and Sebastian (2015) that found a negative correlation between the two variables for a similar horizon. Our findings suggest that bonds do not provide a suitable hedge against inflation.

Several studies have addressed the correlation between bond returns and stock returns in developed economies (See Imanen, 2003; Baele, Bekaert & Inghelbrecht, 2010; Stewart, Piros & Heisler, 2011). The research on South Africa is not as dense. Notable studies include Firer and McLeod (1999) and Auret and Vivian (2014). This study contributes to the literature by updating the correlations documented by these studies. This study documented a lower correlation than Auret and Vivian (2014), which itself documented a lower correlation than Firer and McLeod (1999). Altogether these declining correlations suggest a decoupling of the two markets in the recent years. Moreover, this study takes this correlation investigation further by analysing the bond-stock correlation over periods where stock returns are negative and especially negative, in order to assess the diversification potential of combining bonds together in a portfolio containing stocks. This study finds a negative correlation between the two asset classes when stock returns are negative, and an even stronger negative correlation when stock returns are very negative (below -3.19%). This suggests that bonds are able to provide diversification benefits, particularly when they are needed the most.

This investigation is conducted at the macroeconomic level by examining indices. The JSE's All Bond Indices serve as the proxy for bond investment. The FTSE/JSE All Share Total Return Index serves as the proxy for equity investment. Finally, the Consumer Price Index serves as the proxy used to measure the inflation rate. The sample autocorrelation function is used to investigate mean reversion and the Kendall tau-b test is used for the correlation investigations.

The next section in this chapter describes the South African bond market, which is the backdrop of this study. Chapter 2 reviews the literature; Chapter 3 presents the data and research methodology; and Chapter 4 details and discusses the results. Finally, Chapter 5 concludes the paper, discussing its limitations, and avenues for further research.

1.1 THE SOUTH AFRICAN BOND MARKET

The context of this study is the South African bond market. This section provides a description of this context, detailing the South African bond market's history, global ranking, composition, indices, and foreign investor participation. In addition, this section briefly describes South Africa's monetary policy framework. The South African bond market is then contrasted to bond markets of developed economies, as this is where the bulk of previous literature has focused.

HISTORY

In 1989, a majority of bond trading firms in South Africa came together to establish the Bond Market Association (BMA) (Radier et. al., 2016; Van Wyk, Botha & Goodspeed, 2015). This voluntary exchange-like platform was the first attempt to formalise bond trading in South Africa (Van Wyk, Botha & Goodspeed, 2015). In 1996, BMA was granted an exchange licence and

became the Bond Exchange of South Africa (BESA) (Van Wyk, Botha & Goodspeed, 2015). In 2009, BESA became a wholly owned subsidiary of the JSE, so that all listed money market and capital market securities would trade on a single exchange (Van Wyk, Botha & Goodspeed, 2015). BESA monitors and regulates bond trading in South Africa (Radier et. al.; 2016).

Key developments by BESA include the introduction of an electronic trading platform, and the development of a more refined benchmark yield curve covering a wide range of maturities (Mboweni, 2006). BESA stands apart from other African bond markets due to its sophistication and global significance (Jefferis, 2009). The BESA trading system complies with international G30 standards (Jefferis, 2009).

GLOBAL RANKING OF THE SOUTH AFRICAN BOND MARKET

The JSE was the fourth largest bond exchange in 2013 based on the value of bonds traded, and is the largest bond market in Africa by both market capitalisation and liquidity (JSE, 2013; World Federation of Exchanges [WFE], 2014). Moreover, South Africa's bond market is one of the most liquid emerging bond markets in the world (Van Wyk, Botha & Goodspeed, 2015). In 2012, South Africa's bond market turnover was 14.56 times compared to 0.75 for China, 1.23 for Japan, 0.68 for Thailand and 1.37 for Russia (Asian Development Bank, 2012; WFE 2013). In 2013, outstanding bonds in issue on the JSE were worth approximately US\$180 billion (JSE, 2013). McCauley and Remolona (2000) define a market size of US\$100 billion and above as large and liquid. Bond trading on the BESA constitutes 90% of turnover on the African continent (Capital, 2012).

COMPOSITION OF THE SOUTH AFRICAN BOND MARKET

The top issuers in the South African bond market are government, financials, and state-owned enterprises (SOEs) (Department of National Treasury South Africa, 2015). Government bonds make up the majority of bond issues on the JSE (Van Wyk, Botha & Goodspeed, 2015). In 2014, government bond issuance represented 63% of the total nominal value of debt listed on the JSE, while financials represented 17% and state-owned enterprises (SOEs) represented 13% (Department of National Treasury South Africa, 2015). The manufacturing sector, services sector and special purpose vehicles (SPVs) formed the remaining 7% of total debt listed on the JSE in 2014 (Department National Treasury South Africa, 2015:3). Government bonds are the most liquid and account for 90% of liquidity on the JSE debt market (JSE, 2013; Van Wyk, Botha & Goodspeed, 2015). The corporate bond market is illiquid, and still far behind the government bond market in terms of size, but issuances in this market have shown notable growth across the years (JSE, 2013; Van Wyk, Botha & Goodspeed, 2015).

The South African government currently issues fixed-rate bonds, inflation-linked bonds and foreign currency bonds (Van Wyk, Botha & Goodspeed, 2015). The secondary market for South African government bonds is liquid, and fixed-rate bonds are much more liquid than inflation-linked bonds (Department of National Treasury South Africa, 2015; Van Wyk, Botha & Goodspeed, 2015). Government bonds are issued for a wide range of maturities, from one year to above 30-years. This provides a reliable bond yield curve for pricing corporate bonds and deriving forward rates (The World Bank, 2000).

For a long time, bonds were an asset class that appealed only to institutional investors, because only these investors could afford the high nominal values (Monteiro, 2006). The introduction of government retail bonds in 2004 extended participation in this asset class to individual investors (Monteiro,

2006). These retail bonds, however, are not tradable (RSA Retail Savings Bonds, 2013).

The local governments in South Africa issue municipal bonds. The market for municipal bonds is limited, however, as the local governments' credit worthiness has come to question given their failure to make payments for services rendered by their communities (Van Wyk, Botha & Goodspeed, 2015). Moreover, unlike the US where interest on municipal bonds is not taxed, investors in South Africa are not incentivised to hold municipal bonds as no such tax benefits are enjoyed in South Africa (Van Wyk, Botha & Goodspeed, 2015). Furthermore, the borrowing requirements of small municipalities are not large enough for listing of these bonds to be an option (Van Wyk, Botha & Goodspeed, 2015).

South Africa's corporate bond market still has a lot of room for growth with respect to both its size and liquidity. The proportion of listed securities that are issued both domestically and internationally by private South African corporates is smaller than that of countries such as China, Mexico, Chile, Malaysia and Hungary to name a few (Van Wyk, Botha & Goodspeed, 2015).

Parastatals and water authorities issue bonds typically to raise financing for capital projects (Van Wyk, Botha & Goodspeed, 2015). The market for these bonds is more liquid than that of corporate bonds (Van Wyk, Botha & Goodspeed, 2015).

SOUTH AFRICAN BOND MARKET INDICES

The JSE and the Actuarial Society of South Africa collaborate to issue bond indices that provide an efficient measure of the total return of representative bond portfolios and provide benchmarks against which historical performance, or performance of selected security/securities can be compared

(Van Wyk, Botha & Goodspeed, 2015). These indices include the All Bond Indices, the Government Bond Index (GOVI), and the Other Bond Index (OTHI).

The All Bond Indices comprise the Composite All Bond Index (ALBI), as well as sub-indices of the ALBI that are formed by splitting up the bonds in the ALBI by their maturities. The ALBI consists of the top 20 fixed rate, fixed maturity bonds, ranked dually by liquidity and market capitalisation (JSE, 2013). This index provides a measure of the daily movement in the bond market (JSE, 2013). The ALBI 1-3 year sub-index consists of the bonds in ALBI with terms between one and three years. The ALBI 3-7 year sub-index consists of bonds in the ALBI with terms between three and seven years. The ALBI 7-12 year sub-index consists of bonds in the ALBI with terms between seven and 12 years.

The GOVI consists of the top ten government-issued bonds, ranked dually by liquidity and market capitalisation (JSE, 2013). The bonds in the GOVI form half of the ALBI. The OTHI index contains the remaining bonds in the ALBI that are not in the GOVI, and thus are issued by local government, parastatals or corporates (JSE, 2013).

FOREIGN INVESTOR PARTICIPATION IN THE SOUTH AFRICAN BOND MARKET

Foreign investor participation in South African bond markets is high (37% of government bond holdings in 2014) (Department National Treasury South Africa, 2015). Financial regulation in South Africa does not inhibit their participation in this market (JSE, 2013). This broader investment base has advantages such as increased liquidity and increased efficiency in price discovery (Radier et. al., 2016). However, the frequent inflows and outflows of foreign capital in search of high yields, and in response to increased risk,

result in higher bond market volatility (Radier et. al., 2016). Andritzky (2012) finds that increased foreign ownership of domestic debt is associated with lower, and more volatile bond yields.

MONETARY POLICY IN SOUTH AFRICA

Monetary Policy in South Africa is centred on inflation targeting. South Africa is one of the 27 countries in world that follow this framework (Barnebeck Andersen, Malchow-Møller & Nordvig, 2014). The primary objective of monetary policy in South Africa is to keep inflation within the target band of 3 - 6% (Van Wyk, Botha & Goodspeed, 2015). The South African Reserve Bank (SARB) adjusts the repurchase rate (repo) rate according to the inflationary outlook, considering factors such as the country's growth outlook and consumption levels amongst others (Van Wyk, Botha & Goodspeed, 2015). Consequently, the SARB directly influences short-term interest rates, which in turn, depending on the slope of the yield curve and the term structure of interest rates, affect long-term interest rates (Hassan, 2013).

DIFFERENCES BETWEEN THE SOUTH AFRICAN BOND MARKET AND BOND MARKETS IN DEVELOPED ECONOMIES

Extant literature has focused on bond markets in developed economies, such as the US. South Africa is peculiar for a number of reasons. Firstly, developed markets are bigger and more liquid (Adelegan & Radzewicz-Bak, 2009; Mu, Phelps & Stotsky, 2013). Secondly, as mentioned above, the South African monetary policy focuses on inflationary targeting. Factors driving inflation in South Africa include labour costs and rand exchange rate fluctuations, and these factors differ from factors driving inflation in developed economies such as the US (Kganyago, 2016a; Kganyago, 2016b; Radier et. al, 2016). Given that inflationary expectations directly affect short-

term rates, the unique factors driving inflation in South Africa must be considered when interest rate movements are examined. Thirdly, sovereign credit ratings issued by Standard and Poor in July 2015 assign US bonds a high quality rating (AA+), while South Africa is rated above junk at BBB. These ratings affect the yield of bonds. Finally, there are differences in the structure of the markets. For instance, bond trading in the US is almost exclusively done over the counter, while bond trading in South Africa takes place electronically on the JSE (JSE, 2013; Stewart, Piros & Heisler, 2011). Given these peculiarities, we cannot immediately assume or expect findings for developed markets to apply to an emerging market country such as South Africa.

CONCLUSION

This section has provided a detailed overview of the South African bond market, which is the context of this study. We summarise the pertinent features to note throughout the study. Firstly, government bonds form the largest and most liquid portion of the South African bond market, accounting for 90% of the bond market's liquidity. Secondly, the All Bond Index, the index of the top 20 bonds ranked dually by market capitalisation and liquidity, provides a measure of the daily movement in the bond market. Thirdly, foreign investor participation is high, and high foreign investor participation is associated with increased liquidity and more efficient price discovery, but also more volatility. Finally, the South African monetary policy framework, which is centred on inflation targeting, directly influences short-term rates in response to inflationary expectations. Furthermore, this section detailed why findings in previous literature that are based on developed markets cannot be expected to hold for South Africa. Chapter 2 follows, with a review of the literature.

CHAPTER 2: LITERATURE REVIEW

In this chapter, we review the theory and the empirical evidence concerning all three empirical properties under investigation in this study. Each section of this review has four sub-sections. The first sub-section presents a definition of the empirical property under investigation. The second sub-section presents the theoretical background beginning with a brief overview of the case for stocks before addressing bonds, to allow a comparison of the findings for the two asset classes. The third sub-section details a review of the empirical evidence on the property under investigation. Similar to the theoretical background sub-section, this sub-section begins with stocks before returning the focus to bonds. The fourth and final sub-section details the motivation for investigating that particular property and the contribution this study seeks to make to the literature. This chapter ends with a conclusion summarising the motivations for this study and the hypotheses to be tested.

2.1 MEAN REVERSION

2.1.1 DEFINITION

Mean reversion refers to the tendency of a series of observations to return to a mean value: sharp movements in one direction are followed by subsequent corrective movements in the opposite direction. In the literature, mean reverting behaviour is often described as the process by which an initial deviation of market and fundamental values is corrected in subsequent periods (Porterba & Summers, 1988). The next section details a theoretical background on mean reversion.

2.1.2 THEORETICAL BACKGROUND ON MEAN REVERSION

Conventional finance theory defends the existence of the rational investor. The rational investor incorporates new information according to Bayes Rule, which is the accepted, appropriate way to react to new information (De Bondt & Thaler, 1985; Van Rensburg, 2016). Tversky and Kahneman (1974) observed inconsistencies with this theory. They identified certain heuristics used when individuals attempted to make judgements under uncertainty: representativeness (that individuals take one aspect or description and make it representative of a subject); availability (that individuals attach more weight to more recently available information); and anchoring and adjustment (that individuals hold onto initial anchors when making predictions) (Tversky & Kahneman, 1974). Furthermore, it has been established that individuals tend to be over confident and overestimate their abilities, and tend to favour information that is consistent with their prior beliefs (Bodie, Kane & Marcus, 2014).

Security prices have often exhibited anomalies, beyond the explanations based on the rational investor and solely risk-based pricing models (Nayak,

2010). Behavioural finance theory reconciles the heuristics presented above with anomalies of security price behaviour. Behavioural finance theory seeks to explain how individuals *actually* behave versus how conventional finance models prescribe that they should behave. The failure of conventional finance models to incorporate attributes of human behaviour has lent credit to behavioural finance models. Investor overreaction is one particular attribute recognised by behavioural finance. Investor overreaction is an important consideration in this study because it is the dominant hypothesis offered to explain mean reverting behaviour (De Bondt & Thaler, 1985; Lehmann 1990; Muller, 1999; Porterba & Summers, 1988).

The basis of the overreaction hypothesis is simple. Risk-averse investors are faced with the task of forecasting future payment streams (e.g. dividends in stocks) (Page & Way, 1992). Given the inherent uncertainty in this task, investors attempt to generate returns of shorter-term price movements (Page & Way, 1992). Consequently, investors forecast tomorrow's prices, and not the present value of the future stream of cash flows. In doing so, recent trends are extrapolated into the future (Page & Way, 1992).

Overreaction observed in the market can be attributed to herding behaviour by investors, or confirmation bias - when share price movements are consistent with investors' prior beliefs (Van Rensburg, 2016). The prevalence of noise traders is a further consideration; as such traders tend to overreact to new information (Porterba & Summers, 1988). Behavioural finance theory allows us to link investor overreaction with the focus of this study, mean reversion. Under behavioural finance theory, long term mean reverting behaviour in shares arises from the sustained unwinding of either previous overreactions, when expensive shares begin to underperform, or, underreactions, when cheap shares begin to outperform (Van Rensburg, 2016). In this study, we seek to shift the focus of mean reverting literature from equity to bonds.

Nayak (2010) investigated the impact of investor sentiment on the corporate bond market in the US. Based on a definition originally put forward by Baker and Wurgler in 2006, Nayak (2010) defines investor sentiment as bearing two aspects: firstly, the level of irrational optimism or pessimism in the projections of future cash flows and risks underlying a security; and, secondly, the reflection of the tendency to speculate in securities that are more likely to be mispriced, and are difficult or costly to arbitrage (Nayak, 2010). His study explains that for the bond market, when investor sentiment is low at the beginning of the period, bonds are underpriced relative to fundamentals, and yield spreads widen. When sentiments fade, or rational arbitrageurs catch up, prices rise, and subsequent yield spreads are low. Similarly, when beginning of period investor sentiment is high, prices are high relative to fundamentals, and yield spreads are low. Subsequent revision of these sentiments causes prices to fall, and yield spreads to widen (Nayak, 2010).

The literature is replete on investor overreaction and mean reversion in the stock markets (e.g. Cubin et al 2006; De Bondt & Thaler, 1985; Page & Way, 1992; Porterba & Summers, 1988). However, mean reverting behaviour in the bond market has received little attention. Nayak (2010) attempted to address this gap in the literature. In his paper, he contends that investor sentiment should affect the bond market similarly to its influence on the stock market for the following reasons: both stocks and bonds are joint claims on a firms assets (Merton, 1974); stocks and bonds share common risk factors (Fama & French, 1993); there are information spill overs between the equity and bond markets; and, there have been several periods in the history of many markets where stocks and bonds show a high correlation (Nayak, 2010). Nayak (2010) argues that when investor sentiment affects stock prices, it is a reflection of irrational optimism or pessimism about the firm in its entirety; therefore, this

should affect the prices of the bonds that the firm issues in an analogous manner.

Nayak's assertions notwithstanding, the two asset classes also show pertinent dissimilarities. Bond markets are far less liquid than stock markets; investors in the bond market are primarily institutional investors, while the stock market has a wider retail presence; and, the majority of bond market trading is in new issuances (primary market) while the majority of stock market trading occurs in the secondary market (Stewart, Piros & Heisler, 2011; Van Wyk, Botha & Goodspeed, 2015). Institutional investors are considered to be more sophisticated and more knowledgeable than individual investors, meaning one can expect the bond market to be less susceptible to overreaction than the equity market (Gebhardt, Hvidkjaer & Swaminathan, 2005). However, from the greater liquidity in equity markets, and the greater informational efficiency (given the wealth of research into equities) it can be expected that the equity market shows less deviation from fundamentals than the bond market. What emerges from the differences between the two asset classes, and their possible implications, is that there is room to expect different findings for the two asset classes.

Serial correlation is one way to test for mean reverting behaviour. Returns that exhibit mean reversion will have negative serial correlations over time. Negative serial correlation implies that high returns in one period tend to be followed by low returns in subsequent periods and vice versa (Stewart, Piros & Heisler, 2011). In this study the terms serial correlation and autocorrelation are used interchangeably. Mean reverting behaviour dampens wealth volatility over long horizons and is thus attractive to risk averse investors (Porterba & Summers, 1988; Stewart, Piros & Heisler, 2011). When returns have positive serial correlations, we observe a momentum effect. Thus high returns tend to be followed by high returns, and low returns tend to be followed by low returns. In this case, wealth volatility increases over time,

and all other things held constant, assets displaying such behaviour are less attractive to risk averse investors as the investment horizon increases (Porterba & Summers, 1988; Stewart, Piros & Heisler, 2011)

Several studies on mean reversion in the equity markets employ the reversal strategy (also known as the contrarian investment strategy) to test for mean reverting behaviour (e.g. Cubin et al, 2006; De Bondt & Thaler, 1985; Lehman 1990; Page & Way, 1992; Porterba & Summers, 1988). Under this strategy, stocks are ranked based on their past performance. A long position is taken in the lowest ranked stocks (often called losers), and a short position is taken in the highest ranked stocks (often called winners). This is a zero net investment strategy. The portfolio constructed in this way is held for specified periods. The portfolio is reshuffled after each holding period, buying back stocks that are no longer winners and selling stocks that are no longer losers. If stocks exhibit mean reverting behaviour, the winner stocks will eventually become losers, and the loser stocks will become winners. When returns exhibit mean reversion, an investment strategy that replicates the reversal strategy should be a profitable one (factors such as transaction costs would need to be considered).

It is important to mention that while the overreaction hypothesis is prevalent in mean reversion literature, it is not the only explanation offered. Zarowin (1990) argues that mean reverting behaviour observed could arise from size differences in the stocks, and thus could really be a size effect at play. Lo and MacKinlay (1990) also credit size, and attribute mean reverting behaviour to lead-lag relationships between larger stocks and smaller stocks. Their study presents empirical evidence that more than 50% of the abnormal profits of the contrarian investment strategy could be attributed to cross-effects between stocks, while less than 50% could be attributed to investor overreaction. However, Zarowin (1990) and Lo and MacKinlay (1990) appear

exceptions in the mean reversion literature, which is weighted in favour of the overreaction hypothesis.

In the following section, prior papers on mean reversion are reviewed to present the empirical evidence of long term and short term mean reversion, and develop the hypotheses.

2.1.3 EMPIRICAL EVIDENCE OF MEAN REVERSION

LONG TERM MEAN REVERSION

Mean reversion in stocks has received considerable attention in the literature. De Bondt and Thaler (1985) was the first study to employ behavioural finance theory in explaining mean reverting behaviour. Using the reversal strategy, De Bondt and Thaler (1985) found evidence of mean reverting behaviour in stocks on the New York Stock Exchange (NYSE) over the period 1926 to 1982. Consistent with De Bondt and Thaler (1985), Porterba and Summers (1988) found evidence of long-term mean reversion in the US, Canada, Britain, and 15 other countries over the period 1919 to 1985. Page and Way (1992), Muller (1999), Hsieh and Hodnett (2011), and Cubbin et al (2006) shifted the focus of mean reversion literature to stocks on the Johannesburg Stock Exchange (JSE), all finding results consistent with De Bondt and Thaler (1985).

We briefly consider the case for South African stocks. Page and Way (1992) used the reversal strategy method to analyse returns of 204 liquid stocks, over the period 1974 to 1989. Consistent with De Bondt and Thaler (1985), they found that losers outperformed winners by almost 20% over the three years after portfolio formation (Page & Way, 1992). Cubbin et al. (2006) documented findings consistent with Page and Way (1992). Their investigation covered the period 1982 to 2005, and used P/E ratios to rank

stocks as winners or losers. They found that over a 5-year period, loser portfolios outperform prior winners by an average of 61.5%. Both Cubbin et al. (2006) and Hsieng and Hodnett (2011) find that the reversals of the winner portfolios are delayed. Hsieng and Hodnett (2011) attribute this delay to behavioural biases such as fear or regret, or investors holding on to past winners for too long.

With this brief equity background presented, we now address the few studies that have investigated mean reversion in bond returns. Stewart, Piros & Heisler (2011) investigated empirical properties of US bond returns, and this investigation addressed mean reversion in bond returns over the period 1926 to 2008. Their study analysed monthly log returns of a Treasury note with 5 years maturity at the beginning of each month. They compared the Treasury note results to those of monthly log returns of the S&P 500 Index. Their findings are presented in Table 2.1.1 below.

Table 2.1.1: Serial correlation of S&P 500 returns, and a 5-year Treasury note.

Source: Stewart, Piros & Heisler (2011: 291)

Time	Stocks		Bonds	
Horizon	Nominal returns	Real returns	Nominal Returns	Real returns
3 years	-0.26	-0.26	0.50	0.29
5 years	-0.14	-0.11	0.60	0.33
10 years	-0.04	-0.16	0.58	-0.02

We see that for all horizons presented except for real returns at the 10-year horizon, both nominal and real bond returns exhibit positive serial correlation. This provides evidence of long-term trending behaviour in US Treasury notes. Their findings for equities document evidence of long term mean reversion, consistent with the findings of other papers presented here. Stewart, Piros & Heisler (2011) caution however that there were few non-overlapping periods in the sample for analysing these long horizons.

Moreover, the statistics presented are unconditional, and are thus inaccurate to use when investment opportunities change over time (Stewart, Piros & Heisler, 2011). A further caution to note is that Stewart, Piros & Heisler (2011) do not state the statistical significance of the serial correlations presented.

Stewart, Piros & Heisler (2011) document evidence of long term trending behaviour in bond returns. We thus form the following hypothesis to investigate the case for South African bonds:

H1: South African bond returns display a positive serial correlation over the long term, thus exhibiting long-term trending behaviour.

Nayak (2010) explored the relationship between investor sentiment and corporate bond yield spreads in the US over the period from 1994 to 2004. The method used in this study differed from most studies on mean reversion; Nayak (2010) used a regression model to determine the relationship between corporate bond yield spreads and investor sentiment. The corporate bonds used were vanilla corporate bonds issued by publicly traded firms in the US. Investor sentiment was captured by an investor sentiment index, developed by Baker and Wurgler (2006) in a study that explored the relationship between investor sentiment and equity returns. Nayak (2010) found that investor sentiment has a material impact on corporate bond yield spreads. When beginning of period investor sentiment is low, prices are low relative to fundamentals, and yield spreads are high. When this sentiment fades, or rational arbitrageurs catch up, prices rise, and yield spreads widen. Similarly, when beginning of period sentiment is high, the low yield spreads associated with this high sentiment will subsequently rise once the sentiment fades or rational arbitrageurs catch up (Nayak, 2010). Nayak (2010) found that investors timing and trading solely on sentiment regimes could earn 52 basis points. The study found further that this effect

was more pronounced for high yield bonds, for industrials, and for extreme maturity bonds (Nayak, 2010). Nayak (2010) argues that distressed bonds, such as high yield bonds, are more likely to be mispriced due to investor sentiment, than low yield bonds.

Nayak (2010) documents evidence of mean reverting behaviour in bond yields, contrary to the evidence presented by Stewart, Piros and Heisler (2011). The different findings could be explained by the use of different types of bonds. Stewart, Piros & Heisler (2011) analysed Treasury notes while Nayak (2010) analysed corporate bonds. Moreover, the periods of the two studies differed. Nayak (2010) examined the period 1994 to 2004 while Stewart, Piros and Heisler (2011) examined the longer period of 1926 to 2008.

Nayak (2010) found that the mean reverting effect observed was more pronounced for extreme maturity bonds. Should our investigation compel us to reject the first hypothesis and reveal mean reverting behaviour in bond returns, we will assess whether this is more pronounced for longer-term bonds as Nayak (2010) observed.

H2: If South African bond returns exhibit a negative serial correlation over the long term, then this negative serial correlation becomes more negative with increasing term to maturity

The following section reviews literature on short-term mean reversion.

SHORT TERM MEAN REVERSION

We briefly present the case for short-term mean reversion in stocks. In the section above, we presented the findings of Porterba and Summers (1988) of long-term mean reversion in stocks in 17 countries across the globe. When Porterba and Summers considered horizons less than a year, however, they

found that monthly returns on US, Canadian and British stocks, as well as several other countries, exhibit positive serial correlations. They add the caveat that this could arise from thin trading of some of the stocks (Porterba & Summers, 1988). Bodie, Kane and Marcus (1996) propose the fads hypothesis, and attribute short-term positive serial correlation to investor overreaction.

Muller (1999) investigated investor overreaction on the JSE over the period 1985 to 1998. His findings were consistent with Porterba and Summers (1988). Over the period 1989 to 1997, a portfolio of 20 to 40 winner stocks provided excess market returns of 15% per annum when a three-month holding period was considered, but over longer periods began to underperform the market (Muller, 1999). Muller's findings provide evidence of a short-term momentum effect in stocks on the JSE. Studies such as Jegadeesh (1990) and Lehmann (1990) have documented contrary evidence for the US, presenting evidence of short-term mean reversion.

When we turn to bonds, we again review Stewart, Piros & Heisler (2011). Table 2.1.2 below presents their findings for short-term mean reversion. We see in Table 2.1.2 that serial correlations for one month and one year were positive for both nominal and real returns; thus providing evidence of short-term trending behaviour. From Table 2.1.2, we see further that the magnitude of the correlations for short horizons is smaller than that for long horizons, as presented in Table 2.1.1. We caution again that Stewart, Piros & Heisler (2011) do not detail the statistical significance of the correlations presented. Moreover Stewart, Piros & Heisler (2011) caution that the serial correlations presented are unconditional statistics. As explained earlier, unconditional statistics are not reliable when investment opportunities can change over time (Stewart, Piros & Heisler, 2011).

Table 2.1.2: Serial correlation of S&P 500 returns, and 5 year Treasury Note.

Source: Stewart, Piros & Heisler, (2011: 291)

Time Horizon	Stocks		Bonds	
	Nominal returns	Real returns	Nominal Returns	Real returns
1 month	0.08	0.09	0.15	0.23
1 year	0.01	-0.02	0.21	0.30

Jostova et al. (2013) present findings consistent with Stewart, Piros & Heisler (2011). Their paper documents strong evidence of momentum profitability, based on a sample of investment grade and non-investment grade corporate bonds in the US over the period 1973 to 2011 (Jostova et al., 2013). Their study makes use of a momentum strategy. This is similar to the reversal strategy in terms of portfolio formation. The difference is that the strategy goes long the winner portfolios and short the loser portfolios. Portfolios were formed based on prior six months performance, and held for six months. They found that over the period 1973 to 2011, winner portfolios outperform loser portfolios by 37 basis points over the six months holding period (Jostova et al., 2013). They find further that this momentum profitability is more concentrated in non-investment grade bonds, and particularly, non-investment grade bonds of private firms (Jostova et al, 2013).

Gebhardt, Hvidkjaer and Swaminathan (2005) document contrary findings to Stewart, Piros & Heisler (2011) and Jostova et al. (2013). Their study found that over the period 1973 to 1996, corporate bond returns in the US do not exhibit momentum, and instead show evidence of reversals (Gebhardt, Hvidkjaer & Swaminathan, 2005). Using a standard reversal strategy, they find that a winner portfolio of corporate bonds outperforms a loser portfolio by 45 basis points one month after portfolio formation, and by 57 basis points per month over the next six months after portfolio formation. They caution however that they cannot entirely rule out data errors as the source of the

reversion pattern observed. Thus, they argue that corporate bonds over this period certainly do not exhibit momentum, but could exhibit reversion (Gebhardt, Hvidkjaer & Swaminathan, 2005).

To ascertain the case for South African bonds, we test the following hypothesis:

H3: South African bond returns display positive serial correlations over the short term, thus exhibiting short-term trending behaviour.

As with long term mean reversion, we will test whether any mean-reverting behaviour observed is stronger for longer maturity bonds:

H4: If negative serial correlations are observed over the short-term, then these negative serial correlations become more negative with increasing term to maturity

2.1.4 MOTIVATION AND CONTRIBUTION TO THE LITERATURE

The motivation for investigating mean reversion is that this research is of material importance to investors. As explained in the theoretical background, mean reverting behaviour reduces wealth volatility over time (Stewart, Piros & Heisler, 2011). If bond returns exhibit mean reverting behaviour, then all else constant, risk-averse investors should find this asset class attractive (Stewart, Piros & Heisler, 2011). Moreover, mean reversion in bond returns would mean that employing the contrarian investment strategy could generate profits. Hsien and Hodnett (2011) argue that the contrarian investment strategy in equities could be the safe one to pursue during financial market turmoil due to its low correlations with the market in periods of economic downturn. If mean reversion holds for bonds, it could provide another safe haven for investors to consider. It is important to

caution investors using the findings of this study that knowing whether bond returns exhibit mean reversion is in itself not sufficient. Important considerations for the profitability of the contrarian investment strategy include trading costs, and the ease of employing this strategy (for instance the ease at which the portfolio can be reshuffled when necessary). Moreover, given that the extent of investor overreaction varies over time, the profitability of the contrarian investment strategy could vary over time as well (Cubbin et al., 2006).

This paper seeks to contribute to the literature by addressing mean reversion in an emerging debt market, given that extant literature has focused on developed economies. Moreover, this study provides an in-depth analysis of short-term mean reverting behaviour. Stewart, Piros and Heisler (2011) provide one autocorrelation coefficient to represent all short-term horizons over the period 1926 to 2008. Correlations are not static over time, and so one autocorrelation coefficient cannot represent the serial correlation in all short-term horizons of a large sample period. This study contributes to the literature by assessing how the autocorrelation coefficient changes across different short-term horizons. The size and relevance of South Africa's bond market merit this debt market's consideration in the literature.

2.2 CORRELATION BETWEEN BOND RETURNS AND INFLATION

2.2.1 DEFINITION

The correlation between bond returns and inflation is the extent to which bond returns and the inflation rate move together. We seek to investigate this correlation in order to assess the efficacy of bonds as a hedge against inflation. The effectiveness of an asset as an inflation hedge is defined as the extent to which that asset can be used to reduce the risk of an investor's real return; where risk is taken to arise from uncertainty about the future level of the prices of consumption goods (Bodie, 1976).

Bodie (1976) puts forward two other definitions commonly found in the literature. An asset is a hedge against inflation if it eliminates or reduces the possibility that its real rate of return will violate a specified lower bound (Bodie, 1976). Alternatively, an asset is a hedge against inflation if its real return is independent of the rate of inflation (Bodie, 1976). In the next section, theory on asset returns and inflation is presented.

2.2.2 THEORETICAL BACKGROUND ON THE CORRELATION BETWEEN BOND RETURNS AND INFLATION

Theory presented by Irving Fisher (1930) and Fama and Schwert (1977) is useful in understanding what it means for an asset to provide a hedge against inflation. Fisher (1930) asserted that the nominal interest rate could be decomposed into an expected real return, and an expected inflation rate. The decomposition of expected nominal returns in this way applies to all asset classes (Fama & Schwert, 1977). Furthermore, if the market is an efficient rational processor of information available at time $t-1$, then it will set the price of an asset so that the expected nominal return over the period $t-1$ to t , is equal to the sum of the appropriate equilibrium expected real return, and the

best possible assessment of the expected inflation rate (Fama & Schwert, 1977). Thus, using information available at time $t-1$, the market correctly assesses the expected inflation rate (i), and the appropriate expected real return of the asset (ii), and sets the price so that the expected nominal return is given by (i) + (ii), see Equation 2.2.1 below

$$E(R_{jt}|\phi_{t-1}) = E(i_{jt}|\phi_{t-1}) + E(\Delta_t|\phi_{t-1}) \quad (2.2.1)$$

Where

$E(R_{jt}|\phi_{t-1})$ is the expected nominal return of asset j at time t ;

$E(i_{jt}|\phi_{t-1})$ is the appropriate equilibrium expected real return on asset j at time t ;

$E(\Delta_t|\phi_{t-1})$ is the best possible assessment of the expected inflation rate Δ_t ; and

ϕ_{t-1} is the information available at time $t-1$, on which all expectations are conditional (Fama & Schwert, 1977).

Based on his belief that the real and monetary sectors of the economy are largely independent, Fisher (1930) hypothesised that the expected real return, and the expected inflation rate are unrelated. He believed that real factors such as the productivity of capital and investor time and risk preferences drove the real rate of return (Fisher, 1930). The regression model in Equation 2.2.2 below can be employed to test the joint hypothesis that markets are efficient, and that expected real return and expected inflation return vary independently (Fama & Schwert, 1977).

$$R_{jt} = \alpha + \beta_j E(\Delta_t|\phi_{t-1}) + \varepsilon_{jt} \quad (2.2.2)$$

Where

R_{jt} is the nominal return of asset j at time t ;

$E(\Delta_t|\phi_{t-1})$ is the best possible assessment of the expected inflation rate Δ_t ;

α and β_j are regression coefficients; and

ε_{jt} is the error term of the regression model

A β_j value that is statistically indistinguishable from 1 is consistent with the hypothesis that the variation between the expected nominal return and the expected inflation rate is a one-one correspondence. The expected real return is the difference between the expected nominal return and the expected inflation rate. Thus a β_j value that is statistically indistinguishable from 1 is also consistent with the hypothesis that the expected real return is unrelated to the expected inflation rate, as Fisher hypothesised.

In order to fully hedge inflation, unexpected inflation needs to be accounted for. Fama and Schwert (1977) capture the unexpected component of inflation as shown in Equation 2.2.3 below.

$$\Delta_t - E(\Delta_{t-1}|\phi_{t-1}) \quad (2.2.3)$$

Where

Δ_t is the inflation rate at time t ; and

$E(\Delta_{t-1}|\phi_{t-1})$ is the best possible assessment of the expected inflation rate Δ_t

With unexpected inflation defined in this way, Fama and Schwert (1977) decompose the expected nominal return as follows

$$E(R_{jt}|\phi_{t-1}) = E(i_{jt}|\phi_{t-1}) + E(\Delta_t|\phi_{t-1}) + \gamma_j(\Delta_t - E(\Delta_{t-1}|\phi_{t-1})) \quad (2.2.4)$$

Where $E(R_{jt}|\phi_{t-1})$, $E(i_{jt}|\phi_{t-1})$, $E(\Delta_t|\phi_{t-1})$ are as defined in Equation 2.2.1, and $(\Delta_t - E(\Delta_{t-1}|\phi_{t-1}))$ is as defined in equation 2.2.3.

Estimates of Equation 2.2.4 can be obtained from the regression model in Equation 2.2.5 below.

$$R_{jt} = \alpha + \beta_j E(\Delta_t|\phi_{t-1}) + \gamma_j(\Delta_t - E(\Delta_{t-1}|\phi_{t-1})) + \eta_{jt} \quad (2.2.5)$$

Where α , β_j and γ_j are regression coefficients, and η_{jt} is the error term of the regression

An estimate of γ_j that is statistically indistinguishable from 1 is consistent with the hypothesis that the expected nominal return and unexpected inflation rate vary in a one-to-one correspondence. Under Fisher's model where expected real return and the expected inflation rate vary independently, β_j must equal one. The sign and magnitude of γ_j , however, depends on intuition about the asset j . For assets such as real estate that are believed to be adequate hedges against both expected and unexpected inflation, γ_j should be positive (Boudoukh & Richardson, 1993; Kim & Ryoo, 2011). For long-term bonds with fixed nominal cash flows, the sign and magnitude of γ_j depends on how unexpected inflation is related to the changes in the discount rate used to price bonds (Fisher, 1930).

When the regression in Equation 2.2.5 returns $\beta_j = 1$, then asset j is a perfect hedge against expected inflation. The expected nominal return of asset j varies directly with expected inflation, leaving the expected real return uncorrelated to inflation. When $\gamma_j = 1$, asset j is a perfect hedge against unexpected inflation. The expected nominal return of asset j varies directly with unexpected inflation, leaving the expected real return uncorrelated to unexpected inflation. When the regression results are that $\beta_j = \gamma_j = 1$, then asset j is a perfect hedge against inflation. The nominal return of asset j varies directly with both the expected and unexpected components of inflation and the ex-post real return on the asset is uncorrelated with the ex-post inflation rate (Fama & Schwert, 1977).

In the following section, we review the empirical evidence of the correlation between bond returns and inflation.

2.2.3 EMPIRICAL EVIDENCE OF THE CORRELATION BETWEEN BOND RETURNS AND INFLATION

We begin by presenting a brief overview of the literature on the use of equities as an inflation hedge, to aid comparison. Studies on the use of equities as an inflation hedge abound, however, there does not seem to be a clear consensus on the efficacy of equities as an inflation hedge. Bodie (1976) and Fama and Schwert (1977) find a negative relationship between stock returns and both the expected and unexpected components of short-term inflation over the period 1953 to 1972. The findings of these studies suggest that stocks are poor hedges against inflation for horizons of one month, one quarter, half a year and one year. Consistent with Bodie (1976) and Fama and Schwert (1977), Gultekin (1983) documented evidence against the use of stocks as a short-term inflation hedge in several countries across the world, including the UK, Germany, Canada and South Africa, over the period 1947 to 1979.

Boudoukh and Richardson (1993) look at the use of stocks as a hedge against long-term inflation, and document contradictory findings to the studies above. They find a positive relationship between nominal stock returns and both ex-ante and ex-post long-term inflation, suggesting that stocks do in fact provide some protection against long-term inflation. Alagidede (2009) shifted the focus to Africa, and investigated the relationship between stock returns and inflation for six African countries: Egypt, Kenya, Morocco, Nigeria, South Africa and Tunisia. He found that over the period 1990 - 2006, the Fisher Hypothesis could not be rejected for Kenya at the 12 month horizon; Tunisia at the 60 month horizon; and Nigeria at both the 12 and 60 month horizons, suggesting that stocks provide an adequate hedge against inflation in these countries, particularly over the long run for Tunisia and Nigeria. The remaining countries however, returned negative relationships with inflation,

consistent with the findings of Bodie (1976), Fama and Schwert (1977) and Gultekin (1983).

The use of bonds as an inflation hedge has not received as much attention in the literature as equities have. Fama and Schwert (1977) found that the nominal returns of US government bonds and bills vary directly with expected inflation over the period 1953 to 1971, thereby providing a complete hedge against expected inflation for horizons of one month, one quarter, and half a year. Their data comprised bills with maturity ranging from 1 to 6 months, and bonds with maturities ranging from 1 year to 5 years. In their study, the proxy for expected inflation for a particular period was the nominal interest rate of a T-bill maturing at the end of that period. The unexpected inflation rate was then measured as the difference between the ex-post inflation rate for that period and the above mentioned proxy for expected inflation.

At observations of one month, one quarter, and half a year, Fama and Schwert (1977) found that T-bills and bonds across all maturities varied directly with expected inflation. On the other hand, the relationship between these assets and unexpected inflation was negative and insignificant at the monthly observation, and became more negative as the observation frequency went from monthly to quarterly and to semi-annually. They found however that a strategy of rolling over short term T-bills returned a statistically significant positive relationship with unexpected inflation. A T-bill maturing in three months would not be able to adjust to changes in inflationary expectations within its three-month term. However, month-to-month adjustments in inflationary expectations would be captured by a sequence of three one-month T-bills. The ability of shorter term bills to capture intra-term changes in unexpected inflation allowed for this rolling over strategy to provide some protection against unexpected inflation.

Barr and Campbell (1997) provide some useful insights on the bond-inflation relationship in the UK. Their study used UK government nominal bonds and index-linked bonds to estimate expected future real interest rates and inflation rates. Barr and Campbell (1997) attributed almost 80% of the variation in long-term nominal rates to variations in expected long-term inflation over the period 1985 to 1994. They found that the levels of real rates and expected inflation were positively correlated and this increased with the horizon (Barr & Campbell, 1997). They found further that changes in short-term real rates and expected inflation were negatively correlated, and as the horizon increased this correlation moved to zero (Barr & Campbell, 1997). The latter suggests that over the long run, the correlation between real bond returns and inflation moves to zero. Therefore, real bond returns should be unaffected by inflationary expectations over long-term horizons.

In their investigation of empirical properties of bond returns, Stewart, Piro & Heisler (2011) also address the correlation between bond returns and inflation in the US. Their data comprised monthly log returns of a treasury note with roughly 5 years to maturity at the beginning of each month, and monthly log returns of the S&P 500 Index. Their study examined 5-year intervals over the period 1930 to 2008. They looked at nominal returns and real returns, as well as the income component and the capital gains and losses component of returns. Table 2.2.1 presents their findings.

Table 2.2.1: Correlation of Treasury note returns and S&P 500 returns with realised inflation for all 5 year periods from 1930 to 2008. Source: Stewart, Piro & Heisler (2011: 291)

	Bonds	Stocks
Nominal return	0.19	0.31
Income	0.43	0.01
Capital gains/losses	-0.34	0.30
Real return	-0.61	-0.06

In Table 2.2.1 we see that the nominal returns for both assets are positively correlated to realised inflation. For bonds, the income component exhibits a positive correlation to realised inflation, while the capital gains or losses component exhibits a negative correlation to realised inflation. These findings are logical. Unexpectedly high (low) inflation usually leads to interest rate hikes (cuts) and consequently a higher (lower) discount rate. A higher (lower) discount rate means lower (higher) prices, resulting in capital losses (gains). These losses (gains) are offset by the opportunity to reinvest at higher (lower) rates. Given that the duration of coupon-paying bonds is less than their maturity, this reinvestment is a dominating factor (Stewart, Piro & Heisler, 2011). When inflation is unexpectedly high, the reinvestment gains allow for a higher total return, and when inflation is unexpectedly low, the lower returns from reinvestment dominate and we have a lower total return. It follows that when reinvestment of coupons is considered, the nominal bond return would have a positive correlation with the unexpected component of inflation (Stewart, Piro & Heisler, 2011). However, the magnitude of this positive correlation (0.19) does not allow for bonds to fully hedge against inflation.

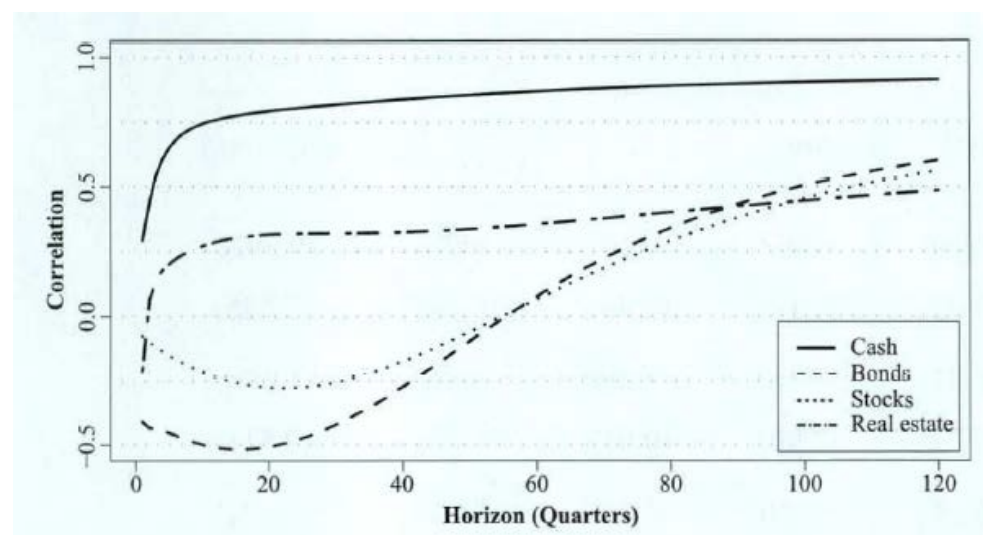
At closer inspection, the findings of Stewart, Piro & Heisler (2011) suggest that bonds are in fact a poor hedge against inflation. The correlation of real bond returns with inflation is -0.61. This suggests that the relationship between bond returns and inflation in the US over the period 1947 to 2008 is inconsistent with the Fisher Hypothesis. Moreover, the findings contradict those of previous studies such as Fama and Schwert (1977). However, given that Stewart, Piro & Heisler (2011) cover a more recent period than Fama and Schwert (1977), the contradictory findings could be the result of a change in the bond-inflation relationship in the years after the Fama and Schwert (1977) study. The findings in Table 2.2.1 suggest that stocks are a better inflation hedge than bonds. This is evident from greater positive correlation between nominal stock returns and inflation (0.31) compared to that between nominal

bond returns and inflation (0.19), and the almost zero correlation between real stock returns and inflation

Koniarski and Sebastian (2015) is a more recent study on the inflation-protecting ability of bonds, as well as other assets such as equities, cash and real estate in the US. Their study looks at both short term and long-term horizons over the period 1978 to 2010. The Ibbotson US Long Term Government Bond Index, which is a 20-year constant maturity bond index, serves as the proxy for bond investment, while the S&P 500 Index serves as the proxy for equity investment. The US Consumer Price Index is used to estimate the inflation rate. Amongst other things, the Koniarski and Sebastian (2015) study examined the correlation between different asset class returns and inflation. Figure 2.2.1 shows the findings of their correlation analysis.

In Figure 2.2.1, both bonds and stocks exhibit negative correlations at horizons less than 5 years, in contradiction to the positive relationship presented by Stewart, Piros & Heisler (2011). This negative correlation holds up until the 15-year horizon, with the effect being stronger for bonds. After the 15-year mark, bond returns are positively correlated with inflation, and this relationship becomes more positive as the horizon increases, reaching a value of about 0.6 at the 30-year horizon. These findings suggest that over the short and medium term (less than 15 years), bonds are poor inflation hedges, contradicting Fama and Schwert (1977), but as the investment horizon increases towards 30 years, bonds appear to provide some protection against inflation, and appear to be better inflation hedges than both equities and real estate. The positive correlation observed for horizons greater than 15 years could arise from a more pronounced coupon reinvestment effect when long horizons are considered. As explained earlier, when coupon reinvestment is considered nominal returns tend to move in the direction of inflation. From Figure 2.2.1, when only correlations are considered, cash appears to be the best inflation hedge across all horizons.

Figure 2.2.1: Correlations of nominal asset returns and inflation. Source: Koniarski and Sebastian (2015:64)



To summarise this review, Fama and Schwert document evidence supporting the use of bonds as a short-term hedge against inflation, based on the period 1953 - 1971 in the US. Stewart, Piros & Heisler (2011) and Koniarski and Sebastian (2015) present evidence against the use of bonds as a short-term inflation hedge in the US, based on an overall period of 1930 to 2010. When we consider long term horizons, Barr and Campbell (1997) and Koniarski and Sebastian (2015) present evidence in favour of the use of bonds as a long term hedge against inflation based on periods 1985 to 1994 in the UK, and 1978 to 2010 in the US respectively.

There is a dearth in the literature on the bond-inflation relationship in Africa. This is not surprising given that many African bond markets are still shallow and underdeveloped. However, South Africa is a striking exception here. The size and relevance of the South African bond market, coupled with the need to address wealth-preservation in the country's high inflationary climate, warrant the investigation of the bond-inflation relationship in South Africa.

A priori, we can form a few reasonable expectations. When an increase in inflation is expected, lenders expect that the real value of their principal and interest payments will depreciate, while borrowers expect to sacrifice less real value to repay their loans than before expectations changed (Gibson, 1972). Thus at any level of market interest rates, the quantity of loans supplied decreases, while the quantity of loans demanded increases (Gibson, 1972). The result of a leftward shift in the supply curve and rightward shift in the demand curve is a higher nominal interest rate. If we assume the real rate of interest remains unchanged, then the nominal rate will rise by the increase in the expected rate of inflation (Gibson, 1972). If on the other hand a decrease in inflation is expected, the supply curve will shift outwards, and the demand curve inwards, altogether lowering the nominal interest rate. It follows that the nominal interest rate will follow the direction of inflation expectations. Ergo, bond prices, which are inversely related to interest rates, will move in the opposite direction to inflation. Thus a priori, we can expect a negative correlation between nominal bond returns and inflation. From this theory, we form the following hypothesis:

H5: Nominal bond returns of South African bonds exhibit a negative correlation with inflation.

The expectations above do not account for coupon reinvestment. When coupons are reinvested, the reinvestment rate will follow the direction of nominal interest rates. The magnitude of the reinvestment income relative to the capital gains or losses made from the movement in bond prices will determine which component of income dominates and hence will determine the overall direction of the movement in nominal returns relative to the inflation rate. However, while reinvestment is an important consideration, we cannot assume that all bond investors reinvest their coupons.

Analysing the correlation between bond returns and inflation is essential in assessing the inflation hedging ability of bonds. Rejection of the above hypothesis would suggest that South African bonds are able to provide some protection against inflation. Moreover, correlation values close to one would suggest that real returns are almost uncorrelated with inflation, consistent with the Fisher Hypothesis, and would lend credit to the use of South African bonds as an inflation hedge.

It is worth highlighting a few points of caution. Correlations are not the only factor to consider when judging an assets inflation-protecting ability. Volatility is a factor that plays a significant role in the ability to hedge against inflation. If nominal bonds returns are less volatile than inflation, then the impact of swings in inflation will be the dominating factor and real returns will likely be negatively correlated to inflation (Stewart, Piros & Heisler, 2011). Fama and Schwert (1977) caution that an asset being a perfect hedge against inflation bears no implications for the variance of its real return. Factors unrelated to inflation can generate variation in returns, which can be smaller or greater than inflation-induced variation. Thus even when an asset is a perfect hedge against inflation, inflation might account for only a small variation in the assets nominal return and the variance of the assets real return may be large relative to the variance of the expected and unexpected components of inflation (Fama & Schwert, 1977).

A further factor to consider is that even if an assets nominal return has a strong positive correlation with inflation, this return could still be less than the inflation rate. Therefore, while a significant positive correlation would suggest that an asset is an adequate hedge, returns less than the inflation rate would suggest otherwise. Thus a positive correlation by itself does not dictate that an asset is an adequate hedge against inflation, but provides a useful point from which to pursue further analysis.

Finally, asset correlations are not static. As such it is crucial to note that significant positive correlations observed for a particular period, may not hold in later periods. Tests on correlations need to be updated regularly.

2.2.4 MOTIVATION AND CONTRIBUTION TO THE LITERATURE

The investigation into the correlation between bond returns and the inflation rate was motivated by a number of factors. Firstly, while equities are considered by many to be an adequate inflation hedge, there are several empirical studies that document evidence to the contrary for markets in the US, the UK, and Africa (Gultekin, 1983; Alagidede, 2009). The lack of consensus on equities as inflation-hedge means investors need accurate information on other assets available to them. As such, it is necessary to investigate the case for South African bonds, in order to better inform investors on the efficacy of bonds as an inflation hedge. This research is especially useful in South Africa, where pressures such as labour costs, a volatile rand, and in recent periods a protracted drought, caused inflation to deviate from the reserve bank's target band of 3-6%. This has eroded the real value of wealth in the country. It is more crucial now for investors to know how to protect themselves and preserve their wealth. Inflation is not only a concern for institutional investors, whose liabilities tend to be tied to consumer prices and wage levels, but also for private investors, as they seek to preserve the real value of their wealth.

This paper seeks to contribute to the literature by adding to the knowledge of the bond market in emerging market economies. Extant literature has focused on the correlation between stock returns and inflation, and has focused on the bond-inflation correlation in developed markets. This study seeks to address this gap by considering the correlation between bond returns and inflation in South Africa, a key emerging debt market in which the inflation rate often threatens to breach the reserve bank's target band.

2.3 CORRELATION BETWEEN BOND RETURNS AND STOCK RETURNS

2.3.1 DEFINITION

The correlation between two variables is a measure of the extent of association between the two variables. The correlation coefficient allows us to assess both the strength of association between two variables, and the direction of their relationship. A cardinal point to note is that correlation tells us about the extent of co-movement between the two variables, but says nothing about whether a causal relationship exists between the two variables. Therefore correlation does not tell us that one variable *causes* movement in another, it simply allows us to judge the direction that the second variable will move when we observe movement in the first. In this paper, the terms correlation and co-movement are used interchangeably. The following section details a theoretical background on the correlation between bonds and stocks.

2.3.2 THEORETICAL BACKGROUND ON THE CORRELATION BETWEEN BOND AND STOCKS

Asset allocation and diversification are critical parts of an investor's investment strategy. Asset allocation refers to how the investor's capital is assigned to different asset classes in order to achieve certain investment objectives (Old Mutual, 2011). Diversification involves allocating capital to those asset classes that complement each other so that altogether the portfolio achieves optimal performance and/or has a reduced risk. These aspects of investment strategy require that we know not only asset returns and asset risks, but also the correlation between asset classes.

If two assets in a portfolio are positively correlated, then if one asset is generating positive returns, the other will also be generating positive returns.

Thus the performance of one asset will be reinforced by the performance of the other. If the assets are performing well, this is great for the investor holding the portfolio. If they are not, however, then both assets are a downward force on the overall portfolio performance. A priori, an investor does not know for certain which direction asset returns will go. Thus a portfolio consisting only of positively correlated assets does not provide much protection, because in the event that one asset is performing poorly, assets positively correlated to it will do the same.

If the assets are uncorrelated, then the performance of one is independent of the other. If for example the assets in the portfolio are stocks and bonds, and these are uncorrelated, then good performance in stocks means nothing for bond performance. Bonds could perform well, or could perform poorly. A crash in the stock market would not imply a crash in the bond market, all other things held constant.

On the other hand, if the two assets are negatively correlated, then poor performance of one asset is offset by good performance of the other. Thus when one asset is pulling portfolio performance down, the other asset serves as an offsetting force. Altogether, when investors are considering diversifying into other assets, correlations allow us to judge in what direction the other assets would pull the returns of the portfolio.

Diversification is essential in controlling risk, and we can quantify the effect of diversification on portfolio risk. The standard deviation is a widely accepted measure of risk. The square of the standard deviation, which is the variance, is often easier to compute. The portfolio variance formula allows us to see the relevance of asset correlations for portfolio risk. Equation 2.3.1 shows the formula for the variance of a two-asset portfolio.

$$\sigma_P^2 = w_A^2 \sigma_A^2 + w_B^2 \sigma_B^2 + 2w_A w_B \rho \sigma_A \sigma_B \quad (2.3.1)$$

Where

σ_p^2 is the portfolio variance

σ_A^2 is the variance of asset A

σ_B^2 is the variance of asset B

σ_A is the standard deviation of asset A

σ_B is the standard deviation of asset B

ρ is the correlation coefficient

w_A is the weight of asset A in the portfolio

w_B is the weight of asset B in the portfolio

Equation 2.3.1 shows that the variance of a two-asset portfolio is not simply the weighted sum of the variance of its components. The correlation between the two assets plays a significant role in the overall portfolio variance. When the correlation coefficient, ρ , is positive, the variance is greater than just the weighted sum of the variances of the constituent assets. When ρ is zero, the variance of the portfolio is exactly equal to the weighted sum of the variance of the individual assets. Therefore the variance of the portfolio is not made worse (larger) than the weighted sum of the individual variances, but it is not improved from this sum either. When ρ is negative, however, the variance is less than the weighted sum of the variances of the constituent assets. Thus a portfolio consisting of two negatively correlated assets would have variance less than total contribution of each asset's variance.

It follows from the discussion above that understanding correlations allows an investor considering diversifying into another asset class to assess two critical factors. Firstly, it allows the investor to assess whether combining one asset, asset A, with another, asset B, works as a reinforcing force; offsetting force; or neutral force on asset A's returns. Secondly, widely accepted risk measures make use of the standard deviation, and its square, the variance. Correlations allow an investor to assess whether combining assets together

would reduce the portfolio variance or not, effectively assessing their risk position.

It is essential to note that correlations are not static values. Thus an understanding of the drivers behind correlations is useful. As correlation values change over time, an understanding of the factors that drive co-movement in asset returns can help in predicting future correlations, and thus better inform investment strategy. This theoretical background reviews the theory presented in the literature on the drivers of co-movement in asset returns.

The traditional theory of asset class correlations stems from economies without frictions and with rational investors (Barberis et al., 2005). In such economies, the price of an asset is equal to its fundamental value, which is the present value (with respect to an appropriate discount rate) of rationally forecasted cash flows (Barberis et al., 2005). By definition, changes in the price of the asset arise from corrections of rational expectations about future cash flows from an asset, or from corrections in the discount rates applied to those cash flows. With the price of an asset dependant on its fundamental value, the traditional view argues that co-movement in asset class prices must arise from co-movement in the factors driving the price (the fundamental value) of these assets (Barberis et al., 2005).

Factors driving the price of an asset that are unique to that asset can be expected to reduce the correlation between stocks and bonds. For instance, news about future dividends, or future excess stock returns for stocks will likely move only stock prices. Using the Dividend Discount Model to calculate price, Ilmanen (2003) highlights that (cash flows aside), the present value of equity depends on the sustainable growth rate and the equity discount rate, while the present value of bonds depends only on the bond discount rate. The discount rates reflect the relative risk premiums of each

asset, and have both shared and asset-specific components (Ilmanen, 2003). Factors that affect the shared components of the discount rate are likely to drive stock and bond prices in the same direction thus increasing the correlation between the two (Li, 2002). Factors affecting only asset-specific components of the discount rates will likely reduce the correlation between the two assets (Ilmanen, 2003; Li, 2002).

Baele, Bekaert & Inghelbrecht (2010) argue that changes in macroeconomic variables are often behind changes in rationally expected cash flows and/or changes in the discount rate of bonds and stocks. Ilmanen (2003) highlights the following macroeconomic variables as those relevant to consider in stock-bond correlations: the business cycle and growth outlook; the inflationary environment; volatility conditions; and, the monetary policy stance.

The implication of the inflationary environment on the stock-bond correlation is not straightforward. Theory put forward by Shiller and Beltratti (1992) suggest that inflation changes should reduce the correlation between stocks and bonds. They argue that the dividend stream of stocks is relatively stable in real terms, while the bond coupon stream is relatively stable in nominal terms. If changes in long-term bond yields are primarily due to inflationary pressures, then this should affect bonds and have little effect on stocks (Shiller & Beltratti, 1992). Consistent with Shiller and Beltratti (1992), Engsted and Tanggaard (2001) found that in Danish stock and bond markets, inflation news affects expectations of future stocks and bonds differently in the long run, and thus such news is likely to reduce the correlation between the two assets. On the other hand, Ilmanen (2003) suggests that in reality, both assets are affected in a high inflation environment. A high inflation environment raises expected short-term interest rates, as well as the inflation-related bond and equity premiums (Ilmanen, 2003). Thus according to Ilmanen (2003), a high inflation environment should induce a positive correlation between equities and bonds. On the other hand, in a low but positive inflationary

environment, interest rates are relatively stable, and so growth uncertainty is a key driver of stock market volatility (Ilmanen, 2003). Ilmanen (2003) asserts that such an environment should induce a lower stock-bond correlation.

In recent periods, pressing macroeconomic issues in South Africa include the phase of the business cycle, given that subdued growth has been a concern; movements or expected movements of inflation outside the 3-6% target band (and the changes in interest rates in response to this); and the rand-exchange rate volatility, particularly as a result of changes in foreign investor confidence. Therefore for the South African landscape, these factors are some of the variables that we can expect to be at play in the correlation between South African stock and bond returns.

Moving onto more theory, Fama and French (1993) found that term structure factors link the stock and bond markets. Their 1993 paper investigates risk factors of stock and bonds respectively, as well as common risk factors between the two assets. Their findings were that stock market factors, such as size and value, capture variation in stocks, but play a little role in the variation in government and corporate bond returns. On the other hand, term structure factors, which explain variation in bond returns, were able to explain the variation in stock returns as well (Fama & French, 1993). The term structure factors in their investigation were a term factor, capturing the effect of unexpected changes in interest rates on bond returns, and a default factor, capturing the effect of the risk of default on bond returns (Fama & French, 1993). What emerges from the findings of Fama and French (1993) is that interest rate movements and changes in the perceptions of default risk, which capture the variation in both stock and bond returns, could drive co-movement of the two assets' returns.

The category theory provides a different view of co-movement in asset prices. Investors group assets into categories such as small capitalisation stocks, or

oil industry stocks, or high-yield bonds, and then allocate funds to the category, and not to its constituent assets (Barberis et al., 2005). In the event that some of these investors are noise traders with correlated sentiments, and if their trading decisions move asset prices, then as these investors move funds between categories, their coordinated demand induces common factors in the return of assets classified under the same category, even when the asset cash flows are uncorrelated (Barberis et al., 2005). Ocran and Mlambo (2009) found excess co-movement in equity and bond returns in South Africa, beyond what can be explained by fundamental variables. Their findings support the category theory, and suggest a possible fad psychology in investors in the South African market.

We consider further, the habitat theory of co-movement. This is often considered a variation of the category theory (Ocran & Mlambo, 2009). Many investors choose to trade only a subset of all available securities and these particular preferences may arise from transaction costs, trading restrictions, or lack of information (Barberis et al., 2005). As risk aversion, investor sentiment, or liquidity needs change, these investors alter their positions in their habitat, and in doing so, induce a common factor in the returns of the assets in this habitat (Barberis et al., 2005). According to the habitat view of co-movement, a specific subset of investors changing the exposures of their preferred set of investments creates a common factor in the returns of the assets of that set (Barberis et al., 2005).

Theories such as the category theory or habitat theory could hold in the South African investment landscape. Bonds and equities are the most preferred asset classes in South Africa (Ocran & Mlambo, 2009). Moreover, institutional investors such as pension funds, that are key players in both markets, typically hold portfolios where bonds and equities are the main constituents. We can view these typical portfolios as a category or habitat – the preferred balanced portfolio. The category and habitat theories suggest that movement

of funds in and out of these common portfolios may induce a correlation between stocks and bonds.

Finally, we present the information diffusion view of co-movement. The presence of some degree of market friction implies that information is incorporated more quickly in the prices of some assets than others. Barberis et al. (2005) argue that this will induce a common factor in the returns of assets that incorporate information at similar rates, increasing their correlations. The following section reviews the empirical evidence.

2.3.3 EMPIRICAL EVIDENCE OF THE CORRELATION BETWEEN BOND RETURNS AND EQUITY RETURNS

Considerable attention has been given to research on the correlation between bond and stock returns in developed markets. Ilmanen (2003) investigated bond-stock correlations in the US over the period 1926 to 2001. The study found that over this period, correlation between bonds and stocks tended to be positive, however there are several extended periods of this changing to negative (Ilmanen, 2003). The investigation revealed further that over the period 1926 to 2001, periods of strong growth and high market volatility in the US were characterised by low correlations between the two asset classes while periods of monetary policy easing and disinflation corresponded with a higher bond-stock correlation (Ilmanen, 2003). Ilmanen (2003) found that in both inflationary and stable expansion environments, and inflationary and stable recession environments, bond and stock correlations were close to zero at 0.19 and 0.2 respectively. A low correlation in both these environments suggests that performance of one asset is almost independent of performance of the other asset, and thus combining the two assets provides some diversification of returns.

The Stewart, Piros & Heisler (2011) investigation of empirical properties of bond returns examines the correlation between bonds and stocks. As mentioned in the previous sections, their investigation analysed monthly log returns of a treasury note with 5 years to maturity at the beginning of each month, and monthly log returns of the S&P 500 Index. Their bond-stock correlation analysis focused on the period 1970 to 2008 in the US. Table 2.3.1 displays their findings.

Table 2.3.1: Correlation of monthly log returns of bonds and stocks over the period 1970 to 2008 in the US. Source: Stewart, Piros & Heisler, 2011: 290.

Period	Correlation coefficient
Overall	0.12
Stocks up	0.23
Stocks down	-0.12
Stocks <-5%	-0.32

In Table 2.3.1 we see that on average, over the period 1970 to 2008, stock and bond returns were positively correlated, at 0.12 (Stewart, Piros & Heisler, 2011). They broke down their sample period into periods where stock returns were positive (“up”), and periods where stock returns were negative (“down”). In Table 2.3.1 we see that when stock returns were up, the correlation between the returns of the two asset classes was a stronger positive, at 0.23. When stock returns were down, the correlation between stock and bond returns was -0.12. A noteworthy result in Table 2.3.1 is that when stocks were performing particularly poorly, with returns less than -5%, the correlation was a stronger negative at -0.32.

The findings of Stewart, Piros & Heisler in Table 2.3.1 (2011) show that for the US over the period 1970 to 2008, bonds were able to provide adequate diversification, particularly when it was most needed. When stocks were performing well, the positive correlation between the two assets meant that

positive bond returns reinforced the performance of the portfolio. When stocks were performing poorly, the negative correlation between the two assets meant that the poor stock performance was slightly offset by bonds performing better. Moreover, when stocks were performing especially poorly, the stronger negative correlation means the bond performance was able to offset these losses even more. A caveat to note concerning the results in Table 2.3.1 is that Stewart, Piros & Heisler (2011) do not state the statistical significance of the correlations presented.

Several other papers address the determinants of co-movements in the two asset classes in developed markets. Fama and French (1993); Li (2002); Barberis, Schleifer and Wurgler (2005) and Baele, Bekaert and Inghelbrecht (2010) are a few examples.

The literature on the correlation between bond and stock returns in emerging markets is not as dense as it is for developed markets. Studies such as Firer and McLeod (1999) and Auret and Vivian (2014) investigate the relative performance of bonds and equities, and in doing so address correlations.

Firer and McLeod (1999) examine the performance of equities, bonds and cash in South Africa, and specifically compare the performance of these assets relative to the inflation rate. The period of their study was 1925 to 1998. In their investigation of each asset class' performance, they address the correlations between the asset classes. The equity data in their study was pulled from three sources. For the period 1925 to 1947, the study used the Industrial and Commercial Share Price Indices published by the Bureau for Economic Research. For 1948 to 1949 an equity index was constructed from industrial share price information from the JSE. For the period 1949 to 1959, the Rand Daily Mail Industrial Index served as the equity investment proxy. Finally from 1960 to 1998, the JSE All Share Index (ALSI) served as the equity investment proxy. For bond data, prior to 1998, the closing yield on the JSE

Gilt floor was used to calculate a bond index (Firer & McLeod, 1999). After 1998, the All Bond Index served as the proxy for bond investment. Their findings for the bond-stock correlations are displayed in Table 2.3.2. Their correlation analysis looked at year-on-year returns, and non-overlapping 3-year, 5-year and 10-year horizons respectively.

Table 2.3.2 reveals that a positive correlation was observed across all horizons. Firer & McLeod (1999) therefore show that over the over the period 1925 to 1998, there were no diversification benefits to be obtained from combining the two assets together in a portfolio: this combination would not reduce portfolio risk, and adverse performance by one asset would only be reinforced by the other. It can also be seen in Table 2.3.2 that there was not much variation in the correlation figures when one compares the 3-year nominal return correlation to the 5 and 10-year nominal return correlations. Thus it appears that the correlation was unaffected by the length of the return horizon. Firer and McLeod (1999) disclose further that their investigation revealed a “progressive uncoupling” of the two markets, as they observed a correlation of 0.88 in the earliest period, but by the last decade this value fell to 0.14.

Table 2.3.2: Correlation between nominal and real stock and bond returns in South Africa over the period 1925 to 1998. Source: Firer and McLeod (1999)

	Correlation between nominal returns	Correlation between real returns
Annual returns	0.48	0.43
3-year returns	0.32	0.39
5-year returns	0.47	0.24
10-year returns	0.49	0.28

Auret and Vivian (2014) investigated the performance of bonds relative to equity in South Africa over the period 1986 to 2014. The All Bond Index

served as the bond investment proxy, and the All Share Index served as the equity investment proxy. They analysed monthly returns of bonds and stocks and obtained a correlation coefficient of 0.265.

Auret and Vivian (2014) document evidence of a positive correlation between the monthly returns of bonds and stocks. Their study, consistent with Firer and McLeod (1999) suggests that there are no diversification benefits to be reaped by combining the two assets together in a portfolio. We add the caveat that neither Firer and McLeod (1999) nor Auret and Vivian (2014) state the statistical significance of the correlations reported.

From the findings of Firer and McLeod (1999) and Auret and Vivian (2014) we form the following hypothesis:

H6: South African bond returns and stock returns are positively correlated.

Furthermore, to better assess the diversification potential, we will break up our sample period following Stewart, Piros & Heisler (2011), and test the following hypotheses:

H7: The correlation between South African bond returns and stock returns is negative when stocks returns are negative.

H8: The correlation between South African bond returns and stock returns is negative when stock returns are very negative.

2.3.4 MOTIVATION AND CONTRIBUTION TO THE LITERATURE

The key motivation for investigating the bond-stock correlation is that this information is vital in understanding whether there are diversification benefits to be reaped from combining these assets together in a portfolio.

Given that bonds and equities are the main assets South African investors consider for their portfolios, an understanding of the bond-stock correlation is crucial for their asset allocation decisions. An investigation of the bond-stock correlation would allow investors to determine whether the returns of bonds reinforce the performance of stocks; whether the returns of bonds are independent of stock returns; or whether the returns of bonds offset the performance of stocks. Moreover, the correlation analysis will reveal whether combining the two assets together would reduce overall portfolio risk, where risk is measured by the variance of the portfolio.

This paper seeks to contribute to the literature by updating the stock-bond correlation values documented by Firer and McLeod (1999) and Auret and Vivian (2014). Moreover, by examining the bond-stock correlation when stock returns are performing particularly poorly, this study seeks to provide a more detailed understanding of the diversification potential of combining the two assets together.

2.4 CONCLUSION

This literature review has presented the pertinent theory and empirical evidence concerning all three empirical properties under investigation in this study. Moreover, the motivations for these chosen avenues of research are detailed, together with the contribution this study plans to make in the literature. Pooling together all the motivations detailed in each section in this review, it emerges that the overall motivation of this study is to add to the knowledge of the bond market, particularly, the South African bond market, in order to enable bond investors to make more informed asset allocation decisions. A number of hypotheses have been formed from the empirical evidence presented.

For mean reversion, this study seeks to test the following hypotheses:

H1: South African bond returns display a positive serial correlation over the long term, thus exhibiting long-term trending behaviour.

H2: If South African bond returns exhibit a negative serial correlation over the long term, then this negative serial correlation becomes more negative with increasing term to maturity.

H3: South African bond returns display positive serial correlations over the short term, thus exhibiting short-term trending behaviour.

H4: If negative serial correlations are observed over the short-term, then these negative serial correlations become more negative with increasing term to maturity.

For the correlation between bond returns and inflation:

H5: Nominal bond returns of South African bonds exhibit a negative correlation with inflation.

For the correlation between bond returns and equities

H6: South African bond returns and stock returns are positively correlated.

H7: The correlation between South African bond returns and stock returns is negative when stocks returns are negative.

H8: The correlation between South African bond returns and stock returns is negative when stocks are very negative.

The following chapter, Chapter 3, presents the data and the methodology.

CHAPTER 3: DATA AND RESEARCH METHODOLOGY

This chapter presents the data and the research methodology used in this study to investigate three empirical properties of South African bonds: mean reversion in bond returns; the correlation between bond returns and the inflation rate; and the correlation between bond returns and equity returns. Section 3.1 of the chapter details the data used in the study and Section 3.2 details the research methodology employed. A conclusion of the chapter follows in Section 3.3.

3.1 DATA

This study is conducted at the macroeconomic level using index data. Table 3.1.1 details the proxies used for bond investment, inflation, and equity investment respectively.

Table 3.1.1 Data used and sources

Proxy Needed	Proxy Used	Period	Source
Bond Investment	JSE All Bond Indices	2000 - 2016	JSE and I-Net Bridge
Inflation	Consumer Price Index (CPI)	2000 - 2016	Bloomberg
Equity Investment	FTSE/JSE All Share Total Return Index (JALSHTR)	2002 - 2016	Bloomberg

THE JSE ALL BOND INDICES

The JSE All Bond Indices include the Composite All Bond Index (ALBI) and sub-indices of the ALBI that cover different maturities. The Composite All

Bond Index (ALBI) consists of the top 20 fixed rate, fixed maturity bonds in the South African bond market (JSE, 2013). The bonds in the ALBI are ranked dually by market capitalisation and liquidity, and consist of both sovereign and non-sovereign bonds (Van Wyk, Botha & Goodspeed, 2015). Non-sovereign bonds include bonds issued by local government, public utilities and corporates. The ALBI covers the full range of maturities in the South African bond market. This index provides a measure of the daily movement in the bond market (JSE, 2013). For this reason we believe it is an adequate proxy for bond investment. The following sub-indices of the ALBI are also used in this study:

- The ALBI 1-3 year split: includes bonds in the ALBI with term to maturity between 1-3 years (JSE, 2013)
- The ALBI 3-7 year split: includes bonds in the ALBI with term to maturity between 3-7 years (JSE, 2013)
- The ALBI 7-12 year split: includes bonds in the ALBI with term to maturity between 7-12 years (JSE, 2013)

The All Bond Indices used in this study are total return indices. The Johannesburg Stock Exchange (JSE) provided ALBI data from as far back as 2000. ALBI sub-indices data are available on I-Net Bridge from 2004.

THE CONSUMER PRICE INDEX

The Consumer Price Index (CPI) is an index of the cost of a representative basket of consumer goods and services, including VAT (Van Wyk, Botha & Goodspeed, 2015). The contents of the basket, and their relative weights are determined from a survey of household income and spending conducted every few years (Van Wyk, Botha & Goodspeed, 2015). The value of the basket in a defined base period is taken as a 100, and each subsequent index value reflects how much prices have changed since the base period. The CPI

serves as a proxy to measure inflation, as changes in the CPI indicate changes in the level of prices. Fama and Schwert (1977) defend the use of an index based on consumption goods as a proxy for inflation, given the assumption that the purpose of investment is for later consumption. For this reason, we believe changes in CPI serve as an appropriate proxy for inflation in this study. CPI data was obtained from Bloomberg, from 2000, to match the data available on bonds.

THE FTSE/JSE ALL SHARE TOTAL RETURN INDEX

The FTSE/JSE All Share Index is a market capitalisation weighted index that represents 99% of the full market capitalisation of all ordinary shares listed on the JSE Main Board (JSE, 2013). The FTSE group and the JSE collaborated to modify the calculation of the equity indices in the country (JSE, 2013). The result of their joint venture was a series of indices that in 2002 replaced the JSE Actuaries indices (JSE, 2013). The FTSE/JSE All Share Index and the FTSE/JSE All Share Total Return Index form part of this series. With 99% of the equity market capitalisation represented in the all share indices, they serve as an adequate proxy for equity investment. This study makes use of the All Share Total Return Index, which includes dividend income. The FTSE/JSE All Share Total Return Index data is available from 2002 on Bloomberg.

3.2 RESEARCH METHODOLOGY

This study employs a quantitative research approach. Quantitative research seeks to test objective theories by examining and identifying relationships among variables (Creswell, 2014). Quantitative research typically involves deductive reasoning and seeks to make observations from a large sample (Creswell, 2014; Leedy & Ormrod, 2015). Quantitative methods tend to assume a post-positivist worldview (Creswell, 2014). The post-positivist

approach to research begins with a theory, collects data in support of or against this theory, and makes necessary revisions. The objective of research under this framework is to *explain* a particular situation through true and sound statements (Creswell, 2014; Leedy & Ormrod, 2015). Although this study employs a quantitative approach, one element of qualitative research will be adopted in the analysis: the analysis will seek an understanding of the context and complexities that underlie the results. We adopt this feature of qualitative research because understanding the intricacies of the context may be useful in explaining the results and in guiding future predictions.

With the research approach thus established, this study employs a non-experimental research design. This type of design provides a quantitative description of trends of a population (Creswell, 2014). This study performs tests directly on the data, thus examining the data directly, as opposed to fitting a model to the data. Stewart, Piros and Heisler (2011) defend the use of this direct analysis, as models may often oversimplify reality. In the following sections, we review the research method employed to investigate each empirical property under analysis in turn. The study is conducted at the macroeconomic level.

3.2.1 INVESTIGATION OF MEAN REVERSION IN BOND RETURNS

We describe the method used to test each hypothesis in turn.

INVESTIGATING H1 USING THE ALBI INDEX

H1: South African bond returns display a positive serial correlation over the long term, thus exhibiting long-term trending behaviour over the period 2000 to 2016

We investigate H1 using monthly returns of the Composite All Bond Index (ALBI). Bond returns can be defined in terms of the yield to maturity, holding period returns, current yield and realised compound yield. In this study we use monthly holding period returns, defined in Equation 3.2.1. Given that this study uses indices, monthly holding period returns make sense, as this is the return received by an investor with a portfolio replicating the index. Moreover, the use of monthly holding period returns, and not yields, allows for direct comparison with monthly holding period returns of the equity index.

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \quad (3.2.1)$$

Where

R_t is the ALBI return for month t

P_t is the index level of the ALBI in month t

P_{t-1} is the index level of the ALBI in month $t-1$

We use serial correlation tests to investigate mean reverting behaviour. In particular, we use the sample autocorrelation function (ACF), a widely known and accepted test for serial correlation (Levich & Rizzo, 1998; Gerolimetto, 2010). The ACF returns the autocorrelation coefficient, ρ_k , which indicates the degree of autocorrelation between values of a time series that are separated by k lags (Levich & Rizzo, 1998). Equation 3.2.2 displays the formula for the autocorrelation coefficient with lag k

$$\rho_k = \frac{cov(y_t, y_{t-k})}{\sigma_{y_t} \sigma_{y_{t-k}}} \quad (3.2.2)$$

Where

ρ_k is the autocorrelation coefficient with lag k

y_t is the time series under investigation

$cov(y_t, y_{t-k})$ is the covariance between observation y_t , and the observation y_{t-k} , which occurs k lags earlier

σ is the standard deviation (Levich & Rizoo, 1998)

The autocorrelation coefficient allows us to assess both the strength and the direction of the serial correlation. A positive coefficient is evidence of trending, and a negative coefficient is evidence of mean reversion. The significance of the autocorrelation coefficient will be tested using the hypothesis test:

$$H_0: \rho = 0$$

$$H_1: \rho \neq 0$$

The alternative hypothesis is two-sided, allowing for ρ to be greater or less than zero. Significance is assessed at the 5% level, therefore, given a two-sided alternative, the critical value for a p-value of 2.5% is used to assess significance. The critical value is obtained from the probability density function for the correlation coefficient documented in Les Underhill and Bradfield (2013). Failure to reject the null hypothesis implies that there is no evidence of mean reversion or trending, and it is more likely that returns in one period are uncorrelated with returns in subsequent periods.

H1 tests for the presence of long-term mean reversion in monthly ALBI returns, where long-term implies mean reverting behaviour over a long horizon. To test this, we examine the overall sample period of 2000 to 2016, and obtain the autocorrelation coefficient at the first lag. Thus, we are testing whether over a 16-year horizon, ALBI returns in one month are correlated with returns in the previous month.

INVESTIGATING H2 USING THE ALBI SUB INDICES

H2: If South African bond returns exhibit negative serial correlation over the long term, then this negative serial correlation becomes more negative with increasing term to maturity

To test H2, we use the three ALBI sub-indices listed in Section 3.1. Serial correlation tests will be performed on the monthly returns of each ALBI sub-index, as was done for the ALBI index. Consistent with the methodology for H1, autocorrelation will be assessed at the first lag, using the ACF. The autocorrelation coefficients obtained for each sub-index will be compared to assess whether longer maturity bonds show stronger mean-reverting evidence.

It is important to stress again that long-term refers to the horizon under consideration, and not the term of the bond. Thus we are comparing the autocorrelation coefficient of bonds across maturities, over the entire sample period of 2000 to 2016.

INVESTIGATING H3 USING THE ALBI INDEX

H3: South African bond returns display positive serial correlations over the short term, thus exhibiting short-term trending behaviour over the period 2000 to 2016

The definition of long term and short term may differ across investors. In this study we treat periods less than five years as short term, and periods greater than five years as long term. We will examine two short-term horizons: three years and five years respectively. Therefore, the overall sample period (2000 to 2016) will be split into non-overlapping periods of three years and five years.

Using the ACF, we will test whether returns in one month are correlated with returns in the previous month over horizons of 3 years and 5 years respectively. In each of these short-term periods, serial correlation tests will then be performed on monthly ALBI returns. Correlations are not constant over time. Thus the objective here is to observe whether the correlation coefficients obtained for each sub-period show any consistency.

INVESTIGATING H4 USING THE ALBI SUB-INDICES

H4: If negative serial correlations are observed over the short-term, then these negative serial correlations become more negative with increasing term to maturity

The ACF will be used to assess serial correlation in each of the ALBI sub-indices over each of the 3 year and 5 year periods. The results for each sub-index will be compared to assess whether there are differences in the findings of short-term mean reversion across maturities.

3.2.2 INVESTIGATION OF THE CORRELATION BETWEEN BOND RETURNS AND THE INFLATION RATE

In the investigation of the correlation between bond returns and the inflation rate, we seek to test the following hypothesis.

H5: Nominal bond returns of South African bonds exhibit a negative correlation with inflation over the period 2000 to 2016.

To investigate H5, we compare the monthly holding period ALBI returns to the monthly inflation rate. The monthly inflation rate is defined as the rate of change of the CPI Index, as shown in Equation 3.2.3 below

$$i = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \quad (3.2.3)$$

Where

i is the inflation rate

CPI_t is the level of the CPI index at month t

CPI_{t-1} is the level of the CPI index at month $t-1$

We use the Pearson r correlation test to assess the correlation between the monthly ALBI returns and the monthly inflation rate. Correlation tests are the standard procedure used in the literature to analyse horizon-dependent inflation hedging properties (Amec et al., 2009; Briere & Signori, 2012; Koniarski & Sebastian, 2015).

The Pearson r statistic is the most widely used correlation statistic to measure the degree of association between linearly related variables (Chen & Popovich, 2002). A computation formula for Pearson's r is shown in Equation 3.2.4

$$r = \frac{Cov(X, Y)}{\sigma_X \sigma_Y} \quad (3.2.4)$$

Where

r = the Pearson r correlation coefficient

$Cov(X, Y)$ is the covariance between variables X and Y , the two variables whose degree of association is under investigation

σ is the standard deviation (Les Underhill & Bradfield, 2013)

Assumptions of the Pearson r correlation test are listed below:

- 1) The two variables are linearly related (Chen & Popovich, 2002)
- 2) Both variables are normally distributed (Chen & Popovich, 2002).

Exploratory data analysis in Chapter 4 will assess whether the assumptions above are satisfied. If the data fail to satisfy the above assumptions, the Kendall Tau-b correlation test will be used. This is a non-parametric test, and thus does not depend on the data following any particular distribution. The Kendall Tau-b test is often used as an alternative to the Pearson r correlation test when the data fail to satisfy the assumptions of the Pearson r test (Lund Research Ltd, 2013). For both the Pearson r and Kendall Tau-b correlation tests, significance is assessed based on a test of the null hypothesis that the true correlation is zero. The alternative hypothesis is two-sided, allowing for either a positive or negative correlation coefficient.

In testing the Fisher Hypothesis that ex-ante real rates are statistically uncorrelated with expected inflation, studies often use an ex-post model, using for example observed nominal returns versus a contemporaneous proxy for expected and unexpected inflation (See Alagidede, 2006; Gultekin, 1983 and Solnik, 1983 for examples that cover both developed and developing markets). This ex-post relationship is then used to draw conclusions about the Fisher Hypothesis. The models used are very often poor fits, with very low R^2 values. This is expected given the variation in nominal returns arises from more factors than just inflation. Moreover, the use of different proxies for expected and unexpected inflation does not always allow for consistent or comparable results. This study is not concerned with finding a model that accurately captures variation in nominal returns, or finding the most adequate proxy for expected or unexpected inflation. Instead, the goal here is an at-the-surface analysis of the correlation between nominal bond returns and inflation, in an attempt to assess the use of bonds as an inflation hedge. As stressed in Section 2.3.3 of Chapter 2, a positive correlation coefficient on its own is insufficient to conclude that an asset provides an adequate hedge against inflation. A positive correlation would merit further investigation to assess whether the returns of bonds are actually greater than the inflation rate.

3.2.3 INVESTIGATION OF THE CORRELATION BETWEEN BOND RETURNS AND EQUITY RETURNS

The correlation analysis of bond and stock returns is performed at the macroeconomic level, as opposed to a microeconomic level. This means the concern is not intra-firm, i.e. the correlation between the bonds and stocks issued by the same firm, but rather, the correlation between bonds and stocks at the market level in general. We describe the methodology used to test each hypothesis in turn.

H6: South African bond returns and stock returns are positively correlated over the period 2002 to 2016.

Monthly holding period returns of the ALBI and the ALSHTR are defined as in Equation 3.2.1. We use the Pearson r correlation test described in Section 3.2.2 above to investigate H6. Should the data fail to satisfy the assumptions of the Pearson r test, we use the non-parametric Kendall Tau-b test, also described in Section 3.2.2 above.

H7: The correlation between South African bond returns and stock returns is negative when stock returns are negative

To investigate H7, we check the months in which the ALSHTR reported negative returns, and pull the ALBI monthly returns corresponding to those negative ALSHTR months. We then use the Pearson r test (or the Kendall Tau-b test) described in Section 3.2.2 to assess the correlation between ALBI returns and the negative ALSHTR returns.

H8: The correlation between South African bond returns and stock returns is negative when stock returns are very negative.

To investigate H8, we need to define what will be taken as “very negative” for the ALSHTR returns. We will use the average of the negative ALSHTR returns as a cut off, and negative values below this average will be considered very negative. We will then pull the ALBI monthly returns corresponding to the very negative ALSHTR returns. The correlation between the two sets of returns will be assessed using the Pearson r correlation test, or the Kendall Tau-b test, both discussed in Section 3.2.2

For a more complete analysis of the correlation between bond returns and stock returns, we will examine this correlation before, during and after the Global Financial Crisis. Given that studies in the literature offer a variation of start and end dates for the Global Financial Crisis (most likely because different markets began to feel the impact of the crisis at different times), it is important to define the before, during and after periods used in this study. We will follow Radier et al. (2016) as this also focused on a South African context. Radier et al. (2016) defined the pre-crisis period as that prior to 2007, the crisis period as 2007 to 2008, and the post-crisis period as that from 2009 onwards.

3.3 CONCLUSION

This study employs a quantitative methodology to investigate the three empirical properties under analysis using a non-experimental research design. The analysis is conducted at the macroeconomic level using indices. The All Bond Indices represent bond investment, the All Share Total Return Index represents equity investment, and the Consumer Price Index is used to calculate the inflation rate. The study period is 2000 to 2016. This study uses the sample autocorrelation function to investigate mean reversion, and uses the Pearson r correlation test to investigate the correlation between bond returns and the inflation rate, and the correlation between bond returns and

equity returns respectively. All statistical tests used to investigate the hypotheses 1 through to 8 will be performed using the statistical software package SPSS. Chapter 4 follows, which provides a preliminary analysis of the data, and details and discusses the results of all the tests conducted.

CHAPTER 4: RESULTS AND ANALYSIS

This chapter presents the results of the tests performed on the data. The chapter begins with a preliminary analysis of the data, presented in Section 4.1. This is followed by Section 4.2, which details and discusses the results obtained.

4.1 EXPLORATORY DATA ANALYSIS

A preliminary analysis of the data is conducted to assess how the data are distributed, to identify any pertinent characteristics or trends, and to assess whether the data satisfy the assumptions of the statistical tests to be conducted.

KEY STATISTICS

Table 4.1.1: Key Statistics for monthly returns of bonds and equities and the monthly inflation rate, 2000 to 2016

STATISTIC	BONDS (ALBI)	INFLATION (CPI)	EQUITY (JALSHTR)
Number of Observations	198	197	175
Range	0.1518	0.0255	0.2731
Minimum	-0.0667	-0.0066	-0.1324
Maximum	0.0851	0.0188	0.1407
Mean	0.0086	0.0047	0.0127
Mean of negative equity returns	N/A	N/A	-0.0319
Standard Deviation	0.0209	0.0046	0.0461
Excess Skewness	0.081	0.527	-0.141
Excess Kurtosis	1.685	0.202	0.760

From Table 4.1.1 we see that monthly equity returns have a significantly wider range than both bond returns and the inflation rate. This, coupled with the greater negative minimum value observed for equities suggests that over the period 2000 to 2016, equities were more risky than bonds when downside swings are considered. The standard deviation values confirm that equities were indeed more risky.

Table 4.1.1 reveals further that the average monthly return over the period 2000 to 2016 is almost zero for bonds (0.86%) and slightly greater than zero for equities (1.27%). The average monthly returns of both assets are greater than the average monthly inflation rate (0.47%). The average of the negative equity returns is -0.0319, or -3.19%. Thus, as discussed in Section 3.2.3 of Chapter 3, in the investigation of the correlation between bond returns and equity returns, equity returns less than -3.19% will be considered very negative returns.

Table 4.1.1 displays excess skewness and excess kurtosis. Excess here is relative to the normal distribution. Bonds appear to be positively skewed, while equities appear to be negatively skewed. Moreover, the distribution of the monthly returns of both equities and bonds appears to have a higher peak than the normal distribution.

SCATTER PLOTS

The Pearson r correlation tests discussed in Section 3.2.2 of Chapter 3 require that the two variables under investigation be linearly related. We used scatter plots to assess whether the assumption of linearity is justified for i) the relationship between ALBI returns and the inflation rate, and, ii) the relationship between ALBI returns and ALSHTR returns. These scatter plots are shown in Figures A1 and A2 in the Appendix. The scatter plots obtained

do not reveal linear relationships. We attempted log transformations of all the variables. The scatter plots using log monthly returns are shown in Figures A3 and A4 in the Appendix. These figures show that the log transformations do not help in obtaining a linear relationship between the variables.

HISTOGRAMS AND TESTS FOR NORMALITY

The Pearson r correlation test assumes that the data follow a normal distribution. To assess normality, we plot histograms of the variables and conduct formal normality tests. The histograms are displayed in Figures A5 to A10 in the Appendix. The formal normality test conducted is the Shapiro-Wilk test. The Shapiro-Wilk test is better suited for small sample sizes, and is the most powerful of the common tests for normality (Razali & Wah, 2011). The null hypothesis of the Shapiro-Wilk test is that returns are normally distributed. Table 4.1.2 displays the results of the tests for normality.

Table 4.1.2 Shapiro Wilk test for normality

Variable	Shapiro-Wilk Statistic	Degrees of Freedom	p-value
ALBI	0.981	198	0.008***
Ln(ALBI)	0.981	198	0.008***
ALSHTR	0.986	175	0.074
Ln(ALSHTR)	0.981	175	0.017**
Inflation Rate	0.975	197	0.001***
Ln(Inflation Rate)	0.975	197	0.002***

** denotes significance at the 5% level

***denotes significance at the 1% level

From Table 4.1.2 we see the following:

- ALBI monthly returns: at the 1% level of significance, we reject the

assumption of normality. Performing a log transformation does not produce a normal distribution, as the p-value is still significant at the 1% level.

- ALSHTR monthly returns: the p-value is not significant the 5% level thus we cannot reject the assumption of normality
- Inflation rate: at the 1% level of significance, we reject the assumption of normality. The log transformation does not produce a normal distribution.

Altogether, the histograms and normality tests have shown that the ALBI returns and the inflation rate are not normally distributed, while the assumption of normality cannot be rejected for the ALSHTR returns. Moreover, the preliminary analysis reveals that the distribution of the data is not improved by taking the natural logarithm; where improvement here means producing a distribution that is statistically indistinguishable from the normal distribution.

Other transformations beyond the log transformation can be performed to try and obtain a linear relationship between variables, or to produce a normal distribution. Such transformations include taking the square or square root of returns for example. However, while these transformations may produce the relationships and distributions needed, they do not hold much practical relevance, and this study seeks to document results that investors can use in practice. The exploratory analysis has revealed that non-parametric tests would serve better for the correlation analysis.

4.2 RESULTS AND ANALYSIS

4.2.1 INVESTIGATION OF MEAN REVERSION IN BOND RETURNS

H1: South African bond returns display a positive serial correlation over the long term, thus exhibiting long-term trending behaviour over the period 2000 to 2016

Table 4.2.1 shows the serial correlation coefficient obtained for the ALBI monthly returns over the period 2000 to 2016. Table 4.2.1 also displays the serial correlation coefficient for the ALSHTR monthly returns for the sake of comparison.

Table 4.2.1: Long term serial correlation coefficients of monthly ALBI and ALSHTR returns

Index	Period	Autocorrelation coefficient
ALBI	2000 - 2016 (16 years)	-0.040
ALSHTR	2002 - 2016 (14 years)	-0.060

The negative serial correlation coefficient obtained for the ALBI provides evidence of mean reverting behaviour. However, this value is very close to zero. A check with the probability density function of the correlation coefficient reveals that for a correlation coefficient of -0.040 based on a sample of 198 observations, we cannot reject the null hypothesis that this coefficient is zero, even at the 10% level of significance. Thus, we cannot rule out the possibility that returns in one period are independent of returns in previous periods. The findings obtained do not support the hypothesis of long-term trending behaviour in bond returns. Failure to rule out independence means it is likely that South African bond returns show neither trending nor mean reversion.

In the theory presented on mean reversion in Chapter 2, we put forward the overreaction hypothesis as the dominant one offered for mean-reverting behaviour. An autocorrelation coefficient that is statistically indistinguishable from zero suggests independence of returns, implying that there are no predictable patterns observable in historical returns. Therefore our findings suggest that over long-term horizons, investor overreaction may not be pervasive in South Africa's bond market. This is corroborated by the fact that institutional investors are the key players in South Africa's bond market. Institutional investors are usually more savvy and sophisticated, and thus less prone to overreaction than individual investors (Gebhardt, Hvidkjaer & Swaminathan, 2005).

A further consideration that emerges from the results obtained is bond market efficiency. Our results could be indicative of an efficient bond market, at least in the weak form. In an efficient market, prices reflect fundamentals and securities are priced to earn an appropriate risk-adjusted return (Fama, 1965). Under the weak form of the Efficient Market Hypothesis, abnormal returns cannot be earned consistently from historical price information. Our results reveal no statistically significant pattern such as mean reversion or trending in ALBI returns over the long term. As mentioned above, this suggests a market in which over the long term, investor overreaction is not a pertinent feature, making it more likely that prices reflect fundamentals. Moreover, the absence of an observable pattern would make it difficult to earn persistent abnormal returns. These points are consistent with the weak form of the Efficient Market Hypothesis. Investigating South African bond market efficiency may therefore be a worthwhile avenue for future studies to pursue.

At face value, the findings obtained are consistent with Nayak (2010), which found evidence of mean reversion in corporate bond yields in the US over the

period 1994 to 2004, and are contrary to Stewart, Piros and Heisler (2011), which found evidence of trending in US Treasury notes over the period 1926 to 2008. However, the lack of statistical significance of our findings makes it difficult to confidently ascertain how the findings for South Africa compare to the findings based on other countries. We cannot rule out the possibility that South African bond returns are independent over the long term.

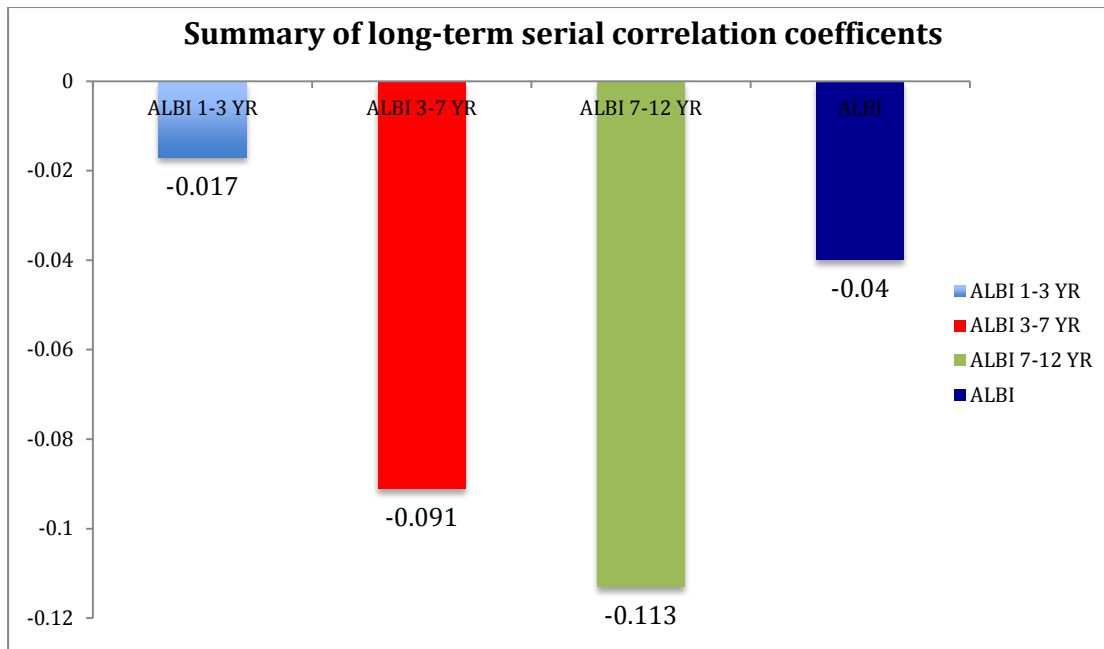
H2: If South African bond returns exhibit negative serial correlation over the long term, then this negative serial correlation becomes more negative with increasing term to maturity

Table 4.2.2 Long-term serial correlation coefficient of ALBI sub-indices (2004 – 2016)

	ALBI 1-3 YRS	ALBI 3-7 YRS	ALBI 7-12 YRS
Serial correlation coefficient (2004 to 2016)	-0.017	-0.091	-0.113

Figure 4.2.1 provides a graphical representation of these findings. This is useful in appreciating the change in the serial correlation coefficient across maturities, and how these findings compare to those for the ALBI itself.

Figure 4.2.1 Summary of long-term serial correlation coefficients



We see in Figure 4.2.1 that the mean reverting effect is stronger for medium term (3-7 years) and long term (7-12 years) bonds. We add the caveat that none of these coefficients are statistically significant, as was the case for the coefficient for the ALBI itself. What these results allow us to deduce is that although the autocorrelation coefficient for the ALBI provides very weak evidence of mean reverting behaviour, this mean-reverting effect, albeit a very weak one, is more pronounced in medium-term and longer-term bonds. The results obtained support the hypothesis that mean reversion is stronger in longer maturity bonds. However, the lack of statistical significance of these results makes it imprudent to conclude that we fail to reject this hypothesis.

One possible explanation for the findings observed is the greater liquidity of the medium and longer-term bonds (Jammine, 2015). Higher liquidity implies that these bonds are traded more, and thus these are the bonds that are impacted when investors' perceptions are changing.

The findings obtained suggest behaviour consistent with that documented by Nayak (2010), which found that mean reverting behaviour in US corporate bonds was more pronounced for extreme maturity bonds. However, the fact

that our results are not statistically significant makes it difficult to make accurate comparisons of the results.

H3: South African bond returns display positive serial correlations over the short term, thus exhibiting short-term trending behaviour over the period 2000 to 2016

Table 4.2.3: Short term serial correlation coefficients of monthly ALBI returns for three year horizons over the period 2000 to 2016

Horizon	Autocorrelation Coefficient
Aug 2000 – Aug 2003	0.086
Oct 2003 – Oct 2006	0.156
Dec 2006 – Dec 2009	0.089
Feb 2010 – Feb 2013	-0.129
Apr 2013 – Apr 2016	-0.325**

** denotes significance at the 5% level

Table 4.2.3 shows that from 2000 – 2009, the autocorrelation coefficient was positive, indicative of trending behaviour, and from 2010 the coefficient turned negative, indicative of mean reverting behaviour. Returns in the last three years of the sample (April 2013 to April 2016) had a strong negative serial correlation of -0.325, which was significant at the 5% level (two-sided test). Thus there is strong evidence of short-term mean reverting behaviour over the past three years.

Serial correlation coefficients up until February 2013 are close to zero, and none exhibit a statistically significant difference from zero at the 10% level of

significance. The only statistically significant autocorrelation coefficient is in the last three years of the sample. This suggests that up until the last three years, bond returns can be considered statistically independent. In the last three years, however, this relationship changed, and we observed statistically significant mean reverting behaviour. We see that the autocorrelation coefficient varies across different short-term horizons, thus the results obtained do not support the hypothesis of short-term trending behaviour.

As explained in Chapter 2, investor overreaction is the dominant hypothesis offered for mean reverting behaviour. When we examined the whole sample period, we found no statistically significant evidence of mean reverting behaviour, suggesting investor overreaction is not a concern in the bond market when long-term horizons are considered. However, when we consider short-term horizons, our findings reveal that there were crucial factors at play over the last three years that changed investors' general perception of the bond market. An understanding of these factors, and how these factors could incite investor overreaction, may explain the mean reverting behaviour observed in the most recent years.

Several factors at play in the South African economy over the period 2013 to 2016 have deteriorated investor confidence in the country. These factors include the dismal outlook on economic growth in the country, an extremely volatile and depreciating rand, and inflation frequently breaching the reserve bank's upper target of 6% (See Marcus, 2013; Marcus, 2014; Kganyago, 2015 and Kganyago, 2016a; Kganyago, 2016b). A common feature in all the monetary policy reports from 2013 to 2016 is the pronouncement of a decline in investor confidence.

The volatility of foreign investor capital flows over the period 2013 to 2016 is a clear indicator of changes in investor confidence in the country. As mentioned in Section 1.1 of Chapter 1, foreign investor participation in the

South African bond market is high (Department National Treasury South Africa, 2015). In 2014, due to lower risk aversion and renewed flows to emerging markets, foreign capital inflows showed a notable increase (Marcus, 2014). However, changing risk perceptions in 2015 caused foreign capital flows to be more volatile, and non-residents were net sellers of South African government bonds worth R12.7bn in May and June 2015 (Kganyago, 2015). In March 2016 this was reversed, and non-residents were net purchasers of South African government bonds to worth R6bn. It is evident that foreign capital flows have been volatile over the period 2013 to 2016, symptomatic of wavering investor confidence. Volatile foreign capital flows increase the volatility in the bond market, and are thus likely to induce mean reverting behaviour.

One of the most significant knocks to investor confidence in the period 2013 to 2016 was the firing of finance minister Nhlanhla Nene. In December 2015, Nene was fired after barely two years in office (Letsoalo, 2015). Nene's stance towards the managing of the country's finances is considered to have been one of integrity and prudence ("Nhlanhla Nene:...", 2015). Investors trusted in Nene's ability to handle the country's finances amidst global volatility and a steep decline in commodity prices ("Nhlanhla Nene:...", 2015). His firing, and subsequent replacement with the relatively unknown David Van Rooyen sent shocks through the economy ("Nhlanhla Nene:...", 2015). The bond market appeared to be the most affected by the announcement of Nene's firing (Jammie, 2015). Bond prices took a marked plunge as yields soared to record levels (Goko, 2015; Jammie, 2015). Following the firing of Nene, interest rates on the R186, one of the most liquid long-term government bonds, rose by over 1% (Jammie, 2015). The yield of this bond exceeded 10% for the first time in 5 years (Jammie, 2015). Yields on the R207, a liquid medium term bond also rose markedly (Goko, 2015).

A further factor adversely affecting investor confidence in South Africa is the rise in South Africa's debt servicing costs. This rise has been brought on by a number of factors. Firstly, long-term interest rates have been on the rise due to upward pressure from inflation, and these rates were increased further by the firing of Nene (Jammine, 2015). Secondly, the uncertain economic and political climate has led to adverse reports from ratings agencies. In December 2015, Fitch downgraded the country to BBB- (one level above junk status), while Standard and Poor revised the country's outlook from stable to negative (Potelwa & Kew, 2015). With 2018-2019 debt servicing needs forecast at R180bn, the higher debt servicing costs are a grave concern for investors ("South Africa's debt...", 2016). Analysts noted that the decline in the perception of South Africa's debt was already being priced in, as the country's debt was costing as much as countries below investment grade, as if its downgrade had already happened ("South Africa's debt...", 2016).

It is evident from all the points above that investor confidence in the country has taken a huge knock over the past few years. The evident uncertainty in the market is likely to cause overreactions, and prices that deviate from fundamentals, even amongst the most savvy of investors, and could be one driver of the mean reverting behaviour observed.

It is worth concluding the discussion on the effects of a change in investor perception by zeroing in on volatility. One of the ways we can expect investor overreaction to materialise is through an increase in the volatility of returns. The results obtained prompted a comparison of the volatility of the ALBI over the period where returns can be considered statistically uncorrelated (August 2000 to February 2013), to the most recent period where statistically significant mean reversion is observed (April 2013 to April 2016). These results are shown in Table A1 in the Appendix. From the period 2000 to 2013, the volatility of the bond market, measured by the standard deviation of ALBI returns, was 0.0194. Over the period 2013 to 2016, this increased to 0.0259.

Volatility increased by 33% in the last three years of the sample. It is likely that this increase in volatility, induced by investor overreaction, is the central driver behind the mean reverting behaviour observed.

Table 4.2.4 displays the serial correlation coefficient for ALBI returns over short-term horizons of five years. The findings over five year horizons are consistent with those for three year horizons: positive autocorrelation coefficients in earlier years, followed by a negative autocorrelation coefficient in the most recent five years. None of the correlation coefficients are significantly different from zero at the 10% level. Thus, overall, when we consider short-term horizons of three years and five years respectively, the only statistically significant short-term serial correlation coefficient is in the last three years of the sample.

Table 4.2.4: Short term serial correlation coefficients of monthly ALBI returns for five year horizons over the period 2000 to 2016

Horizon	Autocorrelation Coefficient
Aug 2000 – Aug 2005	0.081
Oct 2005 – Oct 2010	0.146
Dec-2010 – Dec 2015	-0.189

Our findings reveal that South African bond returns do not show a consistent pattern of either strictly trending, or strictly mean reverting over all short-term horizons. This is contrary to Stewart, Piros and Heisler (2011) and Jostova et al (2013), which both document evidence of short-term trending behaviour in US treasury notes and corporate bonds respectively. These findings are also contrary to Gebhardt, Hvidkjaer and Swaminathan (2005), which documents evidence of mean reversion in US corporate bonds. Our findings have revealed that the South African bond market is sensitive to economic and political developments over the short term, and that changes in

these developments cause variation in the serial correlation coefficient over short-term horizons.

H4: If negative serial correlations are observed over the short-term, then these negative serial correlations become more negative with increasing term to maturity

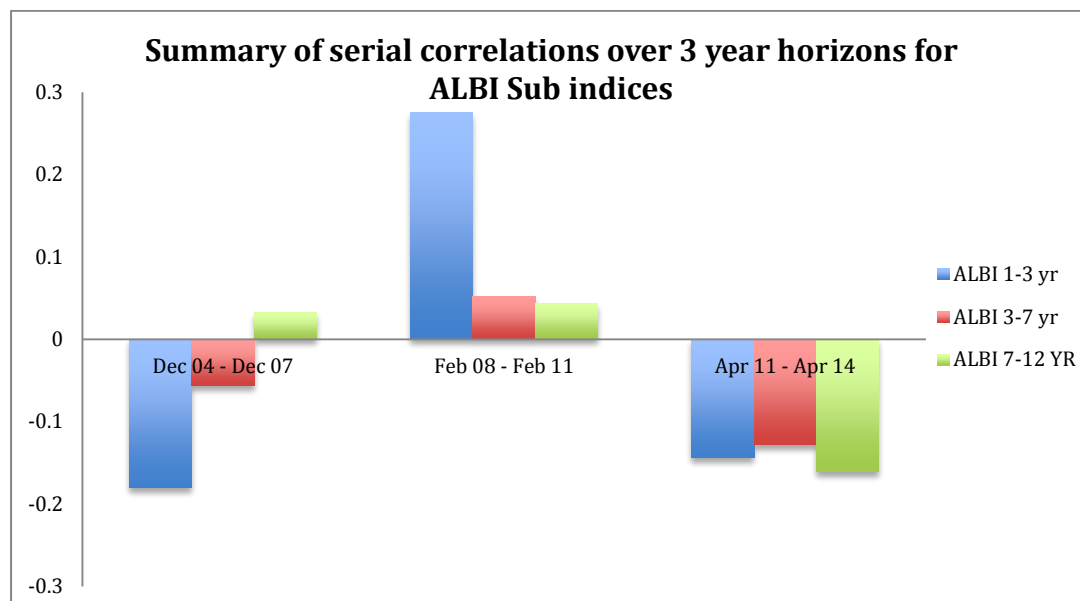
Table 4.2.5: Short term serial correlation coefficients of monthly returns of ALBI sub-indices for three year horizons over the period 2004 to 2016

Horizon	ALBI 1-3 yr	ALBI 3-7 yr	ALBI 7-12 yr
Dec 04 – Dec 07	-0.180	-0.056	0.032
Feb 08 – Feb 11	0.275*	0.052	0.043
Apr 11 – Apr 14	-0.144	-0.128	-0.161

* denotes significance at the 10% level

The graphical representation of these findings shown in Figure 4.2.2 allows us to appreciate the changes in the short-term serial correlation coefficient across maturities.

Figure 4.2.2: Summary of serial correlations over 3 year horizons for ALBI sub-indices



At first glance, we see that the ALBI 1-3 year index and the ALBI 3-7 year index exhibit the same pattern. Both display a negative serial correlation in the first three-year horizon, a positive serial correlation in the second three-year horizon, and a negative serial correlation in the last three-year horizon. On the other hand, The ALBI 7-12 year index shows a positive serial correlation in the first two three-year sub-periods, and a negative serial correlation in the last three-year sub-period. The ALBI 7 - 12 year index shows the same pattern observed for the ALBI itself, suggesting that longer term bonds dominate the ALBI.

In the investigation of short term mean reverting behaviour (H3), we saw that the serial correlation coefficient varied across short-term horizons, thus we could not conclude that bond returns displayed short-term mean reverting behaviour in general. We did however observe statistically significant mean reverting behaviour in the last three years of the overall sample period (February 2013 to February 2016). The April 2011 to April 2014 period in the ALBI sub-index data captures part of this period of mean reverting behaviour. We see in Figure 4.2.2 that the mean reverting behaviour observed in April 2011 to April 2014 does not become more pronounced with increasing term to maturity. The ALBI 1-3 year sub-index has a larger serial correlation coefficient than the ALBI 7-12 year sub-index. Considering these findings, and the lack of statistical significance of all coefficients in this period, we do not have evidence to support the hypothesis that mean reverting behaviour observed over the short term is stronger for longer maturity bonds.

We see in Table 4.2.5 that the only statistically significant autocorrelation coefficient was that obtained for the ALBI 1-3 year sub-index over the period February 2008 to February 2011. The autocorrelation coefficient of 0.275 was statistically significant at the 10% level (two-sided), providing evidence of

trending in returns of the ALBI 1-3 year sub-index over this period. In the first half of 2008, the reserve bank raised the repurchase rate twice in succession by 50 basis points on each occasion (South African Reserve Bank [SARB], 2008). This was because of a dismal inflation outlook due to rising energy and food prices and pressure from wage settlements (SARB, 2008). These successive rate hikes, each of considerable magnitude, and increased risk aversion from the on-going global financial crisis, caused yields on conventional government bonds to rise significantly between mid January 2008 and early July 2008 (SARB, 2008). The marked rise in yields explains the significant trending behaviour observed in this sub-period.

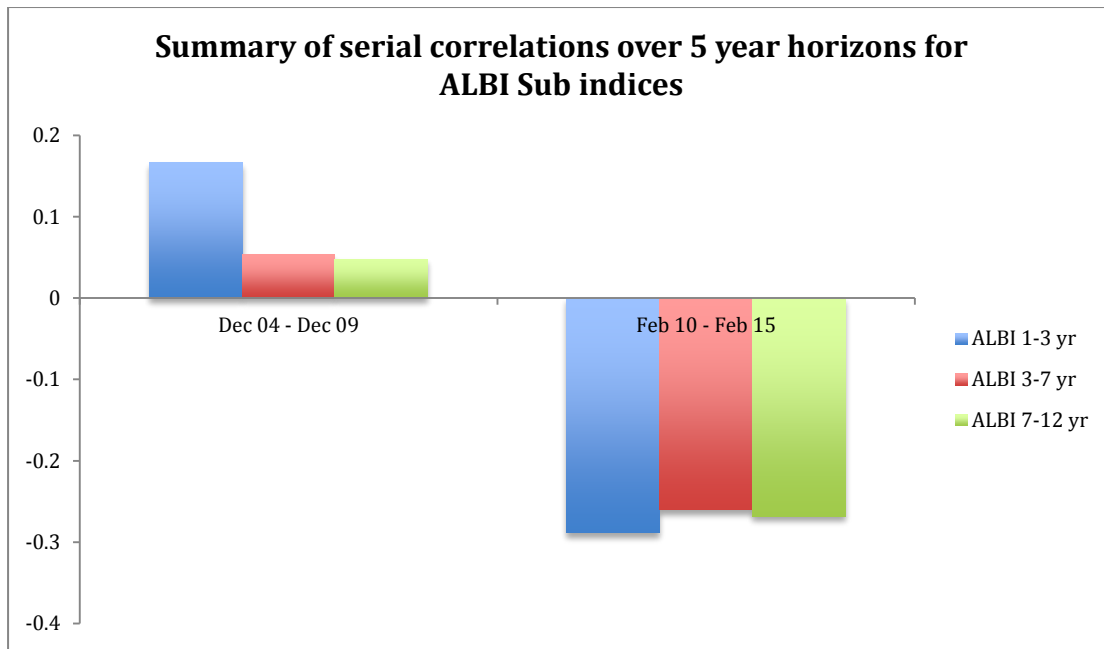
Table 4.2.6 shows below shows the serial correlation coefficients obtained for the ALBI sub-indices for short-term horizons of five years. Figure 4.2.3 provides a graphical representation of these findings.

Table 4.2.6: Short term serial correlation coefficients of monthly returns of ALBI sub-indices for five year horizons over the period 2004 to 2016

Horizon	ALBI 1-3 yr	ALBI 3-7 yr	ALBI 7-12 yr
Dec 04 – Dec 09	0.167	0.053	0.048
Feb 10 – Feb 15	-0.288**	-0.260**	-0.268**

** denotes significance at the 5% level

Figure 4.2.3: Summary of serial correlations over 5 year horizons for ALBI sub-indices



All three sub-indices exhibit positive serial correlation over the first five-year sub-period, and negative serial correlation over the second five-year sub-period. This pattern was also observed for the ALBI itself. Moreover, while none of the serial correlations observed in the first five-year sub-period were statistically significant, all the serial correlations observed over the period February 2010 to February 2015 were statistically significant at the 5% level. Thus all sub-indices show statistically significant evidence of mean reverting behaviour over the most recent five-year horizon. This could be due to investor overreaction over this period, incited by a decline in investor confidence, as explained for the ALBI itself.

The mean-reverting effect observed in the second five-year period appears to be strongest for the shorter-maturity bonds (ALBI 1-3 year). This corroborates what we observed for three-year horizons, that the mean reverting effect over short-term horizons is not more pronounced for longer maturity bonds.

It is surprising that the coefficient for the shorter maturity bonds is larger given that the medium and long-term bonds have greater liquidity. One possible explanation for this particular result could be an increase in the

volatility of short-term rates, induced by the uncertainty of movements in the reserve bank's repurchase rate. Over the period under concern (2010 to 2015), the reserve bank faced the difficult task of trying to keep inflation within target, without crippling an economy already facing fragile growth. Tackling high inflation on one end, and the fears of constraining growth on the other, the reserve bank could not commit to a cycle of strictly raising rates, or strictly lowering them, or keeping them constant. Thus the decision of the Monetary Policy Committee was often difficult to predict. It is logical, therefore, that short-term rates would be volatile over this period, and this could explain the stronger mean reverting behaviour observed for bonds on the shorter end of the yield curve.

IMPLICATIONS OF THE RESULTS

The investigation of long-term mean reversion in bond returns has revealed that we do not have statistically significant evidence to conclude that bond returns revert to a mean. This means that risk-averse investors looking to reduce the volatility of their wealth over long horizons will have to consider other factors to guide this decision. For example, investors could examine the changes in volatility of the bond market over long-term horizons, and use that to inform their decisions. They could also consider investigating mean reversion of returns of portfolios that combine bonds with other assets. Our findings imply further that undertaking the contrarian investment strategy on the constituent bonds in the ALBI is not likely to generate profits.

The investigation of short-term mean reversion revealed that the serial correlation coefficient varies across short-term horizons. Bond returns appear to be sensitive to political and economic developments in the country. This means policy makers need to take great care and thought in the decisions they make, as these are very likely to send ripple effects throughout the economy, and affect investors' wealth. This investigation has revealed that investors

looking to predict serial correlations in bond returns over the short term should attempt to gain an understanding of the political and economic climate at play. This is likely to drive investor perception of the debt market and thus affect serial correlations.

4.2.2 INVESTIGATION OF THE CORRELATION BETWEEN BOND RETURNS AND INFLATION

H5: Nominal bond returns of South African bonds exhibit a negative correlation with inflation.

The exploratory data analysis revealed that the assumptions of the Pearson r correlation test are not satisfied by the monthly ALBI returns and the monthly inflation rate. We thus use the non-parametric Kendall's Tau-b test to assess the correlation between bond returns and inflation. We present the Pearson r correlations as well, for the sake of comparison with other studies.

Table 4.2.7: Kendall Tau-b and Pearson r correlation between bond returns and the inflation rate (2000 to 2016)

	Kendall Tau-b	Pearson r
Correlation coefficient	-0.074	-0.066

Table 4.2.7 reveals a very low negative correlation between ALBI total returns and inflation. This correlation coefficient was not significant at the 10% level of significance. The results obtained support the hypothesis of a negative correlation between nominal bond returns and the inflation rate. However, the lack of statistical significance makes it imprudent to assert that we fail to reject this hypothesis.

As mentioned in Section 1.1 of Chapter 1, South Africa's monetary policy is centred on inflation targeting. The repurchase rate is usually increased when inflation expectations indicate a breach of the upper end of the target, and decreased when inflation is expected to follow a downward trend. Thus the repurchase rate tends to follow the direction of inflation expectations. Consequently, discount rates, which are influenced by the repurchase rate, tend to move in the direction of inflation expectations. This means bonds

prices should move in the opposite direction to the inflation rate, given the inverse relationship between price and the discount rate. Our finding of a negative correlation is consistent with this monetary policy framework, and consistent with the prior expectations formed in the literature review.

The results obtained suggest that bonds do not serve as a good hedge against inflation. A negative correlation implies that increases in the inflation rate coincide with decreases in bond returns. The total return of a bond consists of income earned from price changes (capital gains or losses) and income earned from the periodic interest payments (coupon income). As explained above, unexpectedly high (low) inflation usually leads to interest rate hikes (cuts) and consequently a higher (lower) discount rate. A higher (lower) discount rate means lower (higher) prices, resulting in capital losses (gains). Thus the capital gains component of total bond income tends to have a negative correlation with the inflation rate. Our results therefore suggest that this component of income dominates ALBI total returns. We investigated this further.

We tested the correlation between the clean price index of the ALBI and the inflation rate. The clean price of the bond excludes any interest that has accrued since the bond was issued. Changes in the clean price index reflect the capital gains or losses earned when bond prices change. We obtain a negative Kendall tau-b correlation coefficient of -0.075 for the correlation between monthly changes in the ALBI clean price index (monthly capital gains/losses) and the monthly inflation rate (See Table A2 in the Appendix). This value is almost identical to the correlation coefficient obtained when we compared the total returns of the ALBI to inflation (-0.074). This corroborates the proposition formed earlier, that the capital gains and losses component is the dominating component of ALBI total returns. Consequently, this implies that the coupon component of income is small relative to the capital gains and losses component.

The results obtained so far do not provide much comfort for investors considering using bonds as an inflation hedge. As a final check, we investigated the extent to which the reinvestment of the coupon income of bonds moves with the inflation rate. We used the ALBI interest yield index, as this reflects the rate at which coupons can be reinvested, and tested the correlation between this index and the monthly inflation rate. The Kendall tau-b correlation coefficient obtained here was 0.084, and this was statistically significant at the 10% level (See Table A2 in the Appendix). This significant positive correlation coefficient provides evidence that reinvestment income does move in the direction of the inflation rate. However, the magnitude of the correlation is very small, so reinvestment is unable to provide adequate protection against inflation.

The findings of this study are consistent with Koniarski and Sebastian (2015) for horizons of 15 years or less. For longer horizons, Koniarski and Sebastian (2011) found a positive correlation between bond returns and the inflation rate, suggesting that for longer-term horizons in the US, coupon income is able to provide protection against inflation. Stewart, Piros and Heisler (2011) found a positive correlation between nominal bond returns and the inflation rate for short-term horizons of 5 years in the US over the period 1930 to 2008. However, their analysis showed that real returns had a negative correlation with inflation. Their findings thus lead to the same conclusion that we obtained from our investigation, that bonds provide a poor hedge against inflation.

IMPLICATIONS OF THE RESULTS

The negative correlation coefficient obtained for the correlation between nominal bond returns and the inflation rate suggests that bonds do not provide a suitable hedge against inflation. Our analysis demonstrates that the

capital gains/losses component of income dominates total returns in the ALBI, and this explains why the total return is negatively correlated with inflation. Given the capital gains/losses component of income does not allow for bonds to provide protection against inflation, we investigated whether reinvestment of coupons received provides protection against inflation. We found that reinvestment of coupons does not allow for adequate protection against inflation.

Our results suggest that simply investing in the constituent bonds that form the ALBI will not provide protection against inflation. Given that the ALBI consists of the most traded bonds in the country, these findings suggest that investors in the ALBI constituent bonds are seeking other benefits, such as asset-liability matching for example, and not inflation protection. Future studies may wish to assess how inflation-linked bonds have fared as an inflation hedge. This research may serve useful for investors set on using bonds for inflation protection.

4.2.3 INVESTIGATION OF THE CORRELATION BETWEEN BOND RETURNS AND EQUITY RETURNS

H6: South African bond returns and stock returns are positively correlated over the period 2002 to 2016.

The exploratory data analysis revealed that the assumption of normality could not be rejected for the ALSHTR returns. However, it was rejected for the ALBI returns. Thus we still use the non-parametric Kendall tau-b correlation test, but present the findings for both the Kendall tau-b and Pearson r correlation tests in Table 4.2.8 below:

Table 4.2.8: Correlation between bond returns and equity returns 2002 to 2016

	Kendall Tau-b	Pearson r
Overall sample (2002 - 2016)	0.097	0.054
Stock returns negative	-0.026	-0.196
Stock returns very negative (<-3.19%)	-0.130	-0.358

The Kendall Tau-b correlation coefficient for the overall sample is 0.097. This very small positive coefficient suggests a very low correlation between bond returns and equity returns over the period 2002 to 2016. This coefficient is not statistically significant at the 10% level, thus we cannot rule out the possibility that the actual correlation is zero, implying that movement between the two markets has been independent when the whole sample period of 2002 to 2016 is considered. The results obtained support the hypothesis of a positive correlation between bond returns and equity returns but the lack of statistical significance makes it imprudent to conclude that we fail to reject this hypothesis.

The results obtained prompted a deeper analysis of the co-movement between stock and bond returns over the period 2002 to 2016. To this end, we plotted the standardised returns of the two asset classes over the period 2002 to 2016 (See Figure A11 in the Appendix). Figure A11 shows several intervals in the overall period under examination where the returns of the two asset classes have moved together. Most of these intervals are about a quarter year or half year in length, but a few such as April 2004 to February 2005 and May 2006 to March 2007 have shown co-movement for stretches of 10 months. These short intervals of co-movement are interspersed by intervals where movement in returns of the two asset classes appears to be decoupled. Given that stretches of co-movement and decoupled movement interchange throughout the sample, it is understandable that we obtain a very low correlation coefficient when the overall period is considered. However, the presence of a number of periods that display co-movement, sometimes for stretches that are almost a year long, suggests that it is not accurate to conclude that the two markets are independent. Moreover, it suggests that the bond-stock correlation is one that is better examined at shorter horizons, as the direction of the correlation changes frequently.

In Section 2.3.2 of the literature review, we stated that correlations are not constant over time. What follows from Figure A11 is that for South African bonds and stocks, this fact does not simply mean a variation in the magnitude of the correlation, for example observing periods of low positive correlation and periods of higher positive correlation, but is in fact a change in the direction of the correlation over time as well. For this reason, it is crucial to understand the drivers behind the co-movement (or decoupled movement) in returns.

As explained in Section 2.3.2 of the literature review, factors affecting shared components of the prices of the two assets will likely induce co-movement, while factors affecting only components of the price that are unique to each

respective asset will likely reduce the correlation between the two assets. This analysis has been performed at the macroeconomic level, thus we can expect that macroeconomic variables are the factors at play in the periods of co-movement (or decoupled movement) according to their impact on the shared components (or unique components) of asset prices. This means that investors assessing the correlation between bonds and stocks would need to regularly examine the macroeconomic climate prevalent at the time, and assess how this has impacted the shared and unique components of each asset class.

The motive for investigating the correlation between bond returns and stock returns was to assess the diversification potential to be obtained from combining the two assets together in a portfolio. The low correlation coefficient obtained for the entire sample period suggests that there is little long-term co-movement between the two-asset classes. This means firstly, that an investor would input a low correlation coefficient (one almost close to zero) in the portfolio variance equation presented in Equation 2.3.1 in the literature review, thus allowing them to keep their portfolio risk low (relative to a portfolio of assets with a higher positive correlation, and all else constant). Secondly, the low correlation coefficient obtained means that over the long term, poor bond performance is not strongly reinforced by poor stock performance. Therefore, the results support the use of bonds as a diversifying asset in a portfolio containing stocks. We add the important caveat that this applies to long-term investment horizons. Figure A11 has shown that for short-term horizons, the correlation between the two asset classes changes magnitude and direction frequently.

Our finding of a low, positive correlation for the overall period differs from Firer and McLeod (1999) and Auret and Vivian (2014) that both report a much larger positive bond-stock correlation for South Africa. Firer and McLeod (1999) used annual returns of stocks and bonds and obtained a

correlation coefficient of 0.48 for the period 1925 to 1998. The notably larger coefficient compared to what we obtained (0.097) could arise from the fact that month-month deviations in the stock-bond relationship are smoothed out when annual returns are considered. Moreover, given correlations are not static, the difference in findings could arise from a change in the stock-bond relationship after the study period of Firer and McLeod (1999). Firer and McLeod (1999) observed that the correlation coefficient in the earliest period under examination in their study was 0.88, but that this fell to 0.14 in the last, suggesting a progressive decoupling of the two markets. This observation is corroborated by the lower correlation documented by Auret and Vivian (2014), which looked at period after Firer and McLeod (1999), and the even lower correlation obtained in our study.

Auret and Vivian (2014) examined monthly returns of bonds and stocks, and documented a correlation coefficient of 0.265 for the period 1986 to 2013, again much larger than the correlation coefficient obtained in this study for the period 2002 to 2013. The larger correlation coefficient suggests strong co-movement between the two asset classes in the years in the Auret and Vivian (2014) study that are prior to our study's focus period.

H7: The correlation between South African bond returns and stock returns is negative when stocks returns are negative

From Table 4.2.8 we see that over the period 2002 to 2016, when stock returns were negative, the Kendall Tau-b correlation coefficient was -0.026. However the value is very small, and lacks statistical significance at the 10% level. Thus we cannot rule out independence between negative stock returns and bond returns. While the findings obtained do support the hypothesis that the bond-stock correlation is negative when stock returns are negative, we do not have statistically significant evidence to fail to reject this hypothesis.

The negative correlation coefficient supports the use of bonds as a diversifying asset: 1) an investor would input a negative correlation coefficient into the portfolio variance formula in Equation 2.3.1, thus lowering their risk compared to a portfolio of positively correlated assets and all else constant, and, 2) over the long term, losses in stocks will be slightly offset by gains in bonds. While a statistically significant coefficient would have been the first prize, independence is still not bad news for the investor. Independence means bond returns behave independently of the negative stock returns, and thus poor performance in stocks does not imply poor performance in bonds. Bonds could perform well even when stocks are performing poorly.

These findings are consistent with Stewart, Piros and Heisler (2011). They found a negative bond-stock correlation when stock returns in the US were negative over the period 1970 to 2008 (Stewart, Piros & Heisler, 2011).

H8: The correlation between South African bond returns and stock returns is negative when stocks are very negative.

Over the period 2002 to 2016, when stocks were performing especially badly, the correlation between the two asset classes was -0.130. We defined “very negative” returns as returns less than the average of negative returns over the period, that is, returns less than -3.16%. Our findings do support the hypothesis H8 above. However, once again the lack of statistical significance makes it imprudent to conclude that we fail to reject this hypothesis.

The negative coefficient supports the use of bonds as a diversifying asset in a portfolio with stocks. However, its lack of statistical significance at the 10% level means we cannot rule out independence. As explained above, this still allows the investor to keep their risk low (relative to portfolio of positively

correlated assets and all else constant); and means that adverse stock performance does not imply adverse bond performance.

What is notable in Table 4.2.8 is that the correlation coefficient is more negative when stock returns were very negative, compared to when stock returns were negative (-0.130 versus -0.026). This suggests that not only is there diversification potential from combining bonds with stocks, but that this potential is even greater when it is needed the most, that is, when stocks are performing especially badly.

The findings obtained are consistent with Stewart, Piros and Heisler (2011). They defined very negative returns as those less than -5%. They found that when US stocks were very negative over the period 1970 to 2008, the bond-stock correlation was even more negative than that obtained when stocks returns were negative (Stewart, Piros & Heisler, 2011).

STOCK BOND CORRELATIONS AROUND THE GLOBAL FINANCIAL CRISIS

Table 4.2.9 Correlation between bond returns and stock returns around the Global Financial Crisis

Period	Kendall Tau-b	Pearson R
Before Crisis (2002 - 2006)	-0.022	-0.068
During Crisis (2007 - 2008)	0.000	-0.179
After Crisis (2009 - 2016)	0.189***	0.226**

** denotes significance at the 5% level (two-sided test)

*** denotes significance at the 1% level (two-sided test)

Before the Global Financial Crisis, bonds and stocks had a negative correlation that was not statistically significant at the 10% level. Thus we cannot rule out independence of the two asset classes over this long-term

period. During the crisis, the Kendall Tau-b correlation was exactly zero. This interesting result suggests that the crisis impacted the bond and stock markets differently, inducing a pertinent de-coupling between the two markets. After the crisis, however, returns of the two asset classes showed a positive Kendall Tau-b correlation coefficient of 0.189, which was significant at the 1% level.

At the start of 2008, South Africa's equity market was booming as a result of higher commodity prices (South African Reserve Bank [SARB], 2008). On May 22nd 2008, the JSE All Share Index reached a record high, assisted by the positive influence that higher commodity prices had on resource shares (SARB, 2008). This period coincided with a drop in bond market prices. In response to a deteriorating inflation outlook and increasing risk aversion, yields on conventional South African bonds rose significantly from mid January 2008 to early July 2008 (SARB, 2008). The second half of 2008 saw inflation expectations ameliorate, and as a result bond yields declined (SARB, 2008). However, commodity prices had receded and resource shares took a hit, pulling down the All Share Index (SARB, 2008). It is evident that for a year in the period of the crisis, prices in the stock and bond market were driven different directions, corroborating the correlation figure obtained over the period of the crisis.

Post-crisis, factors that are likely to have induced the statistically significant positive correlation observed include a recovery of the equity markets coinciding with higher bond prices as a low inflationary outlook kept short term rates on a steady decline through to 2010. Moreover, lower risk aversion in the post crisis environment encouraged capital flows to emerging markets, and we can expect this to have impacted both markets positively.

IMPLICATIONS OF THE RESULTS

Our findings reveal that there are diversification benefits to be reaped from combining bonds and stocks together in a portfolio, particularly when these benefits are most needed. However, the lack of statistical significance of the results means that we cannot rule out independence of returns. This is not necessarily a bad outcome, as independent returns still allow for lower portfolio risk (compared to a portfolio of positively correlated assets and all else constant), and independent returns mean adverse performance in one asset does not imply adverse performance in the other asset.

An examination of the returns relative to each other in Figure A11 showed that periods of co-movement between the returns of the two asset classes are interspersed by periods of decoupled movement. Future studies may therefore find it worthwhile to examine bond-stock correlations at shorter intervals across this entire period. Moreover, they could outline the macroeconomic environment prevalent in each of these intervals, and assess whether patterns can be observed that enable investors to determine which way certain macroeconomic variables drive the asset correlations.

CHAPTER 5: CONCLUSION

5.1 REVIEW OF THE STUDY

The purpose of this study was to investigate i) mean reversion in bond returns; ii) the correlation between bond returns and the inflation rate; and, iii) the correlation between bond returns and equity returns. This study focused on South African bonds over the period 2000 to 2016. This research was motivated by the need to inform bond investors on empirical properties of bond returns, in order to allow investors to make more informed decisions concerning bond investments. A further motivation of this research was the need to add to the knowledge of South Africa's bond market. The size and relevance of South Africa's bond market in Africa and in emerging debt markets as a whole merits this debt market's consideration in the literature.

Mean reverting behaviour reduces wealth volatility over time, and is thus attractive to risk-averse investors. This study adds to the literature by addressing mean reversion in an emerging debt market. This study finds evidence of long term mean reverting behaviour in South African bonds, and that this effect appears to become more pronounced with increasing term to maturity. This study contributes further by providing a detailed analysis of short-term mean reverting behaviour. This study shows changes in the serial correlation coefficient across short-term horizons. Short-term serial correlations appear to be sensitive to political and economic developments in the economy. Moreover, short-term mean reverting behaviour is not more pronounced for longer term bonds.

A high positive correlation between nominal bond returns and the inflation rate indicates that bonds may be able to provide protection against inflation. This study contributes to the literature by addressing the bond-inflation relationship in an emerging debt market. This study finds a low negative

correlation between bond returns and inflation. Further analysis revealed that this is the result of the capital gains and losses component of income dominating total returns. Reinvestment of coupons showed a positive correlation with inflation, but this was not large enough to suggest that it would provide adequate inflation protection. Altogether the results obtained suggest that bonds do not provide adequate protection against inflation.

A low or negative correlation between bond returns and equity returns suggests that there are diversification benefits to be reaped from combining the two assets together. This study contributes to the literature by updating the bond-stock correlations documented by Auret and Vivian (2014) and Firer and McLeod (1999). This study found a low positive correlation between bonds and stocks. The bond-stock correlation coefficient shows a decline from the Firer and McLeod (1999) study to the Auret and Vivian (2014) study, and to this study, suggesting a progressive decoupling of the two markets. Moreover, this study found that the bond-stock correlation was negative when stock returns were negative, and even more negative when stock returns were less than -3.19%. Overall, the results suggest that there are diversification benefits to be reaped from combining bonds and stocks together in a portfolio.

The study follows a quantitative research methodology using non-experimental research methods. All investigations in the study are conducted at the macroeconomic level using index data. The All Bond Indices were used as the proxy for bond investment. The FTSE/JSE All Share Indices were used as the proxy for equity investment. The CPI was used as the proxy to measure the inflation rate. Data was examined directly to provide a quantitative description of trends. The sample autocorrelation function was used to investigate mean reversion and the Kendall Tau-b correlation test was used for the correlation investigations.

5.2 LIMITATIONS OF THE STUDY

One limitation of this study is that the correlation investigations are only carried out at a long-term horizon. This study does not explicitly examine these correlations over shorter intervals. Figures A11 and A12 in the Appendix show that the extent of co-movement between bond returns and inflation, and between bond returns and stock returns varies notably across the overall sample. Therefore the analyses of these respective correlations are limited by not examining the shorter term correlations.

A further limitation of this study is that many of the autocorrelation and correlation coefficients obtained were not statistically significant. This made it difficult to make strong assertions about the relationships observed.

5.3 AVENUES FOR FURTHER RESEARCH

Future research may wish to investigate mean reversion in bond returns at very short-term horizons such as a month, a quarter or a year. The sensitivity observed over the three-year and five-year horizons analysed in this study merits further analysis into the very short-term effects of political and economic developments in the country.

Furthermore, future research may consider comparing the findings of this study, which looks directly at the data, to the findings where methods such as vector autoregression (VAR) models are used in the same context. VAR methods model market dynamics, and would thus make it possible to investigate the properties at any horizon. This is particularly useful when small sample sizes are a constraint. Future studies may also find it worthwhile to use a time varying correlation coefficient, as a dynamic

correlation measure should provide for a deeper understanding of the correlation relationships.

Another avenue of research is to consider other asset classes. It might be worthwhile to compare empirical properties of bond returns to those of returns from cash and from property for example.

Moreover, future research may wish to move away from a macroeconomic analysis, and analyse individual bonds of the primary issuers in South Africa's debt market (government, financials, and parastatals). This research could explore bond types beyond the vanilla bonds that make up the ALBI, for instance inflation-linked bonds.

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APPENDIX

Figure A1: Scatter plot of monthly ALBI holding period returns (HPR) versus the monthly inflation rate, 2000-2016

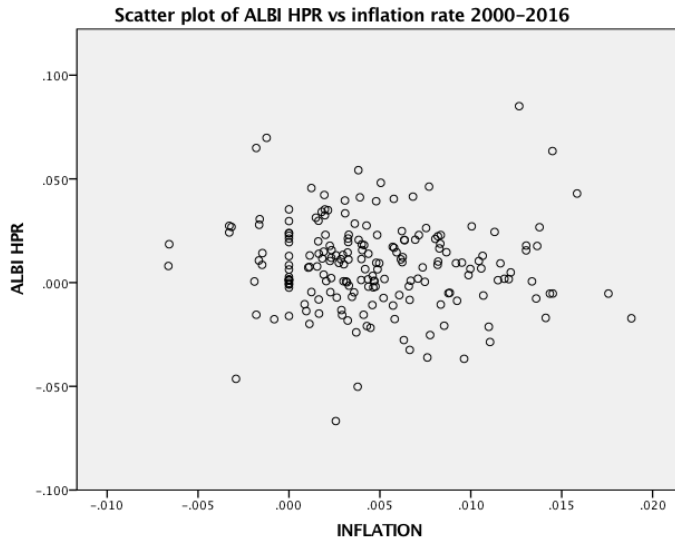


Figure A2: Scatter plot of monthly ALBI holding period returns (HPR) versus the monthly ALSHTR returns, 2002-2016

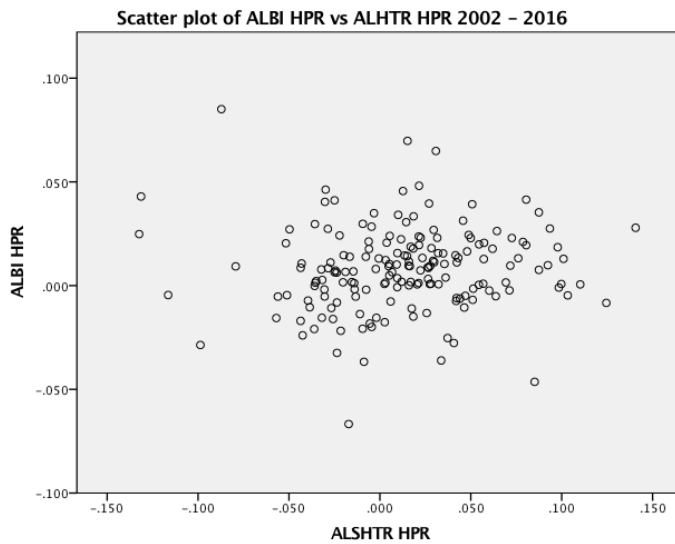


Figure A3: Scatter plot of log monthly ALBI holding period returns (HPR) versus the log monthly inflation rate, 2000-2016

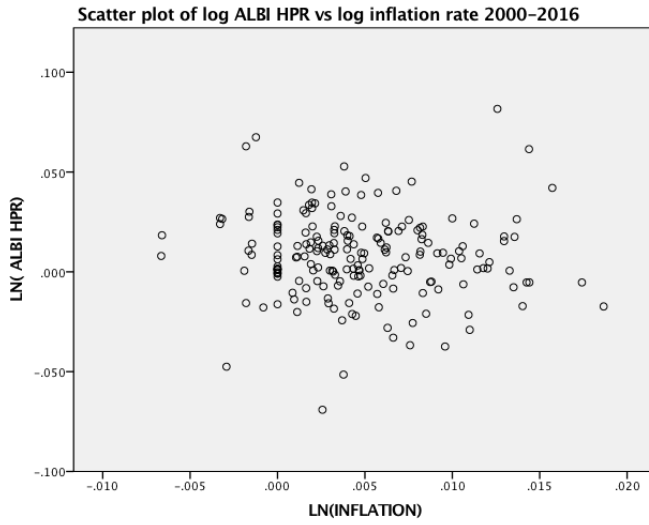


Figure A4: Scatter plot of log monthly ALBI holding period returns (HPR) versus the log monthly ALSHTR returns, 2002-2016

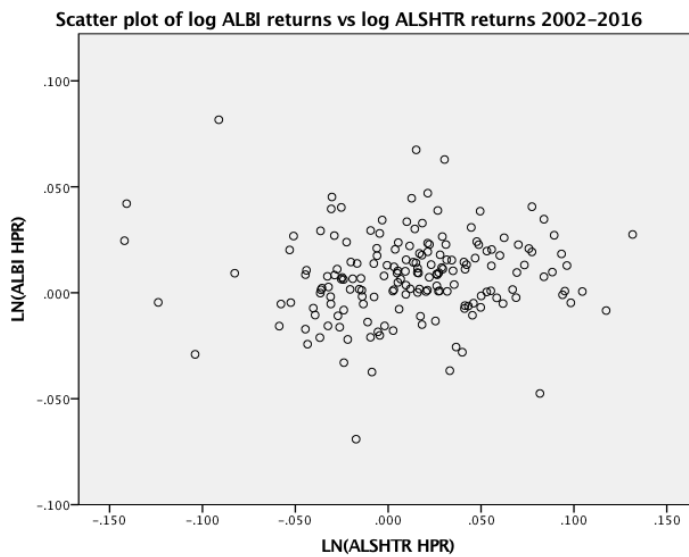


Figure A5: Histogram of the monthly ALBI holding period returns (HPR), 2000 to 2016

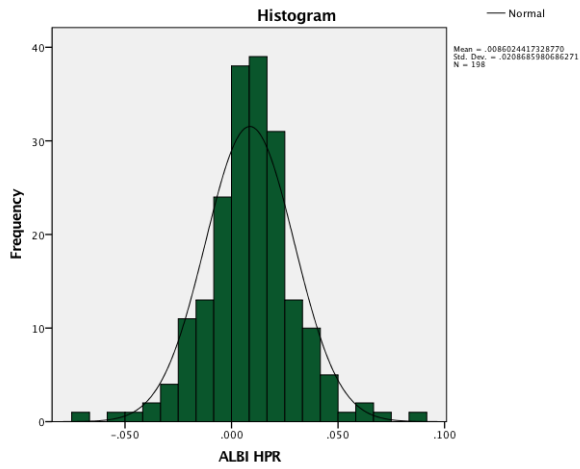


Figure A6: Histogram of log monthly returns of the ALBI, 2000 to 2016

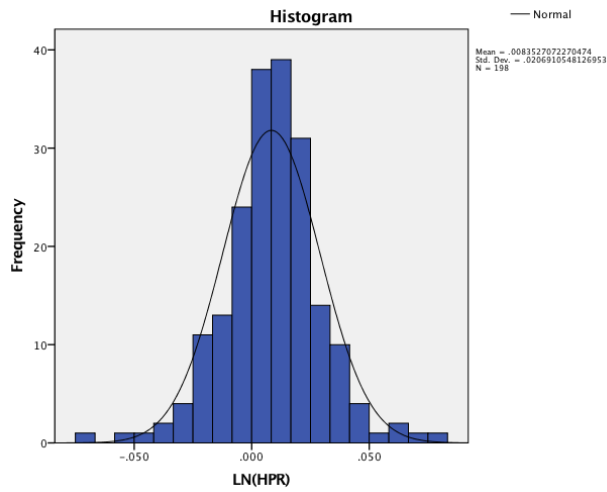


Figure A7: Histogram of monthly ALSHTR returns, 2000 to 2016

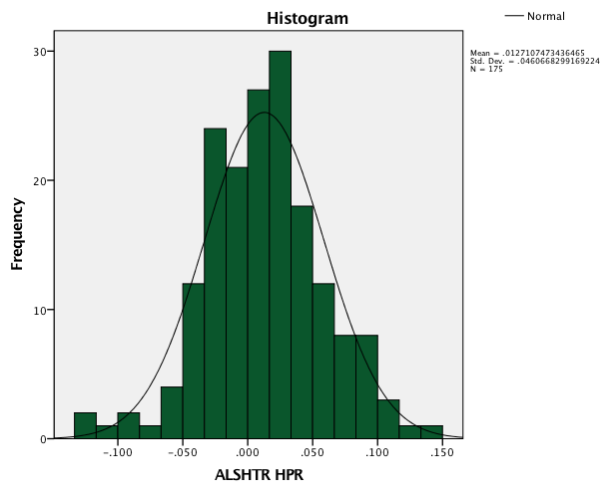


Figure A8: Histogram of log monthly ALSHTR returns, 2003 to 2016

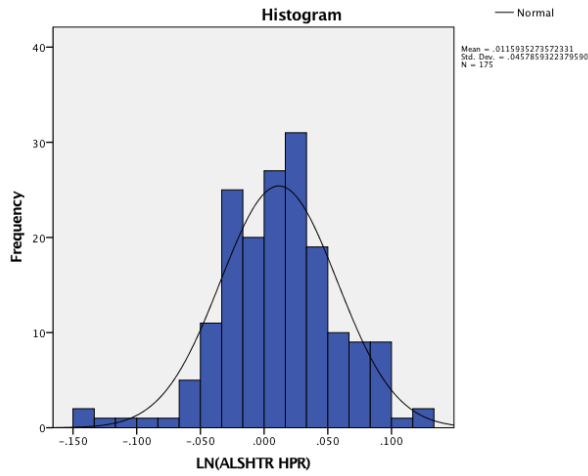


Figure A9: Histogram of the monthly inflation rate, 2000 to 2016

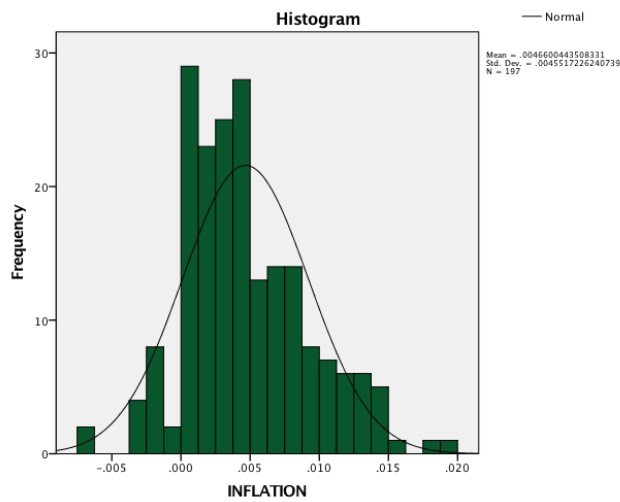


Figure A10: Histogram of the log monthly inflation rate, 2000 to 2016

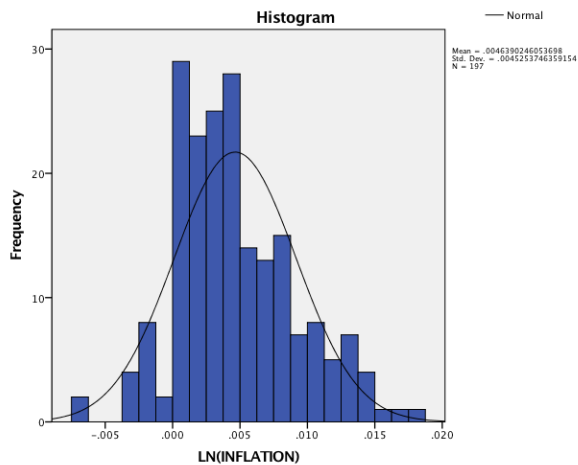


Table A1: Standard deviation of the ALBI returns

Period	Standard Deviation
Overall	0.0209
2000 to 2013	0.0194
2013 to 2016	0.0259

Table A2: Correlation between returns of the ALBI Clean Price Index and the inflation rate and Correlation between the ALBI Interest Yield Index and the inflation rate

Index	Kendall Tau-b coefficient	Pearson R coefficient
ALBI Clean Price	-0.075	-0.077
ALBI Interest Yield	0.084**	0.166*

** denotes significance at the 10% level

* denotes significance at the 1% level

Figure A11: Standardised monthly ALBI returns versus standardised monthly ALSHTR returns, 2002 to 2016

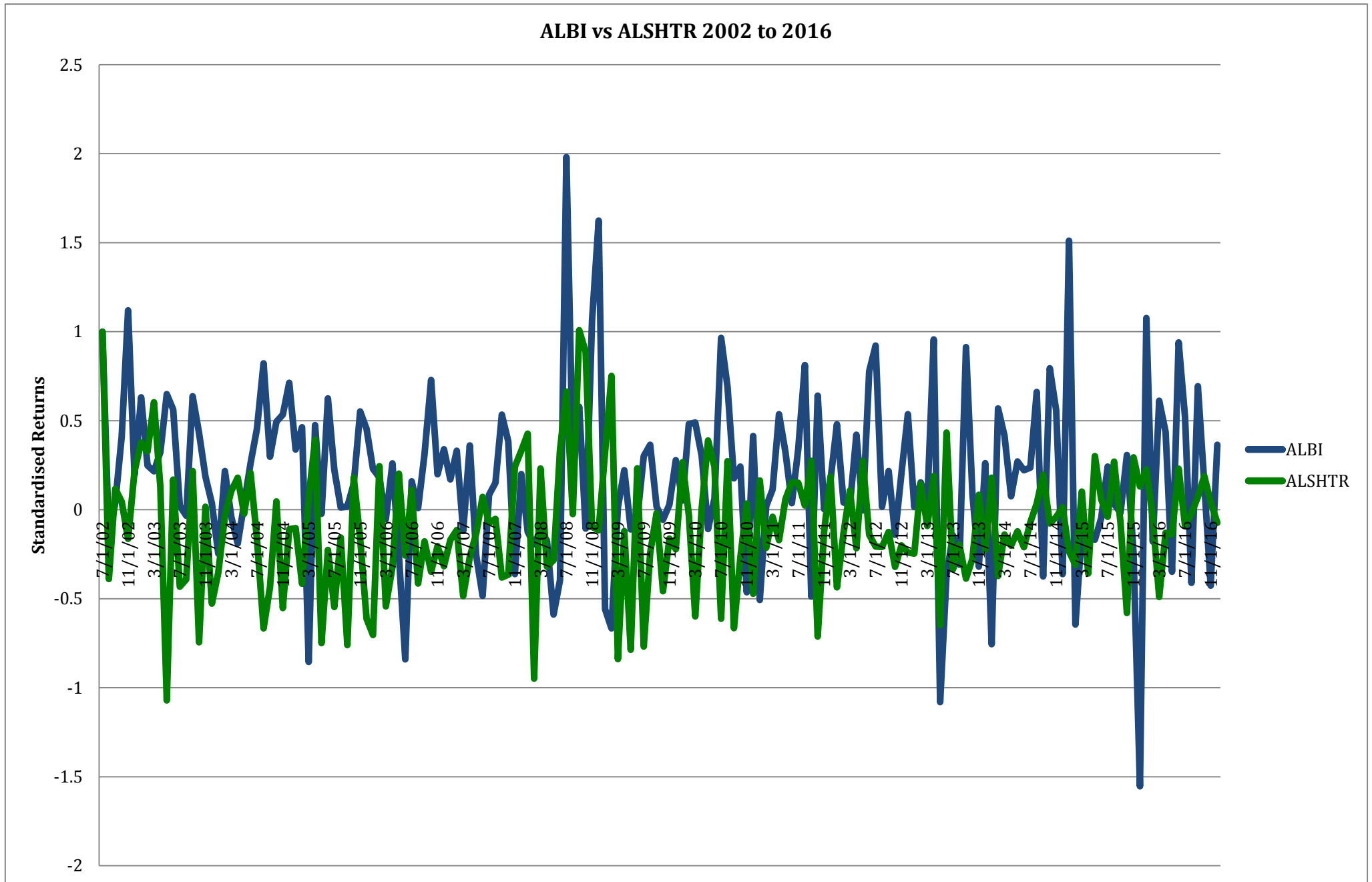


Figure A12: Standardised monthly ALBI returns versus standardised monthly inflation rate returns, 2000 to 2016

