Master of Commerce (Business Finance) Dissertation 735715

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735715

Master of Commerce Dissertation Final Submission

An empirical assessment of the key drivers of sovereign bond yields in South Africa: it's not just about fundamentals

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Johannesburg

November 2017

DECLARATION

I, Sinovuyo Mpakama, hereby declare that this research report is my own unaided work. Where I have used or referred to the work of others, I have clearly marked as such. It is submitted in partial fulfilment of the requirements for the degree of Master of Commerce in Finance at the University of the Witwatersrand. It has not been submitted for any degree or examination at this or any other university before.

ACKNOWLEDGEMENTS

First and foremost I would like to thank the Lord Almighty! Jehova *El Shaddai*, the God of More Than Enough! When I entered the corporate world in 2008, all I had was an undergraduate degree in Economics. An undergraduate degree was not enough to get into the mainstream corporate world, but you were More Than Enough! You carried me through the years as I worked on a fulltime basis and diligently pursued by academic aspirations. This has been a four year long journey, yet you carried me through. Ever faithful! Through you, all is possible. To honour the ability and gift of an inquisitive mind you have bestowed upon me, this shall be the first of three Masters' degrees I will acquire in my life time.

I would like to thank my mother, Nozipho Hlongwane. When you had very little, you prioritised our education as your children. You gave us the best education you possibly could, and as a result we went to some of the best schools in this country. Not only that, your continued pursuit of learning even in your relative older years instilled a desire in me to be the best I can be.

I would like to thank my family, friends and colleagues; your support through the years is treasured!

I would like to thank Professor C. Auret for accepting me into this prestigious and highly sought after programme when you could have chosen dozens of other students. I would like to thank my supervisor, David McClelland, for the patience and guidance in putting this work together. It was not easy and it took a while, but eventually I saw the light through your continued guidance.

Last but not least, to ALL my *haters* who tried to pull me down over the years, you were never ready; this is just the beginning!

Knowledge is Power.

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List of Abbreviations

SAGB:	10 year South African generic government bond yield
SA:	South Africa
US:	United States of America
Fed:	Federal Reserve Bank of the US
SARB:	South African Reserve Bank
CDS:	Credit Default Swap
JP EMBI:	JP Morgan Emerging Market Bond Index
FRA:	Forward Rate Agreement
USDZAR:	US dollar to rand exchange rate
VIX:	Chicago Board Option Volatility Index
ARCH:	Autoregressive Conditional Heteroskedasticity
GARCH:	Generalised Autoregressive Conditional Heteroskedasticity
GDP:	Gross Domestic Product
RMSE:	Root Mean Square Error
MSA:	Mean Absolute Error

ABSTRACT

The writer studies the short-run determinants of bond yield volatility in South Africa (SA) by analyzing the impact that global factors –representing global funding conditions – have on the changes to the rand denominated generic 10-year government bond yield (SAGB). This is followed by a one-period forward forecast of this volatility. The explanatory variables tested in this study are as follows: net bond purchases by foreign investors, Chicago Board Options Volatility Index (VIX), JP Morgan Emerging Market Bond Index (JP EMBI) spread, the US dollar to SA rand (USDZAR) exchange rate, the SA 5 year credit default swap (CDS) rate, the 12 month interest rate expectation/9x12 forward rate agreement (FRA), dollar spot price of gold and dollar spot price of oil. The study period ranges from January 2000 to December 2015. The GARCH modelling technique is used due to its ability to capture the volatility clustering effects observed in time series return data. The writer used the Gaussian distribution as the default model, however in order to control for the skewness and fat-tails in financial market return data, the Student-T and Generalised Error distributions are also tested to see if the non-normally distributed bond returns could be better captured by alternative parametric assumptions. The results show that all the explanatory variables, with the exception of the FRA, are statistically significant in explaining volatility in the local generic 10-year government bond.

CHAPTER ONE

1. INTRODUCTION

1.1.Background

Governments borrow money in the capital markets to finance the difference between their revenue and expenditure. SA's gross government debt outstanding is estimated to amount to R2.2 trillion by 31 March 2017, with the costs of servicing this debt expected to reach R146.2 billion per annum, whilst new debt to be issued in the financial year ending 31 March 2018 is estimated to be R220.8 billion (National Treasury, 2017). Gross government debt to Gross Domestic Product (GDP) is expected to peak at just over 50 per cent, whilst the fiscal deficit as a percentage of GDP is expected to average 2.8 per cent over the next three fiscal years (medium term). Consequently, the costs of servicing government debt are expected to consume an average of 13.3 cents for every R1 in government revenue over this period (National Treasury, 2017).

Understanding the drivers of sovereign bond yield volatility in emerging markets, in particular SA, is of critical importance as bond yields determine the costs at which government can raise funding for both the fiscal and current account deficits. Volatility is a statistical measure of the dispersion of returns for a given security or market index. The dispersion of the returns is informed by the magnitude of the periodical changes to a variable. Volatility can either be measured by using the standard deviation or variance between returns from the same security. The higher the volatility, the riskier the security (Enders, 2010). Whilst the SA government manages the interest rate risk in its' debt portfolio by issuing fixed rate bonds as opposed to floating rate bonds, any changes to market interest rates will have an impact on the debt service costs of newly issued debt. Government issues debt on a weekly basis through three auctions, namely nominal fixed rate bond auctions, inflation-linked (indexed) bond auctions and Treasury bill auctions. Nominal fixed rate and inflation-linked bonds are long-term debt instruments whose maturities are more than 12 months, whilst Treasury bills have maturities up to 12 months (364 days). Nominal amounts of R3.2 billion, R650 million and R10 billion are issued into each of the nominal fixed rate, inflation-linked and Treasury bill auctions. Consequently, significant upward changes to market interest rates will have a profound impact on the debt service costs of the R729 billion in new debt to be issued over the medium term (National Treasury, 2017).

1.2.Problem Statement

Poghosyan (2012) notes that existing literature suggests that borrowing costs depend on fundamental conditions in the economy, in particular the macroeconomic and fiscal variables. The article further notes that the long-run relationship between sovereign bond yields and macroeconomic fundamentals can breakdown in the short-run, especially during periods of financial stress. As noted in Csonto (2014), emerging market countries cannot fully decouple from developments in other emerging markets during periods of financial distress, which tells us that the extent of cross-country correlations means that bond markets will be impacted by changes to global financial conditions in a similar manner. While country-specific fundamentals are important determinants of spreads, the importance of global factors increases during high volatility periods. With such levels of cross-country correlations, risks of contagion amongst emerging market countries become elevated. Any trigger to global market instability could see systemic effects ripple across global financial markets. Any change to global variables which drive volatility of government bond yields would thus have an impact on demand for emerging market debt in general (Csonto, 2014).

According to BBVA Research (2015), the commencement of the process wherein monetary policy in the US returns to pre-financial crisis levels remains a potential trigger to sustained volatility in global capital markets until such time that it is complete. This follows a period in which the size of the balance sheet of the US Fed has ballooned from just 6 per cent of GDP in 2007 to around 25 per cent through continued and sustained asset purchases, the results of which have been a substantial decline in interest rates to historic low levels of near zero per cent. The increase in global dollar liquidity as a result of US Fed policy action has seen increased participation by US and other developed market investors in emerging market economies through increased buying of financial assets in these markets. This in turn has resulted in increased levels of cointegration between developed and developing markets, which is a source of risk and vulnerability to capital markets in developing countries. Any reversal in global liquidity will result in rapid currency depreciation and weakening of the recipient markets from the excess global liquidity (Banco Bilbao Vizcaya Argentina (BBVA) Research, 2015).

1.3.Research Question

Poghoysan (2012) provides an illustration of the breakdown in bond yields to their fundamentals by reference to the fact that despite an increase in general government debt levels in the United States (US) in the aftermath of the global financial crisis, US government bond yields have trended downwards. Conversely, despite a relatively lower initial level of general government debt as a percentage of gross domestic product (GDP), sovereign borrowing costs in some peripheral Euro countries such as Spain have persistently exceeded those of more highly indebted countries such as the United Kingdom (UK). The article further notes that this behaviour of sovereign bond yields suggests that there is a need to distinguish between long-run and short-run determinants of borrowing costs. The hypothesis in Poghosyan (2012) is that sovereign bond yields can temporarily deviate from their long-run equilibrium level, driven by short-run factors. What is clear from existing literature is that whilst fundamental drivers play an important role in determining the long run determinants of sovereign bond yields, global financial conditions play a critical role in ascertaining the short-run determinants, particularly during times of financial stress.

Given that the existing literature suggests that the long-run drivers of government borrowing costs can breakdown during times of financial stress, and given further that during such periods of breakdown the reality is that government borrowing costs can depart from their underlying fundamental drivers (Poghosyan, 2012), the key question contained in this research is to ascertain specifically which global factors drive volatility in short term government bond yields for SA. This is of relevance to financial market researchers as fundamental factors have reduced in relevance as a result of QE by the US Fed. The results of the study will be used to better inform policy-makers of the drivers of volatility which can be taken into account in risk models which inform decisions of the immediate future. The hypothesis of this research is that global funding conditions are statistically significant drivers of sovereign bond yield volatility in the short run.

1.4.Methodological Framework

The article makes use of the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model in measuring and estimating volatility. Financial time series return data has been found to exhibit volatility clustering (Mandelbrot, 1963), which shows that the variance in financial time series return data is not constant over time (Enders, 2010). The GARCH process allows the variance in the error term to change over time with a more flexible lag structure (Bollerslev, 1986), thereby making it the most appropriate tool to measure volatility (Zakaria & Abdalla, 2012). The output of the GARCH regression equation can be interpreted as follows: an X basis point change in an independent variable will change the volatility of the dependant variable by Y in a direction specified by the sign of the coefficient. What it does not say is what change will be in the nominal yield itself, just the volatility of that yield (Gadanecz, Miyajima, & Shu, 2014). The forecast model predicts what volatility at T+1 will be, not what the nominal yield itself will be (Enders, 2010).

GARCH assumes the dataset is heteroskedastic (Enders, 2010). The writer begins with a unit root test for heteroskedasticity on all eight explanatory variables in the study. A stepwise regression process, both the backward and forward selection procedures, is used in order to ascertain which variables should be included in the final model (Johnsson, 1992). Preliminary tests as outlined in Enders (2010), namely the Lagrange Multiplier Test for GARCH errors and volatility clustering in the residuals, are employed to ascertain whether GARCH is an appropriate technique for this study. Three parametric distribution assumptions, namely the Gaussian, Student-t and Generalised Error are used to control for the fat-tailed and leptokurtic nature of financial time series return data, which is not adequately captured by the Gaussian distribution (Mandelbrot, 1963). The Gaussian distribution is asymmetrical around the mean and assumes that random variables have equal chance of being on either side. The Student-t distribution is more suited to capture financial returns due to its fat-tailed nature, whilst the Generalised Error distribution is used to study the tail of the distribution (Mandelbrot, 1963).

The research proceeds with an in-sample and out-of-sample volatility forecasting process. To evaluate the model outcomes the writer makes use of the R^2 as well as the absolute value of the coefficients from the Garch regressions. The writer examines the short-term determinants of this volatility in SA using weekly price data from Bloomberg between the periods of January 2000 and December 2015. The research takes into account possible explanatory variables of factors which have been found in the literature to be significant drivers of bond yield volatility in the short run. Upon ascertaining the significance of these drivers, the research then proceeds to build a forecasting model which is expected to predict a one-period forward trajectory of bond yield volatility.

Guided by existing literature – discussed in detail in the following section – on the global factors which have been found to be significant drivers of changes to bond yields in the short run, this research analyses the influence of the following: global liquidity conditions, global risk appetite, sovereign credit risk profile and market expectations. The global factors are proxied by the following variables: non-SA resident net bond purchases [global liquidity]; Chicago Board Options Volatility Index (VIX), JP Morgan Emerging Market Bond Index spread (JP EMBI) and the USDZAR exchange rate [global risk appetite]; the SA 5 year credit default swap rate [sovereign credit profile]; and 12 month interest rate expectations/9x12 forward rate agreement, dollar spot price of gold and dollar spot price of oil [market expectations]. Each of the global factors is discussed in more detail in the following paragraphs, with specific emphasis on how these global factors interact with the explanatory variables, hence the reason why they have been group in this manner.

1.5.Description of Study Variables

Krishnamurthy & Vissing-Jorgensen (2011) defines global liquidity is the free-flow of US dollars in the global financial system. Since the global financial crisis of 2008, the US Fed has increased the size of its balance sheet by purchasing assets from the global banking system, thus injecting dollars into global capital markets (BBVA Research, 2015). This action has led to a decline in bond yields in developed markets such as the US, the United Kingdom (UK) and Germany, leading investors to seek higher bond returns from more risky assets in the form of emerging market debt. This spurred an increase in portfolio inflows from developed markets to emerging markets in search of higher yields, with bond portfolio flows (non-SA resident bond purchases) representing a portion of these inflows (Krishnamurthy & Vissing-Jorgensen, 2011).

Global risk appetite is a measure of the extent to which investors are able to withstand variability or volatility in their investment returns. When risk appetite increases, investors move further down the credit quality profile curve – they invest in lower investment grade bonds − of the investment universe in search of a higher return, thus assuming higher sovereign credit risk. The more their risk tolerance increases, the further down the credit curve they move (Caceres, Guzzo, & Segoviano, 2010). The VIX is a measure of the implied volatility of S&P 500 index options (Luenberger, 1998). When investor risk tolerance decreases, investor appetite for risk at each unit of volatility decreases to allow him to assume the same amount of aggregate portfolio risk at a higher level of financial market volatility. Aggregate risk is total portfolio risk after rebalancing for higher volatility. In a case where a portfolio made up of 80 per cent equities and 20 per cent cash gives an aggregate volatility of X, and higher volatility in equities increases aggregate portfolio volatility to, say, 1.5X, the investor may reduce the equity/cash split to 50/50, bringing aggregate portfolio volatility back to X. Aggregate portfolio risk has remained the same as before the increase in volatility, but the risk appetite of the investor has decreased (Luenberger, 1998).

The JP EMBI is a composite spread index of emerging market debt to developed market debt. As investor risk appetite increases, so does demand for emerging market debt (Garcia-Herrero & Ortiz, 2005). This results in a substitution effect where developed market debt is substituted for emerging market debt, which in turn results in lower emerging market bond yields and EMBI. An emerging market currency can also act as a proxy for global risk appetite, with the USDZAR exchange rate in particular being known for this. This exchange rate in considered to be a currency risk speculative trade and proxy for other key emerging market currencies which responds instantaneously during periods of global market volatility. This is as a result of its high liquidity and tradability (Bishop, 2016).

When considering the investment credit risk profile of each country in a portfolio of bond investments, countries with lower credit risk/higher credit rating – as measured by credit rating agencies – will offer lower returns *ceteris paribus* than countries with higher credit risk profiles (Mpofu, De Beer, Nortje, & Van De Venter, 2010). Credit rating agency ratings are driven by long-term fundamental factors such as macroeconomic and fiscal variables, which do not fit into the framework of this research (Palladini & Portes, 2011). The creditworthiness of an issuer can also be measured by a credit default swap (CDS), which is viewed as being more efficient in giving information about credit worthiness than credit rating agency reports because the price is more responsive to country developments than the agencies, whose decisions on creditworthiness go through various channels before being made official. The writer makes use of the CDS over credit rating agency ratings due to its higher informational efficiency. A CDS is a financial derivative contract whereby the buyer of the CDS buys 'insurance' against a default in the underlying bond. If the issuer of the underlying bond defaults, the holder (buyer) of the CDS will receive financial compensation from the seller to compensate for his loss as a result of such default (Palladini & Portes, 2011).

Market expectations feed into capital market prices, if we assume the Efficient Market Hypothesis holds true (Mpofu, De Beer, Nortje, & Van De Venter, 2010). Some of the key drivers of bond yields have been found to be the term spread, inflation expectations and central bank policy action. The 12 month forward rate agreement (FRA) is a reflection of what capital markets expect to be the market rates in 12 months due to transactions being priced and concluded at such published rate. These rates may change over time (Xiong & Yan, 2010). Oil and gold prices, both in the spot and futures markets, are reflective of market expectations through their linkages to inflation expectations. When inflation expectations increase, investors require higher returns to compensate for the erosion in real value of their wealth with time, leading to higher bond yields (Christensen, Lopez, & Rudenbusch, 2010). Higher global oil prices generally lead to higher inflation expectations, whilst higher inflation expectations lead to gold being preferred as a store of value over other investment instruments (Neely, 2015).

1.6.Motivation

Given the backdrop highlighted in the problem statement of the introduction, the writer believes that a better understanding of the short run drivers of volatility in government bond yields is of importance given the uncertainty around future global funding conditions.

Kosapattarapim (2013) notes that modelling volatility of financial returns has attracted immense attention in the field of financial research. The reasons given for this are that volatility of returns play a critical role in the global economy due to its use as a measure of market risk. Greater changes in volatility of financial returns raise public policy discussions about the stability of the financial system. Lastly, volatility of returns plays an important role in investor decisions about portfolio allocation and risk management. Al-Najjar (2016) shares similar sentiments, noting that modelling volatility in financial markets is one of the factors that have a direct role and effect on risk management.

The ability to measure volatility of the SA generic government bond yields can be used by public debt managers in the risk management of their debt service costs model employed in the national budgeting process. In modelling the volatility of each of the independent variables, one can model their impact on the volatility of the bond yield. By taking into account possible shocks in each of the variables which have been found to be statistically significant, institutions such as the National Treasury of SA would be able to run stress scenarios on their debt service costs to ascertain what level of shocks in these variables could be withstood before a risk of sovereign default or partial default occurs.

To the best knowledge of the writer, there have not been extensive studies which look into the short-run determinants of government bond yield volatility in SA. In the only official study the writer came across which focused on the determinants of changes to bond yields in SA exclusively, and not part of a collective study, Robinson (2015) focused on the impact of fiscal variables on determining government bond yields, which are long term in nature. All articles reviewed in this research focused either on emerging market economies in general, or specific European countries. The writer is thus of the view that a study focused on a variety of short-run drivers of bond yields in SA is warranted as this would be a much broader scope of work than that in existing literature.

1.7.Delimitation

Given the intended outcome of the study, using long-run variables, or a combination of short-run and long-run, would not serve this purpose well. The reason for this is that long-run data such as macroeconomic and fiscal variables are published on a monthly, quarterly or bi-annual basis. The variables used in the study are priced daily, with the writer having chosen to make use of weekly frequency. Using a monthly or quarterly frequency of a dataset which is priced on a daily basis would have resulted in the series not sufficiently capturing the volatility effects of financial time series data, which may result in estimation bias. Similarly, interpolating quarterly data to create weekly series is highly likely to also create an estimation bias.

The remainder of this research is structured as follows: chapter two is the literature review, chapter three is the theoretical framework, chapter four is the results and analysis and chapter five is the conclusion.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Overview

The literature review section discusses the global financial conditions factors which have been found to have a statistically significant impact on government bond yields. It begins by providing evidence which supports the view that changes to bond yields are not only influenced by fundamental – macroeconomic and fiscal – variables, but by global financial conditions as well. It then follows with a review of each of the following: global liquidity, global risk appetite, sovereign credit profile and market expectations. These categories of factors speak to each of the possible explanatory variables used in the study, with non-resident bond purchases representing global liquidity; the VIX, exchange rate and JP EMBI spread representing global risk appetite; CDS representing the sovereign risk profile; and the price of gold, oil and the forward rate agreement representing market expectations. Further, parts of the literature demonstrate why the variables have been categorised as they have been.

2.2. Impact of Global Factors on Bond Yields and Spreads

Petrova, Bellas and Papaioannou (2010) analyse the determinants of emerging market bond spreads. The article does this by examining the short and long-run effects of fundamental macroeconomic and temporary financial market factors. The article finds that during the global financial crisis of 2008, the spreads on sovereign bonds widened substantially for both developed – other than the US – and emerging market countries. Petrova, Bellas and Papaioannou (2010) note that the widening in spreads had previously been attributed to increasing public debt levels and poor economic fundamentals. The results show us that country fundamentals play an important role in determining emerging market bond spreads in the long run, but that the effect of capital market volatility is of higher importance in the short run than country fundamentals such as macroeconomic and fiscal variables.

Rozada and Yeyati (2006) provide evidence that a substantial make-up of the changes in emerging market bond spreads is attributable to changes in exogenous factors such as the risk spread, global liquidity and financial market contagion. The article further demonstrates that the extent to which these variables relate to each other has not changed by much over the years, strengthens when country-specific fundamental drivers are taken into account, and provides valuable insight into how bond yields are likely to move in future. On a holistic basis, the results show the significance played by exogenous factors in determining the drivers of emerging market bond yields in Latin American countries.

Weigel and Gemmill (2006) study price changes in the bond markets of Latin American countries to ascertain the extent to which the creditworthiness of countries in the region is determined by global, regional and country-specific factors. The article does this by estimating how far each country is from a possible default, with the analysis covering the period 1994 and 2001. The finding is that the distance to default is predominantly influenced by global and regional factors, which are considered to be non-diversifiable sources of credit risk. Weigel and Gemmill (2006) noted that the extent of market spill-overs in Latin American bond markets has significant implications for the effective management of bond portfolio in these markets. Because of this, the writers argue that the credit risk assessment of bond portfolios in these markets should pay closer attention to exogenous global and regional drivers and determinants than to local. Country-specific factors are established to be the least significant in explaining the changes to bond yields.

Alekneviciute (2016) singles out the most significant drivers in determining government bond market co-movements as being exogenous global factors. The article identifies the following five global factors as being the most significant: global risk aversion, the global market portfolio, money market uncertainty, commodity market uncertainty and economic policy uncertainty. The most important of these factors is global risk aversion. Alekneviciute (2016) found that the extent to which these factors play a significant role in determining bond market spreads reduces the benefits to be attained from international diversification. The reason for this is that where markets are disproportionately influenced by common drivers, any change to such drivers will have the same or similar impact on all bond portfolios.

Naidu, Goyari and Kamaiah (2016) study the factors which drive sovereign bond yields in emerging market countries between 1980 and 2013. The article notes that in the midst of the global financial crisis, global debt capital markets saw increased levels of price volatility, cointegration amongst markets and contagion levels increased substantially, the impact of which became a source of instability to the global financial system. The results in Naidu, Goyari and Kamaiah (2016) show that the exchange rate, the US Fed funds rate, oil price, bond yields in the US, gold price and real interest rates are important drivers of bond yields and spreads in developing country economies. These factors are considered to be exogenous and global in nature.

2.3. Global Liquidity

Arslanalp and Tsuda (2014) attempt to estimate the impact of foreign bond inflows into emerging market countries between 2004 and 2013. According to the article, of the US$1 trillion in emerging market government debt held by non-resident investors in local and hard currency bond investments by 2013, it is estimated that about US$500 billion flowed into emerging market countries between 2010 and 2012 alone. A significant proportion of these assets are held by investors based in developed market countries. Arslanalp and Tsuda (2014) further find that foreign investor portfolio inflows to developing economies between 2010 and 2012 were driven by very similar, if not the same, factors during this period as investors aggressively searched for yield on the back of near zero interest rates in markets such as the US. This demonstrates that emerging market assets were considered by investors to be a non-differentiated asset class in nature as they were largely influenced by drivers which were common across all markets rather than country-specific factors.

Sharifuddin and Ling (2014) examine the flattening of the yield curve in Malaysia within the context of ascertaining its determinants. The article further studies what impact the increasing of non-resident investor participation in Malaysia’s bond market in recent years has had on government bond yields. The findings in the article are that the flattening of the bond yield curve since 2002 was the result of a surge in non-resident portfolio investments into the Malaysian bond market. Further, Sharifuddin and Ling (2014) find that non-resident investor activity in the local fixed-income market in Malaysia has had a statistically significant impact in bringing down bond yields in that market.

Bardhan and Jaffe (2007) ascertain the extent to which US Treasury interest rates would increase if the non-resident investors into US bond markets were to dispose of their holdings. The article finds that the final outcome is dependent on the nature of the disposal: in the event that bond assets are disposed of and the proceeds reinvested into other US dollar fixed-income assets, it is likely that the impact on US interest rates and bond yields would be minimal. In a case where there is a switch from US dollar debt to US dollar non-debt instruments, the extent of the impact on bond yields would be higher, albeit there would be minimal impact on the currency as the investments would remain in US dollars. Bardhan and Jaffe (2007) estimate a benchmark case of a 50 basis point increase in US

Treasury interest rates, going up to 100 basis points, if foreign investors sold-off their US assets and invested into alternative currencies.

Carvalho and Fidora (2015) examine whether an increase in foreign capital flows into the Euro-area would have a downward impact on Treasury yields, as had been observed in the US bond market. The results in Carvalho and Fidora (2015) indicate that the increase in non-resident participation in the Euro-area bond market between 2000 and 2006 resulted in a reduction interest rates in the region by around 1.55 percentage points over the long-run. The results showed very high similarities on the impact of foreign portfolio flows with what was observed in the US bond market. Carvalho and Fidora (2015) note that these results are applicable across global financial markets and not specific to the US only, with an increase in foreign investor participation in any market being likely to have a significant downward impact on yields in any local bond market.

Beltran, Kretchmer, Marquez and Thomas (2012) conduct a study to ascertain whether a slowdown in foreign investor flows into a domestic capital market is likely to have any impact on the bond yields in that market. Beltran, Kretchmer, Marquez and Thomas (2012) find that for every USS100 billion in foreign portfolio inflows into the US bond market, bond yields decrease by an estimated 40-60 basis points in the short run, whilst the long-run impact is less at an estimated 20 basis points. Beltran, Kretchmer, Marquez and Thomas (2012) conclude by noting that were it not for China purchasing an estimated US$1.1 trillion between 1995 and 2010, Treasury rates in the US would have been as much as 200 basis points higher by 2010.

Krishnamurthy and Vissing-Jorgensen (2011) calculate what impact the US Fed's Quantitative Easing (QE) program had on long-term Treasury rates in the market. The findings in Krishnamurthy and Vissing-Jorgensen (2011) are that QE resulted in a reduction in bond yields of more than 100 basis points, whilst QE2 resulted in a reduction of about 20 basis points. Inflation expectations increased substantially as a result of QE1, which implies that reductions in real interest rates were more significant than the reductions in nominal interest rates. These reductions in real and nominal interest rates led to a loosening in global financial conditions, which triggered capital to move from developed markets where interest rates were at historic low levels to emerging market economies in search for higher yield.

De Nicolo and Ivaschenko (2009) measure global systematic liquidity shocks embedded in bond spreads. The key findings contained in De Nicolo and Ivaschenko (2009) are as follows: the previous ten year period has seen liquidity increase in all markets and countries, which has been accompanied by higher levels of cointegration in liquidity indicators across countries, and has resulted in higher levels of systemic liquidity shocks across markets; higher levels of globalisation and financial market interconnectedness has resulted in higher levels of correlations amongst liquidity indicators; liquidity indicators play a significant role when it comes to ascertaining bond yield spreads; liquidity indicators in the US are significant drivers of bond spreads in a substantial number of countries.

Ananchotikul and Zhang (2014) examine the impact cross-border portfolio flows and global risk aversion has on financial market volatility in emerging markets. The article suggests that non-resident portfolio flows do play a meaningful role in determining financial asset price volatility in these markets. During time of financial market normality, the impact of foreign portfolio inflows on bond yields is relatively muted, with a financial crisis increasing the impact of this by about 5-10 times.

Feyen, Ghosh, Kibuuka and Farazi (2015) note that from 2009-10, accommodative monetary policies in the US have resulted in a protracted period of historically low global interest rates and low levels of volatility in global financial markets. This protracted period of low interest rates has contributed to excess global funding conditions and increases in investor risk appetite in search for higher returns. Given this, the article examines the impact of global liquidity factors on capital flows to emerging market countries. A key finding in Feyen, Ghosh, Kibuuka and Farazi (2015) is that global factors are a significant driver of primary market bond issuance activity in the international bond market. After taking into account US interest rates, the article finds that a reduction in interest rate volatility accompanied by further increases in the Fed's balance sheet results in a tighter yield to maturity spread at time of issuance.

Warnock and Warnock (2005) study foreign investor inflows in to the US bond market and consider the impact they have on interest rates. The article concludes that foreign investor portfolio flows are a significantly large driver of interest rates in the domestic market. When taking into account fundamental macroeconomic determinants of bond yields, the results suggest that bond yields would be trading at least 150 basis points higher were it not for foreign inflows into the bond market (Warnock & Warnock, 2005).

2.4. Global Risk Appetite

Garcia-Herrero and Ortiz (2005) investigate the extent to which the drivers of global risk aversion explain the movements in Latin American sovereign spreads. A key finding in the article is that global risk aversion plays a significant role in determining sovereign spreads in the region. Countries with higher sovereign risk profiles are found to be more sensitive to changes in global risk aversion. Garcia-Herrero and Ortiz (2005) further find that the impact of global risk aversion on spreads in this region has increased since the Enron scandal.

Herrmann (2016) studies the impact of macroeconomic fundamental factors and a cross-country risk factor on yield spreads in the Euro area. The purpose of the study is to separate the impact of a change in risk aversion to the cross-country risk factor. The article finds that despite macroeconomic fundamental drivers being found to play a significant role in determining sovereign spreads, the cross-country risk factors are responsible for a statistically significant component of the movements to the spreads. Herrmann (2016) further finds that since 2012, cross-country risk factors have played an increasingly important role in determining yield spreads.

Baek, Bandopadhyaya and Du (2005) examine the drivers of the sovereign risk premium with a specific focus on cross-country risk factors. Included in the study is a risk appetite index as one of the explanatory variables, over and above the macroeconomic variables, which is found to play a statistically significant role in determining sovereign yields. Overall Baek, Bandopadhyaya and Du (2005) find that a model to explaining movements in the sovereign risk spread which includes a proxy for risk appetite has higher explanatory power than one which does not. Baek, Bandopadhyaya and Du (2005) note that the implication of this is that in the short-run, risk sentiment plays an important role in determining perceptions around country risk, which is used to explain why a country's risk premium may tell us information which is different to that being implied by its sovereign risk rating.

Margaretic (2008) studies and compares which between aggregate risk factors and economic fundamentals play a more significant role in determining how sovereign bond spreads evolve over time. The article uses the funding liquidity premium, the credit risk premium, the market liquidity premium and the market volatility premium to measure market risk appetite. The main finding in Margaretic (2008) is that when capital markets are functioning under tranquillity, emerging market bond spread changes are determined by country fundamental factors, whereas during times of market volatility, investor risk appetite plays a more significant role.

Culha, Ozatayand Sahinbeyoglu (2006) study the factors which drive sovereign bond spreads in 21 emerging market countries. The results show that the risk appetite of international investors is the one factor which shows up consistently as a common driver of bond spreads. In addition to risk appetite, sovereign country ratings are found to have a significant impact on spreads. The significance of the impact of risk appetite holds even after controlling for possible data biases by making use of a different data frequency.

Bella, Papaioannou and Petrova (2010) estimate an index which captures a country's overall state of financial wellness, and consider the impact this variable has on sovereign bond spreads in emerging market economies. The findings in Bella, Papaioannou and Petrova (2010) indicate that the Financial Stress Index, which is a measure of stability in the financial market system, plays a significant role in determining changes to sovereign bond yields in emerging market countries. In addition to this, changes to the Chicago Board Volatility index (VIX) are also found to have a statistically significant impact on bond spreads in the short-term.

Ferucci (2003) examined the drivers of emerging market bond spreads using a set of non-fundamental as well as fundamental macroeconomic factors. The results demonstrate that there is a strong relationship between sovereign spreads and macroeconomic factors, but also that exogenous factors such as global liquidity conditions also play a critical role, over and above the macroeconomic factors. The findings in Ferucci (2003) suggest that capital markets did not sufficiently factor in sovereign credit risk between 1995 and 1997, and that the decline in sovereign spreads during the period of the study cannot be fully explained by changes to country fundamentals, suggesting that global risk aversion is a significant determinant.

Gadanecz, Miyajima and Shu (2014) study the impact exchange rate risk has in determining local currency bond yields in emerging market countries. The article isolates exchange rate expectations and the variability of these expectations. The finding is that as exchange rate volatility increases, investors' required rate of return for holding emerging market local currency sovereign bonds equally increases. The indication by the US Fed in May 2013 that it would be slowing down its asset purchase program has led to an increase in exchange rate volatility and its corresponding impact on the variability of sovereign bond spreads. (Gadanecz, Miyajima, & Shu, 2014).

Investors tend to use the USDZAR exchange rate as a risk proxy when executing risk on-off investment strategies, which has the effect of making trades in the currency highly speculative and volatile in nature (Bishop, 2016). Bishop (2016) further notes that global risk aversion has an important impact on the local currency due to its very high liquidity, with up to US$25 billion traded on a daily basis, with a substantial portion of this trading activity being noted as being speculative in nature. According to the article the local currency is seen as a strong proxy for global investor risk appetite (Bishop, 2016).

2.5.Sovereign Credit Risk Profile

Jaramillo and Tejada (2011) study what impact sovereign credit ratings have in determining bond spreads, and the article finds that an investment grade credit status versus non-investment grade causes a reduction in bond spreads by 36 per cent, in addition to the fair value estimates suggested by country fundamental factors. The article further finds that the impact of credit rating upgrades within the investment grade class is less significant, with a positive movement leading to a 5 – 10 per cent reduction in spreads, whilst there are little or no changes to yield spreads as a result of upgrades within the sub-investment grade rating class. The better the sovereign credit rating of a country, the lower the credit default swap (CDS) spread of a country will trade (Jaramillo & Tejada, 2011).

Celic (2012) studies the relationship between CDS spreads and bond yields on a sample of 32 companies over the period January 2010 to December 2011. The findings in the article are that the manner in which these two variables relate to each other holds well over the long-term. In the short term, however, CDS spreads do deviate from their implied fair value levels when benchmarked against bond spreads. Another key finding in the article is that CDS markets tend to move ahead of bond markets during times of market normality, but this trend reverses itself during periods of financial market instability. Reasons which can be put forward for this trend include the fact that when volatility increases as a result of financial crises, investors will trade more in bonds than in the CDS due to the fact that bond markets are considered to be more real than CDS markets (Celic, 2012).

Palladini and Portes (2011) examine the long-term relationship between the bond market and the CDS market in six Euro-area countries between 2004 and 2010. The investigation points to the fact that bond and CDS prices should be equal to each other on a fair value basis when markets are in equilibrium. In the short-run, however, bond markets and CDS markets price credit risk differently, resulting in a possible divergence of instrument valuations with the same underlying reference asset (Palladini & Portes, 2011). Further examination in the article suggests that the bond market follows the CDS market in terms of price discovery, which means that the CDS market can be used to forecast bond market spreads.

Sturmans (2013) studies how bond yields and the CDS spread reacts to changes in country credit rating profiles in the Euro area. Sovereign bond yields and the CDS markets are found to have a statistically significant relationship with credit rating agency announcements, especially when the announcements are negative. Moreover, Sturmans (2013) finds that there is a contagion effect present in that bond yields in countries whose sovereign credit ratings did not change are impacted by credit ratings of another country, albeit to a lesser extent.

Hull, Predescu and White (2003) study the interaction between CDS spreads and bond yields, as well as the extent to which credit rating announcements are expected by traders in the CDS market. Hull, Predescu and White (2003) find that the historical relationship between the bond and CDS markets is stable, and that the yield on the 10 year benchmark sovereign bond is about 10 basis points lower than that of the CDS spread. The article further finds that CDS spreads are more efficient in expecting and capturing negative announcements, especially when the credit quality of an issuer declines very rapidly over a relatively short space of time.

Shim and Zhu (2010) study the interactions between the bond and CDS markets in Asia between January 2003 and June 2009. The findings in the article are that, firstly, there is compelling evidence that active CDS markets lead to higher liquidity and lower transaction costs in the primary issuance market as a result of the hedging opportunities CDS markets provide. Secondly, during times of financial crises, the positive impact CDS trading has on the bond market is diluted away.

Fontana and Scheicher (2010) examine the pricing impact of Euro CDS markets on the underlying government bond market of each country. The first main finding in Fontana and Scheicher (2010) is that the factors which drive changes to how credit risk is priced in the CDS market are very similar to those which drive how it is priced in the bond market. Secondly, since September 2008, market price connectedness between the bond and the CDS market does vary across countries, wherein in some countries more efficient price discovery takes place in the CDS market, whilst in other countries a more efficient price discovery takes place in the bond market (Scheicher, 2010).

Li and Huang (2011) examine the price relationship between spreads in the CDS markets and their underlying cash markets. The article demonstrates that the CDS market has become better than the bond market at measuring issuer credit risk, with the level of information content in this spread being argued to be better than what is contained in the bond yield itself. Whilst acknowledging the growing importance of the CDS market in providing information on the creditworthiness of issuers, the article does conclude that the bond yield spread remains the most reliable determinant of issuer credit risk as its informational efficiency does not weaken during crisis periods.

2.6.Market Expectations

Xiong and Yan (2010) consider the impact market expectations have on bond market risk premia. These market expectations induce market participants to engage in speculative trades for their own benefit in their quest to maximise their wealth. The resultant changes to wealth effects as a result of these speculative trades translate to changes to bond price volatility and to a variation in the valuation premium. The results in Xiong and Yan (2010) show that market expectations can play a meaningful role in explaining bond yield volatility.

Chun (2005) considers what impact changes to market sentiment and expectations have on market interest rates. The article shows that the market reacts to changes to expectations on real output, inflation, the exchange rate and monetary policy, with perceptions about inflation being noted as having a particular impact on bond yields. A framework of this kind may provide market participants with new methods of examining the impact a change to market expectations has on bond yields and how these interlink to monetary policy decisions (Chun, 2005).

Hartelius, Kashiwase and Kodres (2008) note that financing conditions in global capital markets have led to a decline in sovereign bond yields since mid-2002, notwithstanding the relatively high levels of financial market volatility since the financial crisis of 2008. The article studies bond spreads from the view of the impact market expectations have in driving the changes to these spreads. The results in Hartelius, Kashiwase and Kodres (2008) demonstrate that market expectations around future interest rates in the US are a significant driver of bond yield spreads in emerging market economies.

Hovath, Kalman, Kocsis and Ligeti (2014) examine forward rate market expectations in Hungary using a set of analyst surveys. The results in Hovath, Kalman, Kocsis and Ligeti (2014) show that during the sample period of 2009 to 2013, bond yields in the US played an important role in determining term premia and forward rate expectations in emerging market economies. The findings specific to the Hungarian markets demonstrate that bond yields and the forward expectations in the interbank market contained useful information on the forward interest rate market (Hovath, Kalman, Kocsis, & Ligeti, 2014).

Altavilla, Giacomini and Costantini (2013) demonstrate that market participants can make use of information contained in the forward rate agreement contracts to accurately forecast bond yield movements based on market expectations and exploit these for profitable gain. The finding in Altavilla, Giacomini and Costantini (2013) is that making market expectations estimates drawn from forward price contract agreements results in superior estimates when compared to alternative estimates. It is further found that this method of obtaining information about market expectations would have allowed an investor to earn substantial excess return over a ten year period.

Crump, Eusepi and Moench (2016) consider whether term premia have any bearing on the term structure of interest rates. The findings in Crump, Eusepi and Moench (2016) are as follows: a significant component of the changes to long-term bond yields is determined by term premiums, and that term premiums have been responsible for a significant component of the decline in bond yields in the US over the last 30 years. The forward rate agreement, to a large extent, is reflective of the term premium in interest rates (Crump, Eusepi and Moench, 2016).

Kurniasih and Restika (2015) study the impact of inflation and exchange rate expectations on government bond yields using monthly data from 2010 to 2013. The results show that inflation, as per the Fischer Hypothesis, has a positive effect on bond yields, i.e. the higher the rate of inflation, the higher the yield on government bonds. Daily oil price changes predict large changes to break-even inflation (Neely, 2015). On the exchange rate, the finding in Kurniasih and Restika (2015) is that the exchange rate has a negative influence on government bond yields, meaning that depreciation in the currency causes a rise in bond yields. To this end, forward expectations priced on these variables could reasonably be expected to have an influence on bond yields.

CHAPTER THREE

3. METHODOLOGY

3.1. Overview

This research uses a statistical procedure which assumes that the dataset is heteroskedastic. In order to test for heteroskedasticity we begin by using the Dickey-Fuller test to ascertain the extent to which the data contains a unit root. Following this is a stepwise regression process to ascertain which of the chosen variables should be included in the regression model. The forward selection starts with no predictors in the model and proceeds to add the most statistically significant variable at each step, whilst the backward selection starts with all predictors in the model and the process removes the least significant variable for each step.

The Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model is used in this empirical investigation. Prior literature (Bollerslev, 1986) has found that this model is the most appropriate framework to employ due to its ability to forecast the variance and size of the error terms. This model is particularly useful when investigating financial market time-series data as this has been found in literature to have a property known as volatility clustering. To confirm that GARCH is indeed the appropriate framework, the writer ascertains whether there is volatility clustering in the residuals and tests for Arch effects. The GARCH process series was subsequently estimated using gold and the forward rate agreement as two interchangeable inputs, given the outputs of the backward and forward selection stepwise regressions which suggested that these two variables are interchangeable between the two techniques, with all other three variables remaining in both models.

The paper proceeds to forecast and compare models and the forecasting accuracy by defining the in-sample and out-of-sample periods based on the understanding that for accurate forecasting one needs to know the values of the explanatory variables during the forecast period, or know a way to forecast the required explanatory variables. Consequently, the paper employs an in-sample historical volatility modelling (03/01/2000 to 30/12/2013) and an out-of-sample (06/01/2014 to 11/01/2016) modelling to evaluate the volatility forecasting performance. The corresponding accuracy measures are the symmetric loss functions which are the Mean Absolute Error (MAE) and Root Mean Square Error (MSE) at an upper limit benchmark of 20 per cent (Chai & Draxter, 2014).

3.2.Data Description

This section provides a detailed description of the data that was collected for the regression analysis that follows. The remainder of this section will start by explaining the dependant variable and then follow with descriptions of each of the explanatory variables. The study considers the following possible short-run determinants of the volatility in government bond yields in South Africa: USDZAR exchange rate, Chicago Board Volatility Index (VIX), 12 month forward rate agreement (FRA), JP Morgan Emerging Market Bond Index (EMBI), 5-year CDS spread, the dollar spot price of gold, the dollar spot price of oil, and lastly, the net bond purchases by non-resident investors – a more detailed description of the explanatory variables is provided. In order to capture the various stress periods during the previous decade and a half, the study examines sovereign bond yields between January 2000 and December 2015. This period duly captures the Argentina Debt Crisis of 2001, the Global Economic Recession of the early 2000s, the Global Financial Crisis of 2008, the European Sovereign Debt Crisis of 2011, and lastly the period during 2013 wherein the US Fed gave its first indication that it would be tapering off its' QE program. The research makes use of daily market close data, from which it selects a weekly frequency to control for extreme volatility effects present in daily data (Enders, 2010).

The dependant variable is the generic 10 year government bond yield. This is a yield to pre-tax maturity and computed using the All Bond Index (ALBI). The underlying benchmark bonds of the ALBI are constituted and published by the Johannesburg Stock Exchange (JSE), which feeds the price data to Bloomberg servers. All data is sourced from Bloomberg. The yields which constitute the ALBI are based on the offer of the market from the bid-offer price and are updated intraday. Using the generic government bond is beneficial to using the actual bond because it allows for analysis of a time series of a '10 year' bond. This is possible because it references different underlying '10 year government bonds' through time, thus allowing for an analysis on a specific point on the yield curve over different periods.

Given the fact that all variables tested in the model are priced in financial markets on a daily basis, they are assumed to reflect all available information at any given point. This includes all policy decisions already made by both monetary and fiscal authorities. To this end, any changes in monetary or fiscal policy actions are assumed to be fully reflected in the price of the instruments.

3.2.1. USDZAR Exchange Rate (USDZAR)

The USDZAR exchange rate is the price of 1 US dollar ($) in terms of South African rand (ZAR). Due to the active participation of non-resident investors in the South African bond market, changes in the currency have an immediate impact on the valuations these investors place on South African bonds (National Treasury, 2017). A weakening currency means that the US$ value of existing bondholders decreases, as such investors will require a higher yield to compensate them for the increased risk of capital loss in US dollar currency terms. It is for this reason that sharp currency moves are very likely to instantaneously lead to significant changes in bond yields (Gadanecz, Miyajima, & Shu, 2014).

3.2.2. Chicago Board Options Exchange Volatility Index (VIX)

The VIX is a measure of implied volatility of S&P 500 index options, calculated by the Chicago Board Options Exchange. This is one of the most popular measures of the market's expectation of stock market volatility over the next 30-day period. As market volatility increases, investors have a preference to invest in shorter dated instruments to minimize risk due to convexity; they thus require higher yield compensation to continue holding longer dated instruments due to their higher convexity risk (Garcia-Herrero & Ortiz, 2005).

3.2.3. Forward Rate Agreement (FRA)

A forward rate agreement (FRA) is a binding agreement between two parties who seek to protect themselves against unfavourable future movements in interest rates. The parties will agree on an interest rate to be applicable at a future date today, and that will be the rate at which the transaction will settle. These agreements are binding on the parties and are traded financial instruments. The FRA allows them to lock-in an interest rate for a stated period of time starting on a future settlement date (Hovath, Kalman, Kocsis, & Ligeti, 2014). This is a reasonable expectation of what the parties expect interest rates to be in the future; as such these instruments are often interpreted to be the markets' expectation of future interest rates. The writer proposes to use the 9x12 FRA, otherwise referred to as 12 month interest rate expectations (Xiong & Yan, 2010).

3.2.4. JP Morgan Emerging Market Bond Index (JP EMBI)

The JP EMBI is an index which tracks the total returns earned by a basket of emerging market bonds. Strong performance by the index when compared to a developed market index gives signal of stronger demand for emerging market debt, as such higher liquidity in such markets. This may also lead to higher investor risk appetite. As investors' risk appetite increase, they will demand more emerging market assets; they thus require lower yield compensation due to their higher tolerance for risk (Ferucci, 2003).

3.2.5. Credit Default Swap (CDS)

A CDS is a specialised swap agreement entered into by two parties wherein the seller of the CDS will compensate the buyer in the event of a loan default or other credit event. The buyer thus insurers himself against default of the underlying issuer. It should be noted that the seller of the CDS need not necessarily be the issuer, it can be any participant in financial markets. The party selling the CDS makes a commitment to the buyer that in the event of a default, the holder of the CDS will receive obligations due to him, as such, the seller thereof takes possession of the defaulted loan after settling existing obligations with the buyer (Jaramillo & Tejada, 2011). An increase in the CDS is reflective of an increase in the perceived credit risk of the underlying reference bond; as such investors require a higher yield to compensate for the increased credit risk (Palladini & Portes, 2011).

3.2.6. Dollar Gold Spot

Gold is used by investors as a store of wealth. It is not a typical investment instrument in that it does not provide income and investing in gold incurs storage costs as it needs to be physically stored. Investors prefer gold as an investment during times of market volatility as it is seen as a safe-haven investment. During times of market stress, investors prefer safe-haven assets whilst at the same time sell emerging market assets. An increase in the price of gold as a result of a desire for safe-haven assets will lead to a decline in the price of emerging market bonds, as such an increase in bond yields (Abdullah & Bakar, 2015).

3.2.7. Dollar Brent Crude Oil Spot

Oil is a commodity that affects all sectors of the economy due its role in transportation and heating. An increase in the price of oil will result in increasing prices of most other goods and services, which in turn will lead to an increase in inflation expectations. The increase in inflation will result in increasing interest rates domestically, both from contractionary monetary policy as well as cost pressures. The increasing interest rates will culminate in an increase of bond yields. Oil is a significant driver of inflation expectations globally, whereas inflation expectations are a significant driver of global bond yields. An increase in inflation expectations as a result of higher oil prices will lead to a weakening of bond yields (Kurniasih & Restika, 2015).

3.2.8. Non-Resident Bond Purchases

South Africa's bond market has seen holdings by non-resident investors increase from 8 per cent in 2008 to a monthly average of 35 per cent as at end 2015(National Treasury, 2017). Higher non-resident holdings of government bonds are evidence of increased demand by such investors. To this end, as the demand for South African government bonds increases, as shown by higher non-resident holdings, the lower the yields. Bond yields are relatively sensitive to non-resident holdings as these can be considered a proxy for global liquidity (Poenisch, 2014).

Table 1: Pre-stepwise regression explanatory variables

Explanatory variable	Hypothesis
ZARUSD exchange rate	As the exchange rate weakens, investors require higher yield compensation for holding local currency government bonds as the hard currency value of their investments deteriorates
Chicago Volatility Index (VIX)	As market volatility, measured by the VIX, increases investors have a preference to invest in shorter dated instruments to minimize risk due to convexity; they thus require higher yield compensation to continue holding longer dated instruments due to their higher risk
12 month interest rate expectations (9x12 FRA)	As investors' expectation of the term spread increases, so do the contracts they conclude to manage their forward interest rate exposure; they thus require higher yield compensation for increased interest rate risk
JP Morgan EMBI	As investors' risk appetite increases, they will demand more emerging market assets; they thus require lower yield compensation due to their higher tolerance for risk
SA 5-yr credit default swap (CDS) spread	As the default risk of an issuer increases, so does the CDS spread; investors thus require higher yield compensation for the higher default risk by the issuer
Gold	As the price of gold increases, this is a sign that global risk aversion in increasing; this leads to an increase in emerging market bond yields. Investors, therefore, demand a higher yield compensation for the higher systemic risk in the global economy.
Oil	As the price of oil increases, so do inflation expectations. An increase in inflation expectations as a result of higher oil prices will lead to investors seeking higher premium for the erosion in the real value of their investments.
Non-resident bond purchases	As demand for SA bonds by non-residents increases, the lower the yields. This happens because investors have lowered their risk premium for emerging market debt.

3.3. Unit Root Testing

The Augmented Dickey-Fuller test has been used to test for stationarity of the series. The results presented in Table 2 below show that all the data variables are stationary, with ρ for all variables not equal to zero.

Table 2: Dickey-Fuller unit root test result summary

Variable	ρ	L1 Coefficient	STD Error	Test Statistic	P-value
SA10-year GB	1.9893	-0.9893	0.7660	-12.9140	0.000
JP EMBI	2.0080	-1.0080	0.7935	-12.7030	0.000
5-year CDS	2.1201	-1.1201	0.8926	-12.5480	0.000
Gold Spot	2.1269	-1.1269	0.8134	-13.8540	0.000
Oil Spot	1.8149	-0.8149	0.6931	-11.7570	0.000
ZARUSD	1.9448	-0.9448	0.8029	-11.7670	0.000
VIX	2.3484	-1.3484	0.9879	-13.6490	0.000
Portfolio flows	2.0999	-1.0099	0.8166	-13.4700	0.000
Forward rate agreement	2.6925	-1.6925	0.1077	-15.7200	0.000

3.4. Stepwise Regression

Johnson (1992) notes that the common problem with econometric studies is that there may be a large set of candidate predictor variables. For model simplicity the article advocates to choose a small subset of variables from a larger set, but in a manner which does not compromise the predictive credibility of the model. It further notes that there are two basic models for selecting predictors, those being the stepwise regression and the best subsets regression. The stepwise regression allows for the entry and removal of predictors, in a stepwise manner, until such time that there is no econometrically justifiable reason to add or remove more variables. The best subsets regression allows for the selection of a subset of predictors that do the best at meeting some well-defined objective criteria.

According to Johnson (1992), the standard stepwise regression both adds and removes explanatory variables at each step of the process. The procedure specifies alpha-to-enter and alpha-to-remove thresholds and tests the p-values against these thresholds. The procedure stops when the variables not included in the model have p-values which are greater than the specified alpha-to-enter value, and when all variables in the model have p-values that are less than or equal to the specified alpha-to-remove. In employing the forward selection procedure, the writer of this research started with no predictors in the model and the process added the most significant variable for each step. The process stopped when all variables not in the model had p-values that are greater than the threshold. The backward elimination started with all the explanatory variables in the model and removed the least significant variable for each step based on the specified threshold. The process stopped when all variables in the model have p-values that are less than or equal to the specified alpha-to-remove value. The significance level used as benchmark in both the forward and backward selection procedures was specified at 0.10 [pe(.10)].With the backward selection procedure, out of all the eight possible predictors, only four have been selected by the stepwise regression process as shown in Table 3 below.

Table 3: Backward selection regression results summary

SAGB	Coefficient	Standard Error	Test Statistic	P-value
USDZAR	33.8504	3.1276	10.8200	0.0000
FRA	0.1159	0.1281	9.0400	0.0000
5-year CDS	0.1733	0.4471	3.8800	0.0000
JP EMBI	-0.9246	0.3691	-2.5000	0.0120
CONSTANT	-0.9117	0.5624	-1.6200	0.1050

The forward selection procedure also added only four variables out of the eight, however it added gold instead of the forward rate agreement, with the remaining three variables the same as in the backward selection process. Due to the two methods giving us slightly different results, both forward rate agreement and gold will be controlled for interchangeably and diagnostic test results will be compared. The selected models are the ones to be used in the GARCH specification.

3.5.Preliminary Testing and Results

3.5.1. Volatility Clustering in the Residuals

To test whether the GARCH framework is an appropriate technique, two conditions have to be met by the data: volatility clustering in the residuals and arch effects in the residuals (Enders, 2010). Volatility clustering is shown graphically, whilst the Arch effects are tested empirically. The writer shows evidence of both:

1. There is volatility clustering in the residuals, which is when periods of low volatility are followed by low volatility, and when periods of high volatility are followed by high volatility. This is tested by estimating the mean model (one without exogenous factors controlled). We plot the residuals from the estimation and observe the trend in the residuals plot.

2. Testing ARCH effect in the residual, which is a post-estimation test run with null hypothesis that there is no arch effect versus alternative that says there is arch effect. A Lagrange multiplier (LM) tests is implemented for this.

Figure 1: Volatility clustering volatility in the residuals

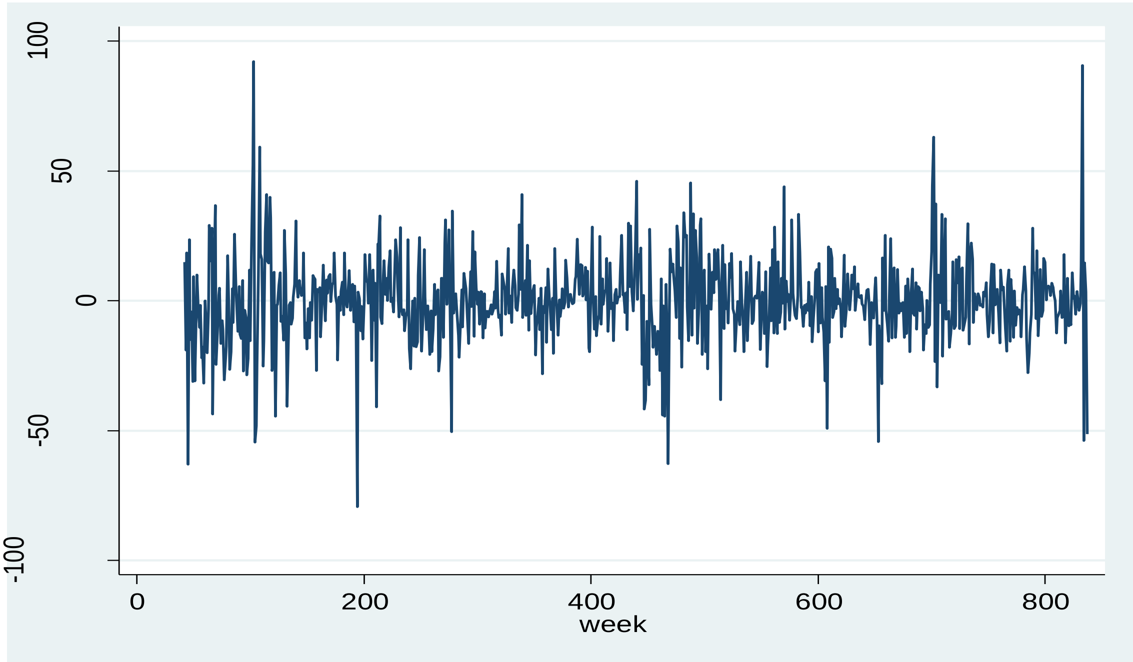


Figure 1 above of the residuals, which is applied to the weekly changes of the generic government bond yield (our dependant variable), shows periods of high volatility and other periods of relative tranquillity – this is based on a differenced approach. The residuals plotted above show periods characterised by high levels of dispersion and others that have substantially lower levels of dispersion. This series shows non-random patterns that indicate volatility clustering is present. This demonstrates that the series a good candidate for autoregressive conditional heteroskedasticity (ARCH) modelling based on volatility clustering condition.

3.5.2. Lagrange Multiplier (LM) Test for GARCH Errors

The ARCH test is a Lagrange multiplier (LM) test for ARCH in the residuals and is computed from a regression of the squared residuals on a constant and lagged squared residuals (Engle, 1982). As the LM test shows a p-value of 0.0000 (Table 4), which is well below 0.05, we reject the null hypothesis of no ARCH effects and concluded that there is ARCH(p) disturbance.

Table 4: LM test for autoregressive conditional heteroskedasticity (ARCH)

SA10-year GB	Coefficient	Standard Error	Test Statistic	P>t
CONSTANT	-0.4781	0.6658	-0.72	0.43
LAGS (p)	Chi 2	DfProb> Chi 2	P-value	
1	59.1370	1	0.0000	

H0: no ARCH effects vs. H1: ARCH(p) disturbance

As displayed above, the two conditions required for GARCH to be applied in the modelling framework are present, those being volatility clustering and the presence of the ARCH effect in the residual. For this reason it is concluded that GARCH is an appropriate modelling technique for this study.

3.6. Theoretical Framework (GARCH)

3.6.1. Background to the GARCH Framework

Conventional time series and econometric models operate under an assumption of constant variance (Bollerslev, 1986). On the other hand, the Autoregressive Conditional Heteroskedasticity (ARCH) process allows the variance in the error term to change over time as a function of past errors leaving the unconditional errors constant (Engle, 1982). Bollerslev (1986) notes that this kind of model behaviour has already proven to be useful in modelling for a variety of economic conditions. The article further notes that past literature ((Engle, 1982), (Kraft & Engle, 1983)) has shown that models for the rate of inflation are constructed recognising that uncertainty of inflation tends to change over time. Mandelbrot (1963) notes that financial time series data exhibit a characteristic known as volatility clustering, which is a phenomenon wherein the movement of financial returns where large changes tend to be followed by large changes and small change tend to be followed by small changes in either direction. This shows that volatility in time series data is not constant over time (Enders, 2010).

Bollerslev (1986) further notes that what is common to the application of the ARCH process in previous studies ((Coulson & Robins, 1985), (Lilien, Engle, & Robins, 1985), (Domowitz & Hakkio, 1985), (Weiss, 1984)) is the introduction of an arbitrary linear declining lag structure in the conditional variance equation to take into account the long memory typically found in empirical work. The article introduces the GARCH model which allows for a more flexible lag structure, which is the reason that the GARCH model is the most appropriate model to use when modelling volatility and forecasting financial returns (Zakaria & Abdalla, 2012).

3.6.2. Stylised Facts of Financial Market Return Data

Mandelbrot (1963) points out that the normal distribution has a kurtosis of three and skewness of zero, but that the probability distributions of many financial returns have kurtosis greater than three, demonstrated by peaks which are taller and narrower, and tails which are fatter than the normal distribution. This makes financial time series data heavy-tailed and leptokurtic in nature (Enders, 2010). Gokcan (2000) confirmed that a well-known characteristic of financial market return data series is that it generally exhibits a non-Gaussian distribution. Because of this, a Gaussian-based GARCH model cannot adequately capture the leptokurtic nature of financial time series return data. In order to effectively model this data, alternative distribution assumptions should be employed, the most common of which being the Student-T and the Generalised Error distributions (Kosapattarapim, 2013). The article combines the Gaussian GARCH framework with other types of non-normal distributions, wherein the finding is that GARCH models with non-normal distribution assumptions outperform GARCH models with a normal distribution.

3.6.3. GARCH Model Specification

The model specification following the GARCH (1, 1) estimation techniques takes on the following form:

$$sa10yr = \mu + \varepsilon_t \qquad (1).$$

This is the mean equation as a function of exogenous variables (X) and error term ε_t, with $sa10yr$ representing the volatility in the SA 10 year generic government bond yield. An associated conditional variance model takes the form:

$$\sigma_t^2 = \omega + \beta_1 \epsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 + \beta_3 X + \varepsilon_t \; (2),$$

Whereσ_t^2 is one period ahead forecast based on past information- known as the conditional variance. ω is a constant term; $\beta_{1,2,3}$ are the beta coefficients, X is the independent variable, ϵ_{t-1}^2 contains information about volatility from the previous period, measured as the lag of the squared residual from the mean equation (arch term); σ_{t-1}^2 is last period's forecast variance, and ε_t is the residual error term. The independent variables reflect the weekly changes to the underlying reference data and not the levels, whilst the dependant variable is the volatility which is explained by the combined changes to the independent variables.

Empirically, we have the following specification tested:

$$sa10yr_t = \omega + \beta_1\epsilon_{t-1}^2 + \beta_2\sigma_{t-1}^2 + \beta_3 USDZAR_t + \beta_4 FRA_t + \beta_5 CDS + \beta_6 JPEMBIi_t + \varepsilon_t (3) .$$

Three distribution assumptions are made about the conditional distribution of the error term ε_t. The three alternative assumptions on the distribution were made and a distinction on the contribution to the log-likelihood for observation t under each assumption can be depicted from the following:

- Gaussian (Normal) distribution assumption:

$$l_t = -\frac{1}{2}\log(2\pi) - \frac{1}{2}log\sigma_t^2 - \frac{1}{2}(y_t - \frac{X'{}_t\theta)^2}{\sigma_t^2}(4)$$

- Student's t-distribution:

$$l_t = -\frac{1}{2}\log\frac{\pi(\gamma-2)\Gamma(\gamma/2)^2}{\Gamma((\gamma+1)/2)^2} - \frac{1}{2}log\sigma_t^2 - \frac{(\gamma-1)}{2}log\left(1 + \frac{(y_t - X'{}_t\theta)^2}{\sigma_t^2(\gamma-2)}\right) (5),$$

where the degree of freedom $\gamma > 2$controls the tail behaviour and the t-distribution approaches the normal as $\gamma \to \infty$.

- The Generalised Error Distribution takes the form:

$$l_t = -\frac{1}{2}\log\left(\frac{\Gamma(1/3)^3}{\Gamma((3+r)(r/2)^2}\right) - \frac{1}{2}log\sigma_t^2 - \left(\frac{\Gamma(\frac{3}{r})(y_t - X'{}_t\theta)^2}{\sigma_t^2\Gamma(1/r)}\right)^{r/2} (6),$$

where the tail parameter r>0 and the GED is normal distribution if r=2, and fat tailed if r<2, $l_t$is the log likelihood for observation t. The parameters σ_t^2 and γ respectively denote the conditional variance at time and the shape parameter of the innovation distribution while Γ is the gamma function. θ is the vector of the parameters that have to be estimated for the conditional mean, conditional variance and density function. X' is the conditional mean and r is the tail thickness. The normal distribution is asymmetric around the mean and assumes there equal probability of observations falling on either side. The Generalized error distribution is useful when the errors in the tails are of special interest. The Student-t distribution takes on a similar shape as that of the normal distribution, i.e. it is bell-shaped, but has heavier tails. What this tells us is that random variables generated under this assumption have a higher chance of generating values which fall far from the mean (Enders, 2010).

CHAPTER FOUR

4. EMPIRICAL RESULTS AND ANALYSIS

This section begins with the discussion on the historical volatility model. The three parametric assumptions made in running the regressions are Gaussian, Student-t and GED distribution and the results are presented in that order. The discussion commences with the results noted using the Gaussian distribution assumption and the implications of the results are expanded upon. From the stepwise regression procedure we got two models – based on the backward and forward selection process – which interchange gold and the FRA as variables, each of these is discussed separately. In interpreting the results from the regression, the writer has taken into account the size of the coefficient. This value tells us how responsive volatility in the government bond yield is to a change in an independent variable. Each variable's coefficient is considered on its own, and the results are compared between the two models employed (one with FRA and other with gold). In interpreting the overall model fit, the writer considers the R^2 which tells us what explanatory power the variables combined have on the government bond yield. The comparison of the distribution assumptions is made on one model only (gold), not both. Choice of which model between the one with gold and the FRA is indifferent as this is not expected to have a material impact on the outcome which tells us which distribution assumption has more predictive power. Results from the Correlogram of residuals, the Portmanteau test and the Bartlett test show that the model estimations are stable, and as such can be relied upon. The stability test results from the different distribution assumptions all point to model stability, as such the discussion is limited to that of the Gaussian distribution. Following the discussion on the results of the historical volatility model is a discussion on the volatility forecasting, which show that the Student-t based model with the FRA has the best predictive ability. The results from the regression are discussed below.

4.1.Historical Volatility Modelling

4.1.1. Gaussian Distribution Test Results

The writer considers statistical significance at 5% (95 confidence level) and makes an assessment on whether the coefficients (Coef.) are statistically significant or not by considering the p-value. The results in Table 5 below show us that changes in the USDZAR exchange rate, the CDS and the JP EMBI are statistically significant in explaining volatility in SAGB as the p-values are less than 0.05, whilst the FRA not statistically significant.

Table 5: Gaussian Distribution ARCH regression (FRA)

		Coef.	Std error	Z	P>z
SAGB	Cons	1,6979	0,5929	-2,86	0,004
HET	USDZAR	3,4313	0,5989	5,73	0,000
	FRA	0,0019	0,0031	0,6	0,548
	CDS	0,0302	0,0093	3,22	0,001
	JP EMBI	-0,02349	0,0061	-3,86	0,000
	Cons	3,7245	0,1634	22,79	0,000
ARCH					
Arch	L1	0,0788	0,2154	3,66	0,000
GARCH	L1	0,7101	0,0378	18,76	0,000

The writer interprets the relationship between the explanatory variables and the dependant variable by considering the coefficient (Coef.), with guidance taken from Gadanecz et al. (2014). The article interprets the coefficient in the following manner: a coefficient of 1 means that a 100 basis point change in an explanatory variable will lead to a 100 basis point change in the volatility of the dependant variable. The results in Table 5 show us that a 100 basis point change in the USDZAR leads to a 343 basis point change to the volatility of SAGB, whilst a 100 basis point change in the CDS and JP EMBI lead to a 3 basis point change and a 2.35 basis point change in opposite direction, respectively, in the volatility of SAGB. As noted in the summary table of the explanatory variables, an increase in the JP Morgan EMBI is reflective of increased investor risk appetite. As investor risk appetite increases, the volatility in SAGB reduces, hence the coefficient in the table is negative. Based on these observations, the writer concludes that all variables, other than the FRA, in the model are statistically significant. The USDZAR result of 343 certainly shows that a change in this variable has the most significant explanation of volatility in SAGB yields.

The significance of the USDZAR exchange rate is more when we consider the results of the model using gold as opposed to the FRA, as shown in Table 6 below. No specific reason has been observed for this. The model with gold as a variable shows that under the Gaussian distribution assumption, all the explanatory variables are statistically significant. A 100 basis point change to the USDZAR exchange rate results in a 374 basis point in the volatility of the SAGB, whilst a 100 basis point change in the price of gold leads to a 0.6 basis point in the volatility of SAGB. That of the CDS is 3.18 basis points whilst that of the JP EMBI is 2.14 basis points in the opposite direction. Given that the results in Table 6 show us that the change in the USDZAR exchange rate is the highest statistically significant variable, followed by that of the CDS, the implications of these two variables are discussed at length insofar as how this relates to the question this research attempts to answer, i.e. what are the drivers of SA bond yields in the short term. The results for the JP EMBI are also discussed further to explain the sign of the coefficient in more detail than what is noted in the previous paragraph.

Table 6: Gaussian Distribution ARCH regression (Gold)

		Coef.	Std error	Z	P>z
SAGB	Cons	-1,6387	0,5808	-2,82	0,005
HET	USDZAR	3,7429	0,5381	6,96	0,000
	GOLD	0,0061	0,0034	1,75	0,080
	CDS	0,0318	0,0091	3,53	0,000
	JP EMBI	-0,0244	0,0061	-3,98	0,000
	Cons	3,6769	0,1615	22,77	0,000
ARCH					
Arch	L1	0,0808	0,0194	4,16	0,000
GARCH	L1	0,7125	0,0366	19,46	0,000

4.1.2. Comparison of the Three Distributions

The software package used in this analysis uses the Gaussian distribution as the default parametric assumption. Three distribution assumptions have been made and GARCH estimated accordingly and, overall, the same conclusion is arrived at across the three assumptions (Gaussian, Student-t and GED) insofar as the statistical significance of the variables is concerned. All three assumptions show that all the explanatory variables have a statistically significant effect in explaining volatility in the government bond yield, with the exception of the forward rate agreement.

The R^2 is used to assess the extent of the overall model fit and to quantify which model is more robust. Based on this, the Student-t distribution assumption on the model with gold as one of the explanatory variables yields the highest R^2 (61.8%), followed by Gaussian distribution at 57% and GED distribution is at 52% (Table 7 below). As per academic literature, financial time series data exhibit fat-tails and are leptokurtic in nature (Mandelbrot, 1963). The Student-t distribution is thus acknowledged as being the most appropriate parametric assumption to capture this property (Kosapattarapim, 2013). It is thus not surprising that it has shown up as being the model with the highest explanatory power. The lower explanatory power of the GED when compared to the Gaussian show that it is more suited to the analysis of errors in the tail of the distribution, which is more likely to be the case during a crisis period (Enders, 2010). It is thus not surprising that its' predictive power is less than that of the Gaussian as the study period would have had much more observations falling outside the tail of the distribution than inside. The absolute value coefficients, as shown in Table 7, under the Student-t distribution also show that this assumption is able to explain more of the movements in the dependant variable as a result of a change in each of the independent variables. As per Gadanecz et al. (2014), if their interpretation of the coefficients is taken as correct, then a model which shows higher coefficients must then have better explanatory power.

Table 7: Comparison of the three distributions Assumptions- Gold model

Distribution Assumption:	Gaussian		Student t		GED	
VARIABLES	mean	HET	mean	HET	Mean	HET
USDZAR		3.7430***		4.2040***		3.8690***
Gold		0.0060*		0.0122**		0.0083*
CDS		0.0318***		0.0380***		0.0342***
JP EMBI		-0.0244***		-0.0263***		-0.0254***
L.arch		0.0808***		0.1570***		0.1160***
L.garch		0.7120***		0.7430***		0.7130***
Constant	-1.639***	3.6770***	-0.940*	2.7810***	-1.03200*	3.4210***
Observations	731	731	731	731	731	731
R^2		57%		61.8%		52%

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

From this it is evident that the volatility in the SAGB yield is thus better explained by the Student-t distribution than the Gaussian. It further confirms that the risk to upward pressure in volatility to bond yields is higher than what conventional Gaussian models would suggest. To this end, any risk management procedures in managing and forecasting debt service costs by government should take this into account. Notwithstanding the better performance of the Student-T distribution model when compared to the other two, they are all good predictors in their own right given their relatively high R^2.

4.1.3. Gaussian Distribution Stability Tests

A Correlogram of the residuals can be used to test for serial correlation and as such the robustness of the model. The stability tests for the Gaussian distribution and the alternative parametric assumptions employed show the exact same results, as such only those which pertain to the Gaussian distribution are discussed.

Table 8: Correlogram of Residuals

LAG	AC	PAC	Q	PROB>Q
1	0.0084	0.0084	0.5936	0.8075
2	0.0421	0.0421	1.5465	0.4615
3	-0.0143	-0.0151	1.7187	0.6328
4	-0.0635	-0.0664	5.1176	0.2754

As shown in Table 8 above, given that Prob.> Q on the very first lag (and all others lags thereafter) is greater than 0.05, we fail to reject the null hypothesis of no serial correlation and conclude that the residuals are indeed not serially correlated and our results are therefore robust. Further to the correlation of residuals, the Portmanteau test for white noise was conducted to check for robustness of the model.

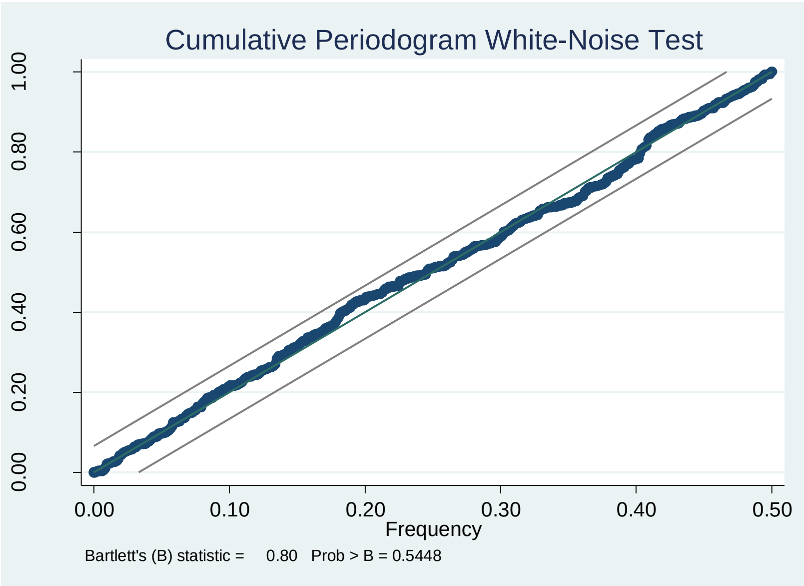
Table 9: Portmanteau test for white noise

Portmanteau (Q) statistic	43.5127
Prob>Chi2(40)	0.3242

As shown in Table 9, the p-value of 0.342 > 0.05 is not statistically significant, therefore we fail to reject the null hypothesis and conclude that there is no serial correlation. Therefore, the model is stable and robust. The Bartlett's test is based on the same hypothesis as Portmanteau test, and has a p-value of 0.5448> 0.05, therefore we fail to reject the null hypothesis of no serial correlation. Further, the visualisation of the test is displayed and if the residuals are within the boundaries - along the line of best fit - there is no serial correlation.

Figure 2 below shows that the residuals are within the boundaries therefore we conclude that there is no serial correlation, normality in residuals is achieved.

Figure 2: Cumulative Periodogram White-Noise Test



4.1.4. Implications of the Test Results

4.1.4.1. USDZAR exchange rate

The results on the statistical significance of the USDZAR exchange rate are consistent with that of Gadanecz et al. (2014), which noted that as exchange rate volatility increases, investors require higher yield compensation for holding emerging market local currency debt. This happens because the hard currency (US dollar) value of investors' investments will equally be volatile, with rapid depreciations to the local currency reducing the hard currency value of the investments. In such a scenario, a possible appreciation in the value of local currency debt when compared to other markets could be negated by currency depreciation, resulting in the reported hard currency values declining. Whilst international investors may hedge the currency risk inherent with investing in emerging market local currency debt, increases in volatility of the exchange rate will increase the costs associated with such hedging activities. This is because the cost of the call or put options is highly dependent on the underlying volatility (Hull, 2012). These point to the important influence that changes to the exchange rate have on local currency bond yield volatility in emerging markets, which relates directly to the question this research attempts to answer on the factors which drive volatility in the SAGB.

Given the highly speculative and volatile nature of the USDZAR exchange rate (Bishop, 2016), any systematic events which may lead to excessive changes in the currency will transmit through to volatility of SAGB. This has two important implications for policy-making institutions such as the National Treasury of South Africa and the South African Reserve Bank because there are two channels through which changes to the exchange rate will impact bond yields, both of which will impact in the same direction, thus compounding the effect.

As we have noted in previous sections, governments borrow money from the capital markets, the cost of which is determined by the yields at which the borrowing instruments trade. If the US Fed is more aggressive in its' monetary policy tightening cycle, the USDZAR exchange rate will be vulnerable to depreciation shocks (Bishop, 2016). The significant impact of the exchange rate (USDZAR) variable seen in Table 5 and Table 6 of this research shows that a currency depreciation shock will lead to higher volatility in the government bond yield in the same direction, resulting in a weakening of bond yields and increased borrowing costs for future debt. This impact of the USDZAR variable shows that the risks/volatility to the debt service costs of the R729 billion to be issued over the medium term may be significantly impacted by the exchange rate. Given that the SA government spends 13.1 cents in every rand to service debt costs, any increase to debt service costs as a result excessive changes to the exchange rate may lead to questions on the sustainability of the fiscus and risks of a sovereign downgrade or partial debt default (South African Reserve Bank, 2016).

The significant impact of the exchange rate (USDZAR) variable seen in Table 5 and Table 6 is that excessive fluctuations to the exchange rate may lead to higher inflation expectations (South African Reserve Bank, 2016). Higher inflation expectations will, in turn, impact bond yields negatively in two ways, the first being that higher inflation expectations will lead to investors requiring a higher risk premium to compensate for the expected reduction in the real value of their investments, placing upward pressure on government bond yields (Chun, 2005). Secondly, the South African Reserve Bank would likely find itself under pressure to contain inflation expectations as a result of the weaker currency, as such would be forced to tighten monetary policy in the domestic economy (South African Reserve Bank, 2016). Because there is an positive relationship between government bond yields and interest rates (Luenberger, 1998), any increase to interest rates by the central bank will add to further upward pressure to government bond yields.

4.1.4.2. The CDS spread

The writer notes and acknowledges that whilst the changes of all the variables in the model, other than the FRA, have a statistically significant impact on the volatility of the SAGB, he is somewhat surprised by the relatively muted strength of the relationship between the volatility in the CDS on that of the SAGB, with a 100 basis point change in the CDS leading to a 3.18 basis point in the volatility of the SAGB. As noted in the literature review section, Li and Huang (2011) find that the CDS market has become better than the bond market at measuring issuer credit risk, wherein the articles argues that the level of information content in the CDS spread is better than what is contained in the yield itself. Fontana and Scheicher (2010) find that factors which drive how credit risk is priced in the CDS market are very similar to those which drive how it is priced in the bond market. Hull, Predescu and White (2003) find that the historical relationship between the bond and the CDS market is stable, and that the yield on the 10 year benchmark sovereign is 10 basis points lower than that of the CDS spread.

Palladini and Portes (2011) findings suggest that bond and CDS prices should equal one another on a fair value basis when markets are in equilibrium.

Given the literature which clearly finds that these two variables have a close relationship to the extent that the CDS spread is often proxied for bond yields, especially in less liquid capital markets, the writer is unclear as to why a 100 basis point change in the CDS will only lead to a 3 basis point change in the volatility of the underlying bond yield. Perhaps this could be answered by a finding in Celic (2012) that when volatility increases as a result of a financial crisis, CDS spreads do tend to deviate from their implied fair value levels when benchmarked against underlying bonds. The article further finds that during such times of financial distress, investors will tend to trade in bonds more than in CDS markets as they are more real and not synthetic. Whilst statistically significant, changes to the CDS will not give us as significant economic information on the likely changes to volatility of the SAGB when, for instance, compared to the USDZAR exchange rate. It is very likely that the USDZAR variable suppresses that of the CDS, and perhaps the CDS would show up as having a higher coefficient when considered on its own.

4.1.4.3. JP Morgan EMBI

As shown in the results in Tables 5 and 6, changes to the JP Morgan EMBI has a statistically significant relationship to the volatility in the SAGB. This discussion will focus on the negative direction of this relationship. The EMBI is described earlier in this study as being an index which tracks total returns earned by a basket of emerging market bonds. It is noted that strong performance of the index (appreciation) gives signal of strong investor demand for emerging market debt. As noted in Ferucci (2003), as investor risk appetite increases, investors demand more emerging market assets. The negative sign of the coefficient is thus consistent with literature. What this tells us is that as investor risk appetite increases, the volatility in SAGB reduces, likewise when investor risk appetite reduces, volatility in SAGB increases. Evidence of this is seen in the increased volatility of emerging market debt when the US Fed announced for the first time its intention to taper down its quantitative easing programme, which caused a sharp increase to global risk aversion and a decline to the EMBI (Gadanecz, Miyajima and Shu, 2014).

4.2. Volatility Forecasting Model

After estimating the GARCH models, forecasting of volatility of the 10-year bond returns is done. The one-step ahead forecasts of the sa10yr are obtained from:

$$sa10yr_{t+1} = f(sa10yr_t | ב_t) \quad (7)$$

Where t+1 represent one week ahead; $ב_t$ is the information set at time t obtained from the control variables we have in the model. This gives us:

$$sa10yr_{t+1} = \alpha + \beta_0 sa10yr_t + \beta_1 USDZAR_t + \beta_2 FRA_t + \beta_3 CDS_t + \beta_4 JPEMBIi_t + \varepsilon_{t+1} (8)$$

The accuracy of the forecasts is then evaluated based on two metrics, namely the Root Mean Square Error (RMSE) and the Mean Absolute Error (MAE). The MSE and MAE are the most widely used statistical loss functions for evaluating the forecasting performance of models due to their simple mathematical structures. The sample contains 836 observations (weeks) between 6 January 2014 and 11 January 2016.

Table 10 below reports the out-of-sample volatility forecasting performance based on the error statistics values MSE and the MAE. The best and most accurate model for volatility forecasting possess the lowest error statistics values and in this case it was the one with the FRA.

Table 10: Volatility forecasting performance

Loss Function	Gold Model			FRA Model		
	Gaussian	Student t	GED	Gaussian	Student t	GED

RMSE	15.3	15.7	15.5	14.3	12.1	13.6
MAE	9.9	10.3	10.1	9.1	7.8	8.7
Ranking of Models	4^{th}	6^{th}	5^{th}	3^{rd}	1^{st}	2^{nd}

It is worthwhile to note however that both models exhibit relatively accurate forecasting power based on the low RMSE and MAE values that are below 20 per cent overall. The MAE show by what percentage are the forecasts wrong, values of below 10 per cent are preferred. This means that the out-of-sample forecasts of the models are close to the actual values (Chai & Draxter, 2014). It is concluded that the model with FRA outperforms the gold one with the student t distribution assumption yielding the best results followed by Generalised Error and then Gaussian. Given the results of the forecasting performance in Table 10, this can be used by policymakers to effectively model the forward trajectory of the volatility of the bond yield. Making use of this will allow authorities to run stress test scenarios on the exchange rate, given that it has the most significant influence on volatility in the bond yield. This will lead to useful insight on how big a shock to the exchange rate can be absorbed before risks of a partial or full sovereign default occurs. The out-of-sample forecasting performance of each model is shown in the figures below. The graphs depict actual observation of sa10yr alongside the forecast values (out-of–sample discussed above) derived from forecasting based under the three different distribution assumptions, showing that they are indeed good model fits. The graphs are displayed in the appendix.

CHAPTER FIVE

5. CONCLUSION

The study examines data between January 2000 and December 2015, with Bloomberg being the only source of data. The possible explanatory variables used in the study are as follows: non-SA resident net bond purchases; Chicago Board Options Volatility Index, JP Morgan Emerging Market Bond Index spread and the USDZAR exchange rate, the SA 5 year credit default swap rate; and 12 month interest rate expectations/9x12 forward rate agreement, dollar spot price of gold and dollar spot price of oil. These variables are grouped according to global factors which have been found in literature to be significant drivers of sovereign bond yields, namely: global liquidity, global risk appetite, the sovereign credit profile and market expectations.

The writer begins by noting that existing literature on the determinants of sovereign bond yields in the long run are driven by fundamental macroeconomic and fiscal policy factors. In the short run, however, this trend has been found to breakdown as a result of market stress. Evidence points to global funding conditions taking a more prominent role in determining sovereign bond yields in the short run (Poghosyan, 2012).

The GARCH framework is employed in this process due to its ability to capture the volatility clustering effects of financial time series data by allowing the variance in the error term to change over time (Bollerslev, 1986), in order to address the heavy-tailed and leptokurtic nature of financial market return data found by Enders (2010), the writer made use of three different distribution assumptions: the Gaussian (normal), the Student-T and the Generalised Error distributions to test which contains better estimation abilities.

The first key result is that the exchange rate has the most explanatory power of the variables chosen in the study. The model with gold showed that all variables are statistically significant, whilst that with the forward rate agreement showed that this variable is not statistically significant. Whilst the majority of the explanatory variables are statistically significant, the exchange rate and the CDS are the most statistically significant variables, as the values of the coefficients of the other variables suggest they do not impact bond yields in any meaningful manner. It is noted that the co-efficient of the CDS is significantly less than that of the USDZAR exchange rate. The reasons behind this have not been investigated as this would require a separate study on its own. It could be that the exchange rate duly captures the effect that volatility in portfolio flows and the CDS, for instance, has on volatility to the SA bond yield, and as such suppresses the co-efficient sizes of these variables. Whilst it is expected that the exchange rate volatility would have a statistically significant impact on bond yield volatility, it was not entirely expected that the other variables would have such small co-efficient sizes, especially the CDS.

These results are noted as having important implications for the managing of debt service costs of government debt, which are directly determined by volatility in the bond yields. The first of these is that any factor which has a significant impact on the exchange rate will have a significant impact on the volatility of the SAGB. Public debt managers can use the results to model what the changes in global funding conditions which impact the currency specifically could have on government bond yields, with global dollar liquidity being one such factor. This allows debt managers to run specific scenarios to ascertain what impact a change in any of these variables will have on the volatility in bond yields, which could be aggregated to measure the overall impact.

The biggest risk factor noted is the normalization of interest rates by the US Fed, which is likely to cause a reduction in global liquidity, which in turn will cause a shortage of dollars in the global financial system, and as such an appreciation of the US dollar. A strengthening of the US dollar will by definition lead to a weakening of the USDZAR exchange rate. Whilst financial markets have priced in expectations of interest rate increases, any upward surprises by the Fed could lead to substantially increased volatility in global markets. Given these results, policymakers can run stress tests on the currency to ascertain what magnitude a move in this variable can be withstood before bond yields, and as such debt service costs, pose a risk to fiscal sustainability; higher volatility in the SAGB is likely to result in upward pressure in yields themselves due to the fat-tailed nature of the changes in financial data. Secondly, given that the volatility forecasting model has shown to be a reliable forecasting tool, this could be used by debt managers to forecast volatility in the generic government bond yield over a specified time period, and compare the results thereof to existing debt service costs forecast.

The comparison of the three distribution assumptions showed us results of the overall model predictive ability based on an $R^2$of 61.8 per cent for the Student-T, 57 per cent for the Gaussian and 52 per cent for the Generalised Error parametric distribution. This tells us that the Student-T distribution is the most appropriate parametric assumption to use when modeling financial time series as has been found in literature (Enders, 2010). In addition, the value of the coefficients, which have been used to evaluate the extent of a variables explanatory power on bond yield volatility as per Gadanecz et al. (2014), further show that the Student-T distribution has the most explanatory power of the variables. Broadly speaking, all three distribution assumptions showed that they are good predictors in explaining volatility in the generic government bond yield in their own right when judged by their respectiveR^2.

The results from the volatility forecasting model show us that based on the results of the Mean Square Error and Mean Absolute Error with an upper limit of 20 per cent, the Student-T model with the FRA as one of the explanatory variables more accurately forecasts volatility in the bond yield. The question of why the exchange rate has by far the largest co-efficient is something which can potentially be explored further as this result was unexpected.

References

Abdullah, A., & Bakar, M. J. (2015). The Application of Gold Price, Interest Rates and Inflation Expectations in Capital Markets. *International Journal of Economics and Finance 7 (2)* , 293 - 302.

Alekneviciute, E. (2016). Global Factors Influencing Government Bond Market Co-movements. *Science and Studies of Accounting and Finance: Problems and Perspectives 10 (1)* , 1 - 7.

Al-Najjar, D. (2016). Modeling and Estimation of Volatility using ARCH/GARCH Models in Jordan's Stock Market. *Asian Journal of Finance and Accounting 8 (1)* , 152 - 167.

Altavilla, C., Giacomini, R., & Costantini, R. (2013). *Bond Returns and Market Expectations.* London: Centre for Micrdata Methods and Practice Working Paper CWP20/13.

Ananchotikul, N., & Zhang, L. (2014). *Portfolio Flows, Global Risk Aversion and Asset Prices in Emerging Markets.* Washington DC: International Monetary Fund Working Paper WP/14/156.

Arslanalp, S., & Tsuda, T. (2014). *Tracking Global Demand for Emerging Market Sovereign Debt.* Washington DC: International Monetary Fund Working Paper WP/14/39.

Baek, I.-M., Bandopadhyaya, A., & Du, C. (2005). Determinants of Market-Assessed Sovereign Risk: Economic Fundamentals or Market Risk Appetite? *Journal of International Money and Finance 24 (4)* , 533-548.

Bardhan, A., & Jaffe, D. (2007). *The Impact of Global Capital Flows and Foreign Financing on US Mortgage and Treasury Interest Rates.* Washington DC: Research Institute for Housing America.

BBVA Research. (2015, June 30). Global Risk Aversion, Fed Rates and Emerging Markets: US Growth and Local Vulerabilities. *Global Economic Outlook* .

Bella, D., Papaioannou, M., & Petrova, I. (2010). *Determinants of Emerging market Sovereign Bond Spreads: Fundamentals vs Financial Stress.* Washington DC: International Monetary Fund Working Paper WP/10/281.

Beltran, D., Kretchmer, M., Marquez, J., & Thomas, C. (2012). *Foreign Holdings of US Treasuries and US Treasury Yields.* Washington DC: Board of Governors of the Federal Reserve System.

Bishop, A. (2016). *Rand Outlook: Running in the down case of an intensifying commodity slump, rising expectations of rapid, sharp domestic interest rate hikes and rating downgrades; and global risk-off behaviour.* Johannesburg: Investec Bank Limited.

Bollerslev, T. (1986). Generalised Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics 31* , 307 - 327.

Caceres, C., Guzzo, V., & Segoviano, M. (2010). *Sovereign Spreads: Global Risk Aversion, Contagion or Fundamentals?* Washington DC: International Monetary Fund Working Paper WP/10/120.

Carvalho, D., & Fidora, M. (2015). *Capital Inflows and Euro Area Long-Term Interest Rates.* Frankfurt: European Central Bank Working Paper Series WPS1798.

Celic, M. (2012). *The Empirical Relationship between CDS Prices and Bond Yields after the Financial Crisis.* Copenhagen: Copenhagen Business School.

Chai, T., & Draxter, R. (2014). Root Mean Square Error (RMSE) or Mean Absolute Error (MAE)? Arguments against avoiding RMSE in the Literature. *Geoscientific Model Development 7* , 1247 - 1250.

Christensen, J., Lopez, J., & Rudenbusch, G. (2010). Inflation Expectations and Risk Premiums in an Arbitrage Free Model of Nominal and Real Bond Yields. *Journal of Money, Credit and Banking* , 143 - 178.

Chun, A. L. (2005). *Expectations, Bond Yields and Monetary Policy.* Stanford: Stanford Institute for Economic Policy Research.

Claudia-Florinana, B. (2008). *Determinants of Spreads on Romanian Sovereign Bonds.* Bucharest: The Academy of Economic Studies - Dcotoral School of Finance and Banking.

Coulson, N., & Robins, R. (1985). Aggregate Economic Activity and the Variance of Inflation: Another Look. *Economics Letters 17* , 71 - 75.

Crump, R., Eusepi, S., & Moench, E. (2016). *The Term Structure of Expectations and Bond Yields.* New York: Federal Reserve Bank of New York Staff Report no. 775.

Csonto, B. (2014). Emerging Market Sovereign Bond Spreads and Shifts in Global Market Sentiment . *Emerging Markets Review 20* , 58 - 74.

Culha, O., Ozatay, F., & Sahinbeyoglu, G. (2006). *The Determinants of Sovereign Spreads in Emerging Markets.* Ankara: The Central Bank of the Republic of Turkey Working Paper no.06/04.

De Nicolo, G., & Ivaschenko, I. (2009). *Global Liquidity, Risk Premiums and Growth Opportunities.* Washington DC: International Monetary Fund Working Paper WP/09/52.

Domowitz, I., & Hakkio, C. (1985). Conditional Variance and the Risk Premium in the Foreign Exchange Market. *Journal of International Economics 19* , 47 - 66.

Enders. (2010). Applied Econometric Time Series. In Enders, *Applied Econometric Time Series* (p. 123). Hoboken: John Wiley & Sons.

Enders, W. (2010). Applied Econometric Time Series. In W. Enders, *Applied Econometric Time Series* (pp. 157-158). Hoboken: John Wiley & Sons, Inc.

Engle, R. (1982). Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of UK Inflation. *Econometrica 50* , 987 - 1008.

Engle, R. (1983). Estimates of the Variance of US Inflation based on the ARCH Model. *Journal of Money, Credit and Banking 15* , 286 - 301.

Engle, R. (1983). Estimates of the Variance of US Inflation based on the ARCH Model. *Journal of Money, Credit and Banking 15* , 286 - 301.

Engle, R., Lilien, D., & Robins, R. (1985). *Estimation of Time Varying Risk Premiums in the Term Structure.* San Diego: University of Carlifornia Discussion Paper 85 - 17.

Feri Euro Rating Services. (2015, March). Sovereign Rating - Rating Methodology. *Country Credit Rating* .

Ferucci, G. (2003). *Empirical Determinants of Emerging Market Economies' Sovereign Bond Spreads.* London: Bank of England Working Paper 205.

Feyen, E., Ghosh, S., Kibuuka, K., & Farazi, S. (2015). *Globa lLiquidity and External Bond Issuance in Emerging Markets and Developing Economies.* Washington DC: World Bank Group Policy Research Working Paper WPS7363.

Fontana, A., & Scheicher, m. (2010). *An Analysis of Euro Area Sovereign CDS and their Relation with Government Bonds.* Frankfurt: European Central Bank Working Paper Series no.1271.

Gadanecz, B., Miyajima, K., & Shu, C. (2014). *Exchange Rate Risk and Local Currency Sovereign Bond Yields in Emerging Markets.* Basel: Bank for Interntaional Settlements Working Paper no. 474.

Garcia-Herrero, A., & Ortiz, A. (2005). *The Role Of Global Risk Aversion In Explaining Latin American Sovereign Spreads.* Madrid: Banco De Espana Documentos de Trabajo no. 0505.

Garita, J., & Leon, J. (2015). *Sovereign Risk: Global and Local Factors.* San Jose: Banco Central De Costa Rica.

Gokcan, S. (2000). Forecasting Volatility of Emerging Stock Markets: Linear versus Non-linear GARCH models. *Journal of Forecasting 19* , 499 - 504.

Hartelius, K., Kashiwase, K., & Kodres, L. (2008). *Emerging Market Spread Compression: Is It Real or Is It Liquidity.* Washington DC: International Monetary Fund Working Paper WP/08/10.

Herrmann, F. (2016). *Risk Aversion, Macro Factors and non-Fundamental Components in Euro Area Yield Spreads: A Macro-Financial Analysis.* Dortmund: TU Dortmund University.

Hovath, D., Kalman, P., Kocsis, Z., & Ligeti, I. (2014). *Short-Rate Expectations and Term Premia: Experiences from Hungary and other Emerging Market Economies.* Basel: Bank for International Settlements Paper no. 78.

Hull, J. (2012). *Options, Futures and Other Derivatives 8th Edition.* Essex: Pearson Education Limited.

Hull, J., Predescu, M., & White, A. (2003). *The Relationship Between Credit Default Swap Spreads, Bond Yields and Credit Rating Announcements.* Toronto: University of Toronto.

Jaramillo, L., & Tejada, C. (2011). *Sovereign Credit Ratings and Spreads in Emerging Markets: Does Investment Grade Matter?* Washington DC: International Monetary Fund Working Paper WP/11/44.

Jiang, W. (2012). *Using the GARCH Model to Analyse and Predict the Different Stock Markets.* Uppsala: Uppsala University Department of Statistics.

Johnsson, T. (1992). A Procedure for Stepwise Regression Analysis. *Statistical Papers 33 (1)* , 21 - 29.

Kang, W., Ratti, R., & Yoon, K. (2014). *The Impact of Oil Price Shocks on US Bond Market Returns.* Canberra: Centre for Applied Macroeconomic Analysis Working Paper 33/2014.

Kosapattarapim, C. (2013). *Improving Volatility Forecasting of GARCH Models: Applications to Daily Returns in Emerging Stock Markets.* Wollongong: University of Wollongong.

Kraft, D., & Engle, R. (1983). *Multi-Period Forecast Error Variances of Inflation Estimated from ARCH Models.* Washington DC: Bureau of the Census: Applied Time Series Analysis of Economic Data.

Krishnamurthy, A., & Vissing-Jorgensen, A. (2011). *The Effects of Quantitative easing on Interest Rates.* Evanston: Kellog School of Management.

Kurniasih, A., & Restika, Y. (2015). The Influence of Macroeconomic Indicators and Foreign Ownership on Government Bond Yields: A Case of Indonesia. *Mediterranean Journal of Social Sciences 6 (5)* , 34-42.

Li, & Huang. (2011). Price Discovery Between Sovereign Credit Default Swaps and Bond Spreads of Emerging Markets. *Journal of Emerging Markets 10 (2)* , 197-225.

Lilien, D., Engle, R., & Robins, R. (1985). *Estimation of Time Varying Risk Premiums in the Term Structure.* San Diego: University of Carlifornia Discussion Paper 85 - 17.

Luenberger, D. (1998). *Investment Science.* New York: Oxford University Press.

Malliaropulos, D., & Migiakis, P. (2016). *The Re-Pricing of Sovereign Risks Following the Global Financial Crisis.* Athens: Bank of Greece.

Mandelbrot, B. (1963). The Variation of Certain Speculative Prices. *Journal of Business 36* , 394 - 419.

Margaretic, P. (2008). *A Microfounded Decomposition of Emerging Markets Sovereign Bond Spreads.* Toulouse: University of Toulouse.

Mpofu, R., De Beer, J., Nortje, A., & Van De Venter, T. (2010). *Investment Management 3rd Edition.* Pretoria: Van Schaik Publishers.

Naidu, S., Goyari, P., & Kamaiah, B. (2016). Determinants of Sovereign Bond Yields in Emerging Market Economies: Some Panel Inferences. *Theoretical and Applied Economics 3 (608)* , 101 - 118.

National Treasury. (2017). *Budget Review* . Pretoria: National Treasury of South Africa.

Neely, C. (2015). How Much Do Oil Prices Affect Inflation? . *Economic Synopsis no.10* .

Palladini, G., & Portes, R. (2011). *The Information Content of Euro-area Sovereign CDS Spreads.* Unknown: European Commission Framework Programme for Research.

Petrova, I., Bellas, D., & Papaioannou, M. (2010). *Determinants of Emerging Market Sovereign Bond Spreads: Fundamentals or Financial Stress.* Washington DC: International Monetary Fund Working Paper WP/10/281 .

Poenisch, H. (2014). Global Liquidity and Impact of Capital Flows on Exchange Rate. *High Level Impact of Capital Flows on Exchange Rate in Emerging Asia.* Bandung, Indonesia.

Poghosyan, T. (2012). *Long-run and Short-run Determinants of Sovereign Bond Yields in Advanced Economies.* Washington DC: International MOnetary Fund Working Paper WP/12/271.

Robinson, Z. (2015). An Analysis of Sovereign Risk in South Africa with the Focus on Fiscal Determinants. *Southern African Business Review 19 (3)* , 154 - 173.

Rozada, M., & Yeyati, L. (2006). *Global Factors and Emerging Market Spreads* . Washington DC: Inter-American Development Bank Working Paper #552.

Sharifuddin, S. T., & Ling, L. P. (2014). *Flattening Yield Curve Amidst Rapid Inflows: The Malaysian Experience.* Kuala Lumpur: Bank of Negara.

Shiller, R., Campbell, J., & Schoenholtz. (1983). Forward Rates and Future Policy: Interpreting the Term Structure of Interest Rates. *Brookings Papers on Economic Activity* , 173-223.

Shim, I., & Zhu, H. (2010). *The Impact of CDS Trading on the Bond Market: Evidence from Asia.* Basel: Bank for International Settlements Working Paper no.332.

South African Reserve Bank. (2016). *Financial Stability Review.* Pretoria: South African Reserve Bank.

Sturmans, A. (2013). *The Impact of Credit Ratings on Sovereign Bond Yields.* Tilburg: Tilburg University.

Thupayagale, P., & Molalapata, I. (2012). Dynamic Co-movement and Correlations in Fixed Income Markets: Evidence from selected Emerging Market Bond Yields. *Investment Analysts Journal 76* , 25 - 38.

Vahamaa, S. (2004). *Option-Implied Asymmetries in Bond Market Expectations around Monetary Policy Actions of the ECB.* Frankfurt: European Central Bank Working Paper no. 315.

Warnock, F., & Warnock, V. (2005). *International Capital Flows and US Interest Rates.* Washington DC: Board of Governors of the Federal Reserve System International Finance Discussion Paper no.840.

Weigel, D., & Gemmill, G. (2006). What Drives Credit Risk in Emerging Markets? The Roles of Country Fundamentals and Market Co-Movements. *Journal of International Money and Finance 25* , 476-502.

Weiss, A. (1984). *Asymptotic Theory for ARCH Models: Stability, Estimation and Testing.* San Diego: University of Carlifornia Discussion Paper 82 - 36.

Xiong, W., & Yan, H. (2010). Heterogenous Expectations and Bond Markets. *The Review of Financial Studies 23 (4)* , 1433-1466.

Zakaria, S., & Abdalla, S. (2012). Modeling Stock Returns Volatility: Empirical Evidence from the Saudi Stock Exchange. *International Research Journal of Finance and Economics 85*, 166 - 179.

APPENDIX

Table 11: SAGB 10-year Augmented Dickey-Fuller test for unit root

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-12.914	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.sa10yr	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
sa10yr						
L1.	-.9892997	.0766043	-12.91	0.000	-1.139662	-.8389373
LD.	.0014744	.0677322	0.02	0.983	-.1314734	.1344223
L2D.	.0552603	.0588145	0.94	0.348	-.0601836	.1707043
L3D.	.0328286	.0487785	0.67	0.501	-.0629161	.1285734
L4D.	-.0405034	.035453	-1.14	0.254	-.1100923	.0290855
_trend	.0040091	.0027749	1.44	0.149	-.0014377	.0094559
_cons	-2.099197	1.344216	-1.56	0.119	-4.737687	.5392926

Table 12: JP Morgan EMBI Spread Augmented Dickey-Fuller test for unit root

Z(t)	-12.703	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.jpmembis~d	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
jpmembispr~d						
L1.	-1.008001	.0793486	-12.70	0.000	-1.16375	-.8522515
LD.	-.0487095	.0713282	-0.68	0.495	-.1887158	.0912968
L2D.	-.0262216	.0621419	-0.42	0.673	-.1481967	.0957534
L3D.	.0008684	.0506502	0.02	0.986	-.0985503	.1002871
L4D.	.0136818	.0347681	0.39	0.694	-.0545626	.0819262
_trend	.0018983	.0030008	0.63	0.527	-.0039919	.0077884
_cons	-.9544013	1.451713	-0.66	0.511	-3.803891	1.895089

Table 13: 5-year CDS Augmented Dickey-Fuller test for unit root

Z(t)	-12.548	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.zarcds	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
zarcds						
L1.	-1.12008	.0892607	-12.55	0.000	-1.295298	-.9448618
LD.	-.0084335	.0798414	-0.11	0.916	-.1651617	.1482948
L2D.	-.0949605	.0691757	-1.37	0.170	-.2307519	.0408309
L3D.	.0041303	.053973	0.08	0.939	-.1018184	.110079
L4D.	-.0027976	.0358641	-0.08	0.938	-.0731987	.0676035
_trend	.0025205	.0027803	0.91	0.365	-.0029372	.0079782
_cons	-.7969671	1.279159	-0.62	0.533	-3.307949	1.714015

Table 14: Gold Spot ($) Augmented Dickey-Fuller test for unit root

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-13.854	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.gold	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gold						
L1.	-1.126883	.0813384	-13.85	0.000	-1.286538	-.9672286
LD.	.1100756	.072452	1.52	0.129	-.0321365	.2522877
L2D.	.1124063	.0608312	1.85	0.065	-.006996	.2318086
L3D.	-.007379	.0496593	-0.15	0.882	-.1048527	.0900946
L4D.	.0590075	.0347956	1.70	0.090	-.0092909	.1273059
_trend	-.0029845	.0036701	-0.81	0.416	-.0101884	.0042194
_cons	2.327359	1.780248	1.31	0.191	-1.166995	5.821713

Table 15: Oil Spot ($) Augmented Dickey-Fuller test for unit root

Z(t)	-11.757	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.oil	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
oil						
L1.	-.8149262	.0693113	-11.76	0.000	-.9509736	-.6788788
LD.	-.12228	.0639968	-1.91	0.056	-.2478959	.003336
L2D.	-.0794714	.0570394	-1.39	0.164	-.191431	.0324882
L3D.	-.025437	.0478561	-0.53	0.595	-.1193712	.0684971
L4D.	.0332105	.0349211	0.95	0.342	-.0353343	.1017554
_trend	-.00054	.0004227	-1.28	0.202	-.0013696	.0002896
_cons	.2270125	.2042575	1.11	0.267	-.1739138	.6279387

Table 16: ZARUSD Exchange Rate Augmented Dickey-Fuller test for unit root

Z(t)	-11.767	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.zarusd	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
zarusd						
L1.	-.9448314	.0802942	-11.77	0.000	-1.102437	-.7872262
LD.	-.0414961	.0716622	-0.58	0.563	-.1821581	.0991659
L2D.	-.0772948	.0624322	-1.24	0.216	-.1998396	.04525
L3D.	-.0257442	.0502888	-0.51	0.609	-.1244535	.0729651
L4D.	-.0400171	.0357313	-1.12	0.263	-.1101522	.030118
_trend	.0000535	.0000299	1.79	0.074	-5.12e-06	.0001121
_cons	-.010401	.0143641	-0.72	0.469	-.0385956	.0177935

Table 17: VIX Augmented Dickey-Fuller test for unit root

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-13.649	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.vix	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
vix						
L1.	-1.348436	.0987956	-13.65	0.000	-1.542356	-1.154515
LD.	.0415218	.0876659	0.47	0.636	-.130553	.2135966
L2D.	-.004476	.0743356	-0.06	0.952	-.1503855	.1414334
L3D.	.0159447	.0574312	0.28	0.781	-.0967839	.1286733
L4D.	-.0014327	.0349408	-0.04	0.967	-.0700162	.0671507
_trend	.0000592	.0004713	0.13	0.900	-.0008658	.0009842
_cons	-.0249668	.2279412	-0.11	0.913	-.4723805	.4224469

Table 18: Net Foreign Bond PurchasesAugmented Dickey-Fuller test for unit root

Z(t)	-13.470	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.netbondp~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
netbondpur~s						
L1.	-1.099875	.081655	-13.47	0.000	-1.260151	-.9395986
LD.	.0789757	.0728137	1.08	0.278	-.0639465	.221898
L2D.	.044095	.0624418	0.71	0.480	-.0784687	.1666587
L3D.	.0227109	.0503234	0.45	0.652	-.0760662	.1214879
L4D.	.0329661	.03511	0.94	0.348	-.0359495	.1018817
_trend	.010253	.1788226	0.06	0.954	-.3407484	.3612544
_cons	-81.77208	86.73628	-0.94	0.346	-252.0221	88.47798

Table 19: Forward Rate Agreement Augmented Dickey-Fuller test for unit root

Z(t)	-15.718	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

D.fra9x121~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fra9x1212m~s						
L1.	-1.692519	.1076787	-15.72	0.000	-1.903876	-1.481162
LD.	.3992668	.0933239	4.28	0.000	.2160863	.5824472
L2D.	.2089239	.0765085	2.73	0.006	.0587495	.3590983
L3D.	.1088592	.0568449	1.92	0.056	-.0027187	.220437
L4D.	.0028339	.0348766	0.08	0.935	-.0656235	.0712914
_trend	.0042488	.0061314	0.69	0.489	-.0077861	.0162837
_cons	-2.404629	2.966768	-0.81	0.418	-8.227941	3.418684

Table 20: Gaussian Distribution ARCH regression (Gold)

sa10yr	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
SAGB						
_cons	-1.638765	.5807702	-2.82	0.005	-2.777054	-.5004769
HET						
USDZAR	3.742982	.538023	6.96	0.000	2.688476	4.797487
gold	.0060191	.0034367	1.75	0.080	-.0007167	.0127549
CDS	.0317811	.0090025	3.53	0.000	.0141366	.0494256
JP EMBI	-.0244116	.0061264	-3.98	0.000	-.0364192	-.0124041
_cons	3.676945	.1614841	22.77	0.000	3.360442	3.993448
ARCH						
arch						
L1.	.0808338	.0194148	4.16	0.000	.0427815	.1188861
garch						
L1.	.7124741	.0366045	19.46	0.000	.6407305	.7842177

Table 21: Student-T Distribution ARCH regression

SAGB	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
SAGB						
_cons	-.9404034	.5016864	-1.87	0.061	-1.923691	.0428838
HET						
USDZAR	4.20353	.7961523	5.28	0.000	2.6431	5.76396
gold	.0121942	.0056383	2.16	0.031	.0011434	.023245
CDS	.0379699	.0129335	2.94	0.003	.0126208	.063319
JP EMBI	-.0262567	.0099265	-2.65	0.008	-.0457123	-.0068011
_cons	2.781172	.264628	10.51	0.000	2.26251	3.299833
ARCH						
arch						
L1.	.157424	.0354931	4.44	0.000	.0878587	.2269892
garch						
L1.	.7426018	.0415302	17.88	0.000	.661204	.8239995

Table 22: Generalised Error Distribution ARCH regression

SAGB	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
SAGB						
_cons	-1.032481	.5299781	-1.95	0.051	-2.071219	.0062569
HET						
USDZAR	3.868594	.7302491	5.30	0.000	2.437332	5.299856
gold	.0083214	.0048726	1.71	0.088	-.0012287	.0178714
CDS	.0342212	.011817	2.90	0.004	.0110603	.0573821
JPEMBI	-.025351	.0082182	-3.08	0.002	-.0414583	-.0092436
_cons	3.421056	.2391265	14.31	0.000	2.952376	3.889735
ARCH						
arch						
L1.	.1164601	.0312647	3.72	0.000	.0551823	.1777379
garch						
L1.	.713397	.0502985	14.18	0.000	.6148138	.8119802

Model specification on Stata

The GARCH (1,1) estimations had the following set up in STATA software

Gold Model:

Gaussian (normal)

```
arch sa10yr, arch (1) garch(1) het(zarusdgoldzarcdsjpmembispread)
```

Student t-distribution

```
arch sa10yr, arch (1) garch(1) distribution (t 10)
het(zarusdgoldzarcdsjpmembispread)
```

GED Distribution

```
arch sa10yr, arch (1) garch(1) distribution (ged 1.5)
het(zarusdgoldzarcdsjpmembispread)
```

Fra Model:

Gaussian (normal)

```
arch sa10yr, arch (1) garch(1) het(zarusdfrazarcdsjpmembispread)
```

Student t-distribution

```
arch sa10yr, arch (1) garch(1) distribution (t 10)
het(zarusdfrazarcdsjpmembispread)
```

GED Distribution

```
arch sa10yr, arch (1) garch(1) distribution (ged 1.5)
het(zarusdfrazarcdsjpmembispread)
```

Figure 3: Gold Model Forecast- Gaussian distribution assumption

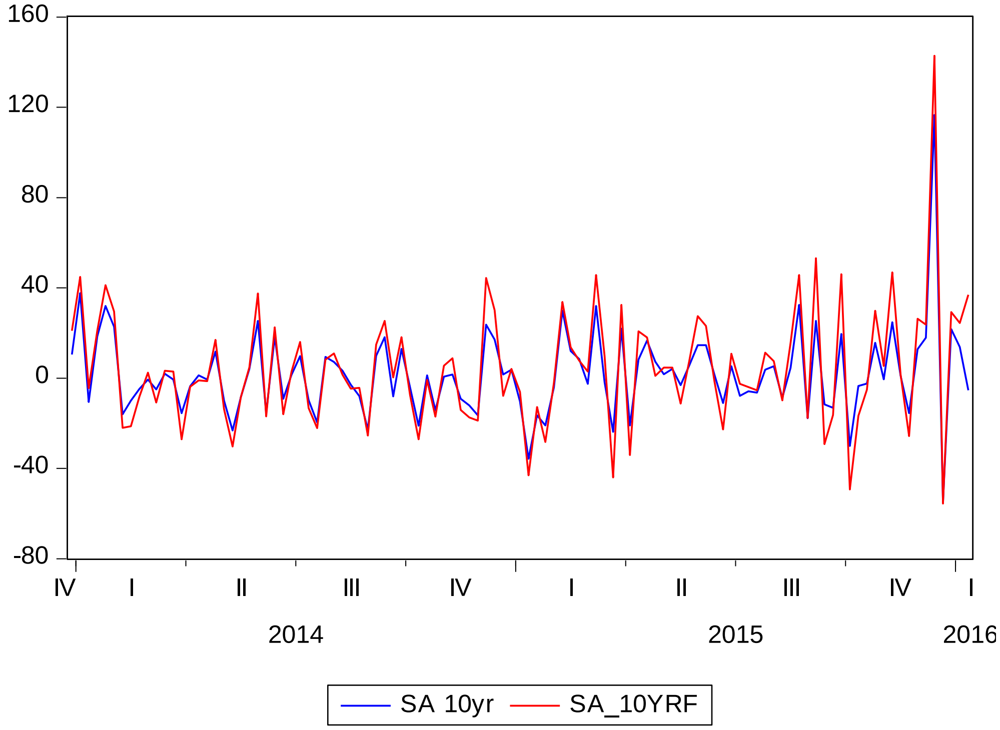


Figure 4: Gold Model Forecast- GED distribution assumption

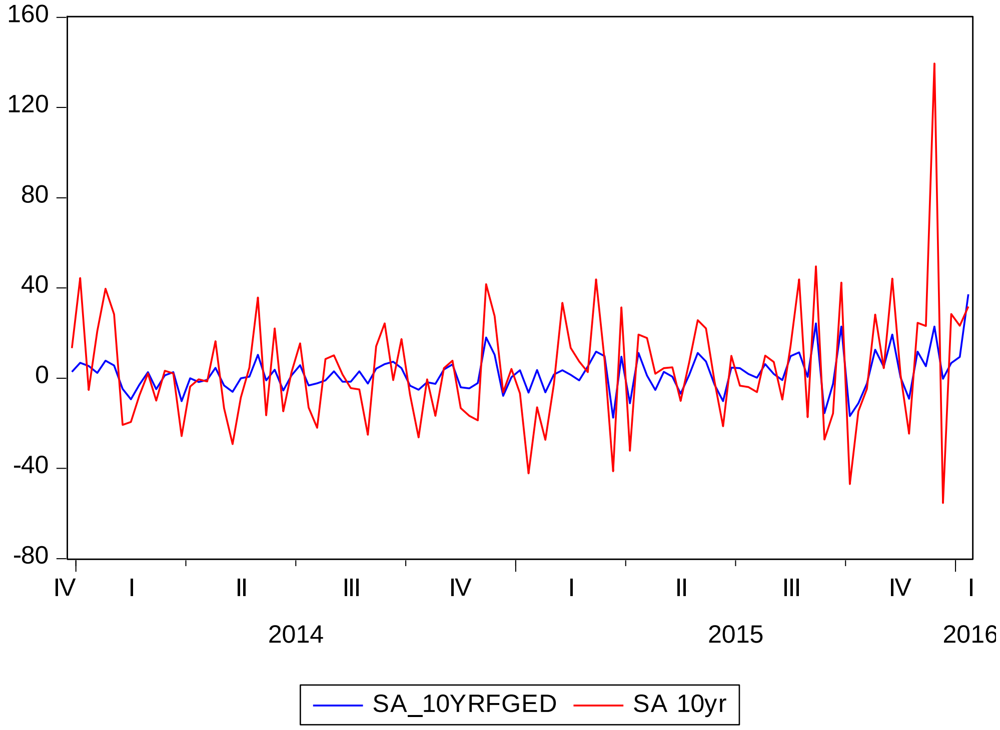


Figure 5: Gold Model Forecast- Student t-distribution assumption

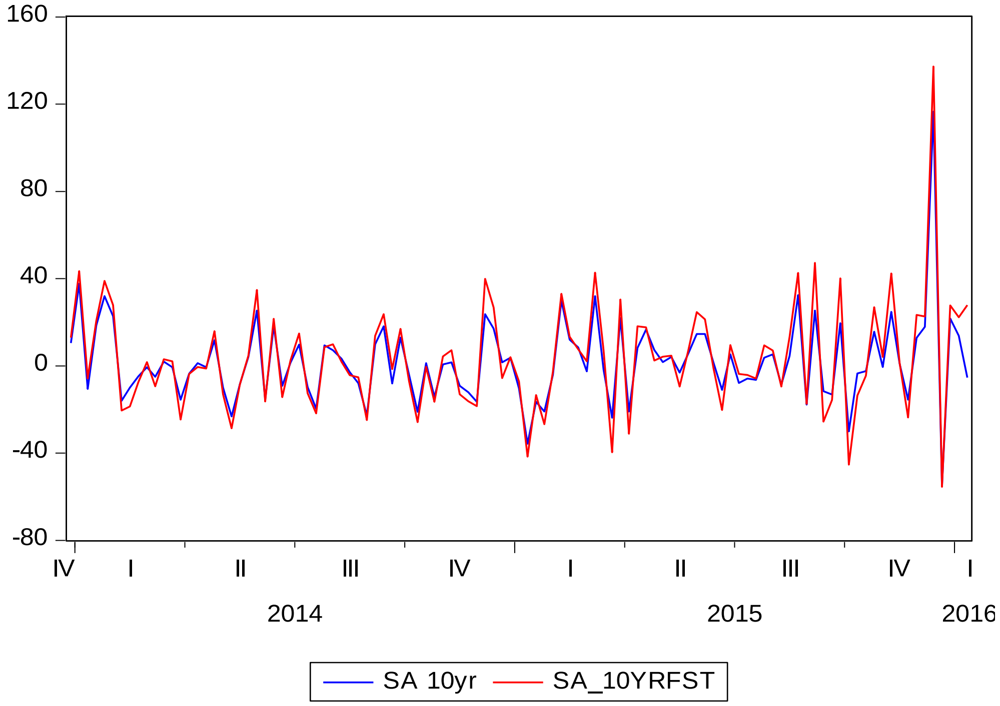


Figure 6: Fra Model Forecast- Gaussian Distribution Assumption

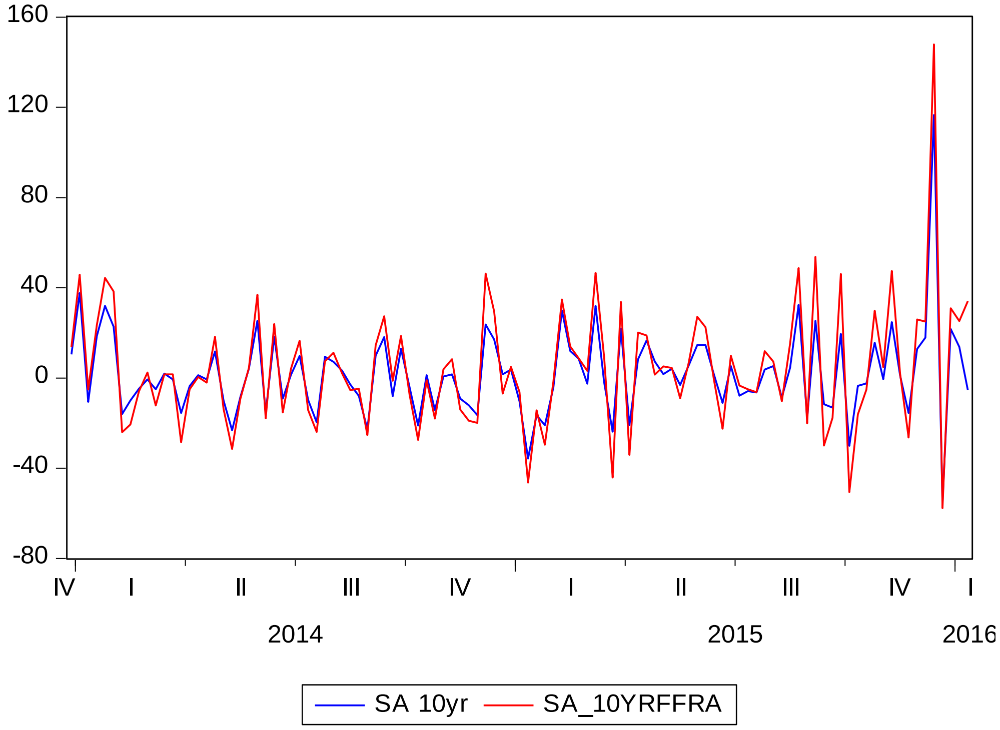


Figure 7: Fra Model Forecast- Student t-Distribution Assumption

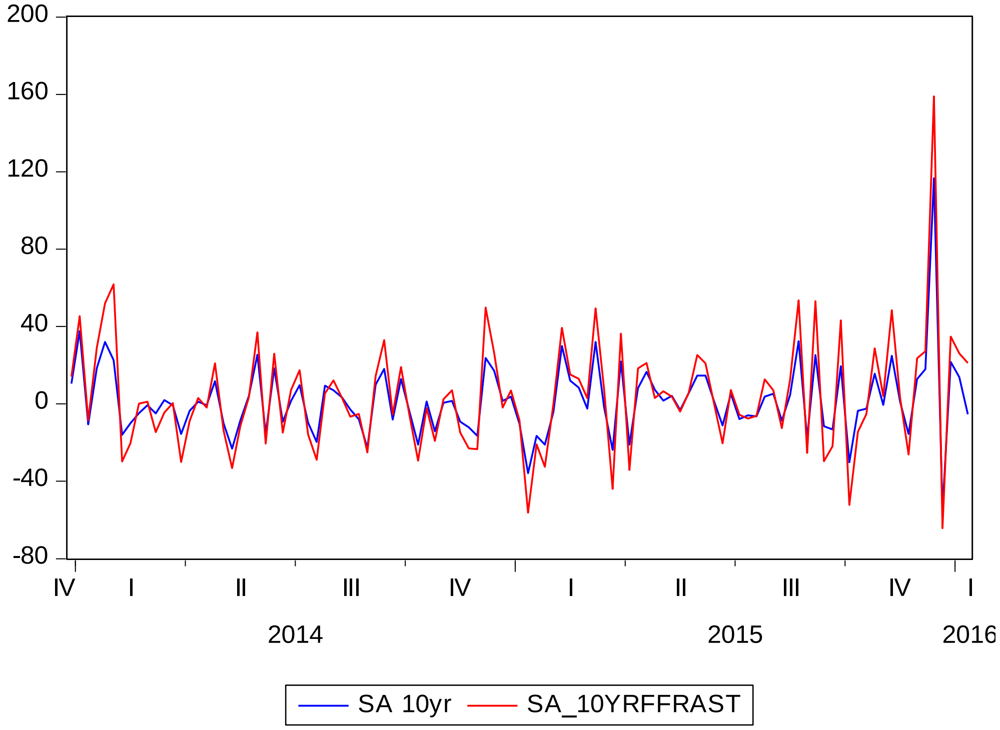


Figure 8: Fra Model Forecast- GED-Distribution Assumption