BOTSWANA'S BOND MARKET YIELDS: ARE THEY DETERMINISTIC OR DO THEY FOLLOW A STOCHASTIC PROCESS?

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ABSTRACT

This paper examines Botswana's bond market seeking to establish if the bond yields are predictable. The logarithmic bond index returns for the Government Bond Index (GorvI), Corporate Bond Index (CorpI) and Botswana Bond Index (BBI) are used as proxies for the bond yields. The yields are derived from a nine year index series covering a period of 2010 through 2018. The results of the Unit root tests (ADF and KPSS), and Heteroscedasticity (GARCH) model, homogeneously reject the random walk process governing the bond index series. These results suggest that Botswana's bond returns are characterised by an anti-persistent trend reversing and deterministic chaotic process. This therefore means investors can easily predict bonds market returns hence rendering the market informational inefficient. Policy makers and capital market regulators and the Central Bank therefore need to strengthen their efforts to improve the efficiency of the bond market and hence rendering the Botswana's Bond market to be attractive to investors. The Botswana Bond Market Association is also encouraged to continue lobbying for the bond market development so as to contribute to the improved efficiency.

Key words: Botswana, Bond Returns, Stochastic process, Unit Root, Heteroscedasticity

INTRODUCTION

Since the adoption of efficient markets hypothesis (EMH) which was coined by Bachelier in 1900 and later refined by Fama in 1965, researchers have conducted studies to check the efficiency of capital markets across the world and thus far, empirical research reveals mixed results in efficiencies of different markets. The general consensus, however, indicates that developed markets seem to exhibit some efficiency whilst their emerging markets counterparts are less efficient due to financial infrastructural differences (Thupayagale, Fixed Income Market Efficiency: Evidence from Kenya's 10-Year Local Currency Bond, 2014). Notwithstanding the above, financial market reforms that took place over the past years and continuing in the present time in developing markets which are geared towards improving the efficiency have been successful in some developing markets. As a result, a number of researches were conducted in the past decade in order to account for these reforms and developments and gauge their impact on capital markets efficiency. The majority of the research work though has mainly focused on the equity market side and limited research has been conducted focusing on the bond markets of these developing countries. One could attribute this to the ease of understanding of equity markets and relatively high participation levels by investors in the equity markets compared to the bond market which is characterised by complex pricing models and limited investor base, usually large institutions (Edwards, Harris, & Piwowar, 2007). It is on this backdrop that it becomes intriguing and motivating to carryout research on the bond market developments in Botswana and check if they have contributed to the efficiency of the bond market. Moreover the research will contribute to literature on the efficiency of Botswana's capital market as a whole, which is currently skewed towards stock market efficiency. The research will also contribute to a pool of limited fixed income market research in Botswana and hence also is expected to help in policy formulation.

More particularly, this research seeks to test the validity of EMH by checking the randomness of the bond market returns in Botswana using time series data derived from Botswana Stock Exchange Limited. A number of statistical tests are carried out for this purpose which includes the Augmented Dickey-Fuller Test (ADF), Kwiatkowski-Phillip-Smidt-Shin Test (KPSS) and the Generalised Auto Regressive Conditional Heteroscedasticity Model (GARCH).

The rest of this paper is structured as follows, next we look at an overview of the bond market reforms in Botswana, followed by literature review, data and Methodology, presentation of findings and discussions and ending with concluding remarks and recommendations.

OVERVIEW OF THE BOND MARKET REFORMS IN BOTSWANA

The existence of Botswana's bond market dates back as far as the 1990's and its establishment was not out of necessity to borrow from the public but to help in the development of the bond market (Bolokwe, 2016). For many years, Botswana had fiscal surpluses which meant that the revenue collected exceeded the spending requirements of the government and as a result, there was no need to borrow from the public to finance fiscal budgets. This was also observed by Jefferis (2009) who notes that the Botswana government would generally run budget surpluses, and with substantial accumulated financial balances, had no fiscal need to borrow. This however did not stop the government from developing a bond market nonetheless. The bond market was developed rather out of the intent to maintain presence in the bond market, facilitate and promote issuances by the corporate sector (Bolokwe, 2016).

Botswana Development Corporation (BDC), Botswana Telecommunications Corporation (BTC) and Botswana Building Society (BBS) were among the first public entities to issue and list bonds on the Botswana Stock Exchange (BSE) between 1999 and 2000, preceding the issuance of government bonds. Due to the issuance of bonds by the public entities, this later served as a catalyst for the government to make its first issuance. Shortly after, in 2002, Bank of Botswana managed to issue the inaugural Government bond, BW001, as part of a programme to support development of domestic capital markets (Bank of Botswana, 2018). In 2004, the Government also issued a range of quasi-government bonds through a parastatal entity (DPCF) with maturities up to 21 years (Jefferis, 2009). Table 1 below show listed bonds as at September 2018.

Table 1 List of Bond Issuers as at September 2018

Security	Nominal Value(BWP Million)	Maturity Date	Coupon Rate
	Government Bonds		
BW007	1974	10-03-2025	8%
BW008	2147	08-09-2020	7.75%
BW011	2103	10-09-2031	7.75%
BW012	1528	13-06-2040	6.00%
BW013	705	07-06-2023	4.50%

BW014	129	05-09-2029	4.80%
BW015	301	02-09-2043	5.30%
Quasi-Government Bonds			
DPCF005	100	02-06-2019	10.60%
DPCF006	55	02-06-2022	10.75%
DPCF007	35	02-06-2025	10.90%
Supranational Bonds			
IFC001*	260	20-09-2024	
Corporate Bonds			
BBB016	156	31-10-2019	8%
BBS004	75	26-11-2019	11.10%
BBS005	150	03-12-2023	11.20%
BDC001*	82	09-06-2029	-
BDC002*	131.5	16-08-2022	-
BDC003*	142.5	09-06-2029	-
BHC020	103	10-12-2020	0.101
FML025	150	23-10-2025	8.20%
FNBB005	126	11-11-2020	-
FNBB006*	112	11-11-2022	-
FNBB007*	161.84	01-12-2026	-
FNBB008*	40	01-12-2026	7.48%
FNBB009	126.35	08-12-2024	5.95%
GBL001	50	31-1-2021	18.00%
GBL002	21.8	24-02-2020	15.00%
GBL003	15	31-12-2020	15.00%
GBL004	25	10-04-2021	15.00%
GBL005	5	23-03-2019	11.00%
INB001*	113.38**	28-12-2027	-
LHL06	200	08-11-2023	10.50%
LHL07	75	08-11-2025	10.50%
LHL08	25	08-11-2027	11.00%
PTP021*	96	10-06-2021	-
PTP024	59	10-06-2024	8.50%
PTP026	70	29-11-2026	9.00%
SBBL063	98	15-10-2019	7.54%
SBBL064*	128	18-06-2020	-
SBBL065*	153	18-06-2020	-
SBBL066*	140	15-06-2027	-
SBBL067	60	15-06-2027	7.80%
SCBB003	50	20-12-2020	10.50%
SCBB006*	70	12-05-2021	-
SCBB007*	50	27-06-2022	-
SCBB008	127	27-06-2022	8.20%
WUC002	205	26-06-2026	10.60%

BOND MARKET SUMMARY

#Government Bond data is reported with a one(1) day (as updated by Bank of Botswana)

*Variable Coupon Rate
**United States Dollars

Bond Symbol	Full Name
BW	Government of Botswana Bond
DPCF	Debt Participation Capital Funding Limited
IFC	International Finance Corporation
BBB	Barclays Bank Botswana
BBS	Botswana Building Society
BDC	Botswana Development Corporation
BDCL	Botswana Development Corporation Limited
BHC	Botswana Housing Corporation
FML	Furnmart Limited
FNBB	First National Bank Botswana
GBL	GertBucks Limited
INB	Investec Limited
LHL	Letshego Holdings Limited
PTP	Prime Time Property
SBBL	Stanbic Bank Botswana Limited
SCBB	Standard Chartered Bank Botswana
WUC	Water Utilities Corporation

Source: Botswana Stock Exchange Limited

Despite the initial impact of government bond issuance being good, the lack of further government bond issues weakened the bond market. In 2008, the Government then committed to undertake a regular bond issuance and launched a P5 billion note issuance programme which was later exhausted in 2010 prompting an increase in the Government's domestic debt limit to P15 billion (Bolokwe, 2016). It is important to note that unlike the earlier years; the bonds issued under the P15 billion note programmes were used to help the government finance its budget deficits which it was experiencing from 2008 (see to Table 2 below).

Table 2: Fiscal Balances (P Million)

Year	2004	2005	2006	2007	2008	2009	2010
Revenue	17956.6	22266.6	27397.7	28629.5	30455.1	30023.1	31909.4
Expenditure	17382.6	17631.9	19737.4	24821.9	35150.7	39489.2	38417.5
Surplus / Deficit	**574**	**4634.7**	**7660.3**	**3807.6**	**(4695.6)**	**(9466.1)**	**(6508.1)**

In 2010, a Botswana Bond Market Development Strategy (BBMDS) was set out to promote the development of the bond market in response to the relatively weak bond market in Botswana. This led to several developments occurring in the bond market in the subsequent years. First, Botswana Bond Market Association (BBMA) was established in 2010 and officially registered in 2013 with a key mandate of resolving structural issues impeding bond market development such as lack of a robust risk free yield curve, lack of neutral indices and poor information dissemination (Botswana Bond Market Association, 2017). Secondly, the BSE launched its Automated Trading System (ATS) in 2012 and the bond market conventions were established and built into the ATS to address pricing issues (Tsheole, 2016). Another development was the introduction of three bond indices namely Botswana Bond Index (BBI), Government Index (Govi) & Corporate Index (Corpi) by BSE in 2013 which were back-dated to commence from 1 January 2010. Govi and Corpi are independent indices whereas BBI constitutes both the Govi and Corpi as an aggregate bond index. The introduction of these indices was to alleviate the challenge due to the lack of neutral bond indices as the only bond index at the time was the Fleming Aggregate Bond Index (FABI) which is managed by "outsiders" Fleming Advisors. Later in 2018, there were amendments to the Botswana Bond Index Series (BBIS) ground rules which include a change to the weighting methodology of the indices from equally weighted to market cap weighted and the introduction of the Botswana Fixed Rate Composite Bond Index. Furthermore, all debt securities were dematerialised into the BSE Central Securities Depository (CSD) which facilitates holding of securities in electronic accounts and this may help attract international investors to our bond market as many international fund managers will only trade bonds in a market with dematerialised bonds (Botswana Bond Market Association, 2017). Lastly, there are on-going discussions to centralise bond trading and settlement in the ATS and CSD which potentially could make the market more efficient by improving information dissemination, transparency and liquidity. Other expected development is the introduction of separate debt listing requirement which are currently not available as such but used to be bundled together with Equity listing rules in one book. There are discussions also in several fora for the introduction of infrastructure bonds, retail bonds and green bonds which will be other exciting developments in the bond market. All the above developments are expected to have improved the efficiency of the market and therefore as one of the objective of this research we check the level of efficiency of Botswana's bond market in the backdrop of these bond market development initiatives.

LITERATURE REVIEW

Published research on the capital markets in Botswana is fairly limited. Many of the studies that have been reported are on the equity market and little research has been done regarding the bond market. Therefore, attempting to review literature on the Botswana's bond market proved to be a challenge.

Nonetheless, in some of these limited research work, Sebate (2009) conducted research on 39 listed bonds during 2006-2007 to determine the liquidity and efficiency of the local bond market. They used the Houwelling, Mentink and Vorst liquidity model, simple regression and latent models to gauge the liquidity and a static model to gauge efficiency in the bond market. The test results from this study discovered that Botswana's bond market is inefficient and illiquid. Jefferis (2009) examined Botswana's bond market through reviewing publicly available information and conducting interviews with key institutions involved in the bond market development. It was noted from the study that the turnover and liquidity in the bond market was relatively low with government bonds accounting for 90% of the trading activity and trading was characterised as sporadic. This was attributed to institutional investors with "buy and hold" strategies holding a majority of the bonds and lack of a bond issue programme to promote liquidity (Jefferis, 2009). Ahwireng-Obeng (2016) shared the same sentiments in research seeking the performance determinants of local currency bond markets in African economies. The research discovered that Botswana struggles with very few government bond issues due to budget surpluses and hence there has been lack of bond market development. The findings by Jefferis and Ahwireng-Obeng point out market information that contributes to the inefficiency of the Botswana's bond market.

In the emerging markets space, some authors have found the bond markets to be inefficient. Thupayagale (2014) tested for long memory in the yield changes and volatility of Kenya's 10-year government bond using the AFRIMA-FIGARCH model on daily bond yields from 2004 till 2012. The result of that study concluded that there was a presence of long memory in bond yield changes suggesting that the recent bond market reforms in Kenya did not significantly improve the efficiency of the bond market. In another research, Thupayagale (2012) makes use of ADF, GARCH and Risk Metrics models to determine the presence of long memory of local bond markets in Hong Kong, Mexico and South Africa. At the end of the study, it was revealed that the emerging bond markets demonstrated evidence of long memory which meant that the markets were weak-form inefficient. On the other hand, Babu (2017) discovered by employing Variance Ratio (VR) tests, that the variance tests performed on the Indian bond market did not follow the RWB. As a result, the Indian bond market is also considered to be weak-form inefficient. In addition, Bhat (2017) evaluated the efficiency of India's sovereign bond market using the Runs test, ARMA, E. GARCH and T. GARCH model on bond yields from 2011 to 2016. The findings showed no randomness in the bond yields thus the sovereign bond market is regarded as weak-form inefficient.

On the contrary, there is research output that indicates that some bond markets are efficient. Liu (2013) examined the South African bond market by testing the efficiency of three bonds (a government bond, a corporate bond and all bond index) through a simple regression model with time varying parameters and a test of evolving efficiency (TEE). The data set for government bond consisted of 752 data points of daily return covering 2009 through 2012 whereas that of a corporate monthly bond returns covered between 2010 to 2012. The bond index data run between 2004 and 2012. The tests suggested that the South African bond market is weak-form efficient. Therefore, investors cannot use technical analysis to beat the market. In addition, Guduza and Phiri (2017) used unit root tests (ADF, KPSS and Philips-Perron) to determine the efficiency of the South African bond market. They used monthly data for 7 bond market index returns between 2002 and 2016. The research established that their results too point to evidence of weak-form efficiency in the bond market. Furthermore, in assessing the impact of automated trading system on the Nairobi bond market, Kiuna (2010) collected bond turnover, prices and deals data for a period between June 2003 to June 2010 and applied mean scores, standard deviations and t-tests to examine the bond market's efficiency before and after the introduction of the automated trading system in 2006. The automation of the bond market was found to have increased the bond turnover, improved bond prices and increased liquidity hence the Nairobi bond market was seen to be more efficient.

With regards to developed markets, most authors found the bond markets to be efficient. Kroon (1991) mentioned in his study that the Dutch government bond market is weak-form efficient as evidence makes it difficult to reject the random walk hypothesis. The research was carried by applying the Martingale model as a suitable test equation on Dutch bond return indices. Hotchkiss and Ronen (2002) examined the returns of twenty high yield bonds on the NASD's Fixed Income Pricing System by employing regression models and found that information is quickly incorporated into bond prices. As a result, it can be concluded that the bond market is efficient. In addition, Ying (2006) used an Autoregressive Conditional Duration (ACD) model over a 3 year period (2002-2003) on U.S. bond transaction records to analyse the effect of macroeconomic announcements on bond prices. It was concluded that bonds quickly incorporated firm-specific information to their prices hence demonstrating efficiency in the market in the semi-strong form. Though Yin (2006) study is based on semi-strong form market efficiency and not weak form as in our current study it gives us an idea on the overall efficiency of the U.S bond market. Pesando (2015) applied the Modigliani-Sutch and Modigliani-Shiller models on long term Canadian bond yields on a 6 year period (1971-1976) and the results showed that both sets of tests support that the Canadian bond market is efficient in the weak form.

Based on the above literature we formulate the hypothesis below for this study:

H_0 = Botswana' bond market is inefficient in the weak form

H_1 =Botswana's bond market is efficient in the weak form

DATA AND METHODOLOGY

Data

The data used for this research is sourced from Botswana Stock Exchange Limited (BSEL) bond index database and it includes three indices namely; the government bond index (GovI), corporate bond index (CorpI) and Botswana bond index (BBI). The GovI is used to measure bond returns for the listed government bonds whilst CorpI measures bond returns for listed corporate bond issues on the BSEL whereas the BBI is a composite index representing all the listed bonds issued in Botswana. These indices which are collectively called the Botswana Stock Exchange Bond Index Series (BBIS) represent the performance of fixed and floating interest instruments issued in local currency and listed on the BSEL. Since the indices were introduced in 2013 and back-dated to commerce from 1 January 2010, for the purposes of this research, the data period covered will be from January 2010 to December 2018 forming a nine year time series data presented in both daily and monthly series.

In terms of their computational process, the bond prices in the indices are calculated using fair value prices of bonds as derived from the Zero-Coupon Yield Curve (Botswana Stock Exchange, 2018). This Zero-Coupon Yield Curve is a risk free curve based on inputs from Bank of Botswana Certificates, Treasury Bills and government bond yields. The best bid and ask for each respective government bond is used to determine the midpoint for inclusion in the yield curve. Whilst individual bonds used in the index are weighted according to their nominal amounts of each bond index. As a result, the index calculations are based on the constituent bond prices and weights. The total return index is calculated as follows:

$$TRIt = TRIt - 1 * \frac{\Sigma i(CPi, t + Ci, t) * TWi, t - 1}{\Sigma i\, DPi, t - 1 * TWi, t - 1}$$

Where: TRIt is total return index

$DP_{i,t}$ is the dirty price of the i^{th} bond at day t

$CP_{i,t}$ is the clean price of the i^{th} bond at day t

$C_{i,t}$ is the coupon paid out on coupon payment day t for the i^{th} bond

$Tw_{i,t-1}$ is the weight of the i^{th} bond in the TRI as at the end of day t-1

METHODOLOGY

This research uses a mixed methodology in terms of statistical tests applied to test the randomness of bond return series. Taking guidance from literature review presented earlier we apply several tests to achieve our goal and these include the Augmented Dickey Fuller test (ADF), Kwiatkowski-Philips-Schmidt-Shin (KPSS) test, and Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model**.** We briefly discuss each test below.

Unit Root Tests

The following tests are used for testing a dataset for presence of a unit root. A unit root is a feature of some stochastic processes that prevents a time series from having a constant mean and constant variance (Duffee, 2007).i.e the data is non-stationary. By testing data for presence of a unit root, the presence of such unit root would mean that the data is non-stationary and hence the data follows a random walk and hence there is weak-form market efficiency. In time series forecasting, stationary data is also required for effective forecasting. Therefore, as an example if we are to apply forecasting models such as GARCH to test if bond returns can be predicted, a stationary data will be one of the necessary conditions. We use two unit root tests to check for stationarity in our bond return series which are the Augmented Dickey-Fuller test and Kwiatkowski-Phillips-Schmidt and Shin test. The two tests are discussed next, starting with the Augmented Dickey Fuller test.

Augmented Dickey Fuller (ADF) Test

The Augmented Dickey Fuller is the most commonly used statistical linear test used to check if data is stationary as was evidenced in the literature review presented earlier. A stationary time series is one whose statistical properties such as mean and variance are all constant over time (Grenander & Rosenblatt, 1957). The ADF model below is used for testing data for presence of a unit root:

$$\Delta y_t = \alpha+\beta_t+\gamma y_{t-1}+\delta_1\Delta y_{t-1}+\cdots+\delta_{p-1}\Delta y_{t-p+1}+\epsilon_t$$

Where α is a constant, β is coefficient on a time trend and ρ is the lag order of the autoregressive process (Elliott, Rothenberg, & Stock, 1996). Imposing the constraints $\alpha = 0$ and $\beta = 0$, corresponds to modelling a random walk (Elliott et al., 1996).

For the ADF test, the null hypothesis is that there is a unit root observed in the data hence the data is not stationary. The alternate hypothesis, however, is that the time series is stationary, and the null hypothesis is rejected. Failing to reject the null hypothesis would mean that bond returns follow a random walk and alternatively, rejecting the null hypothesis would imply that bond returns do not follow a random walk.

Kwiatkowski-Philips-Schmidt-Shin (KPSS)

Most unit root tests like ADF discussed above have a relatively high Type I error rate and as a result. To take care of this problem we also employ the Kwiatkowski-Philips-Schmidt-Shin (KPSS) model to complement the ADF in order to deal with the Type I error. The KPSS is also used to determine if a time series is stationary around a mean or is non-stationary due to a unit root. KPSS is based on linear regression and is modelled as follows:

$$X_t=r_t+\beta_t+\epsilon_1$$

Where r_t is a random walk, βt is a deterministic trend and ε_t is a stationary error (Kwiatkowski, Philips, Schmidt, & Shin, 1992).

Contrary to the ADF model, the null hypothesis for the test is that the data is stationary and the alternative hypothesis is that the data in not stationary. Rejecting the null hypothesis would therefore mean the time series is not stationary hence proving the bond market to be weak-form efficient and failing to reject the null hypothesis would mean the bond market is not weak-form efficient.

Generalised Autoregressive Conditional Heteroscedasticity (GARCH)

The GARCH model is a statistical model used for forecasting volatility. It is primarily used to gauge the impact of past value volatility on the current day value volatility. GARCH formulae used is as follows (Thupayagale, 2012):

$$h_t=\omega+\alpha\varepsilon^2_{t-1}+\beta h_{t-1}$$

Where, h_t is the volatility of our respective bond returns, ω is the constant term, α denotes the alpha coefficient of the ARCH term, β is the beta coefficient of the GARCH term , ε^2_{t-1} = ARCH term and h_{t-1} = GARCH term. Both ε^2_{t-1} and h_{t-1} are endogenous variables that can affect the volatility of our respective bond returns.

DATA ANALYSIS, FINDINGS AND DISCUSSIONS

The three bond indices computed by the Botswana Stock Exchange Limited, namely BBI, GovI and CorpI are used for this research. The sample includes daily index data from 2010 – 2018 and this data is transformed into continuously compounded returns using the formulae:

$R_t = \log (P_t) - \log (P_{t-1})$.

Where R_t is the compounded return at time t, P_t is the price index and P_{t-1} is the prevailing price index. We used log returns, as most statistical tests generally require that the data used for testing be normally distributed hence logarithmic returns are more likely to be normally distributed (Radikoko, 2014). To account for the problem of illiquidity or thinness in trading which is normally associated with emerging/developing markets the bond return series is also calculated on trade to trade basis and adjusted for interval variability using the following formula:

$\acute{R}_t = 1/K_t\,[\,\ln(P_t) - \ln(P_{t-K_t})]$

This approach removes most zero returns between trading periods, Bowie (1994), Mlambo & Biekpe (2007) and Radikoko (2014).

Distributional Properties of the data

Table 3 below shows a summary of the descriptive statistics of the three daily bond indices under investigation.

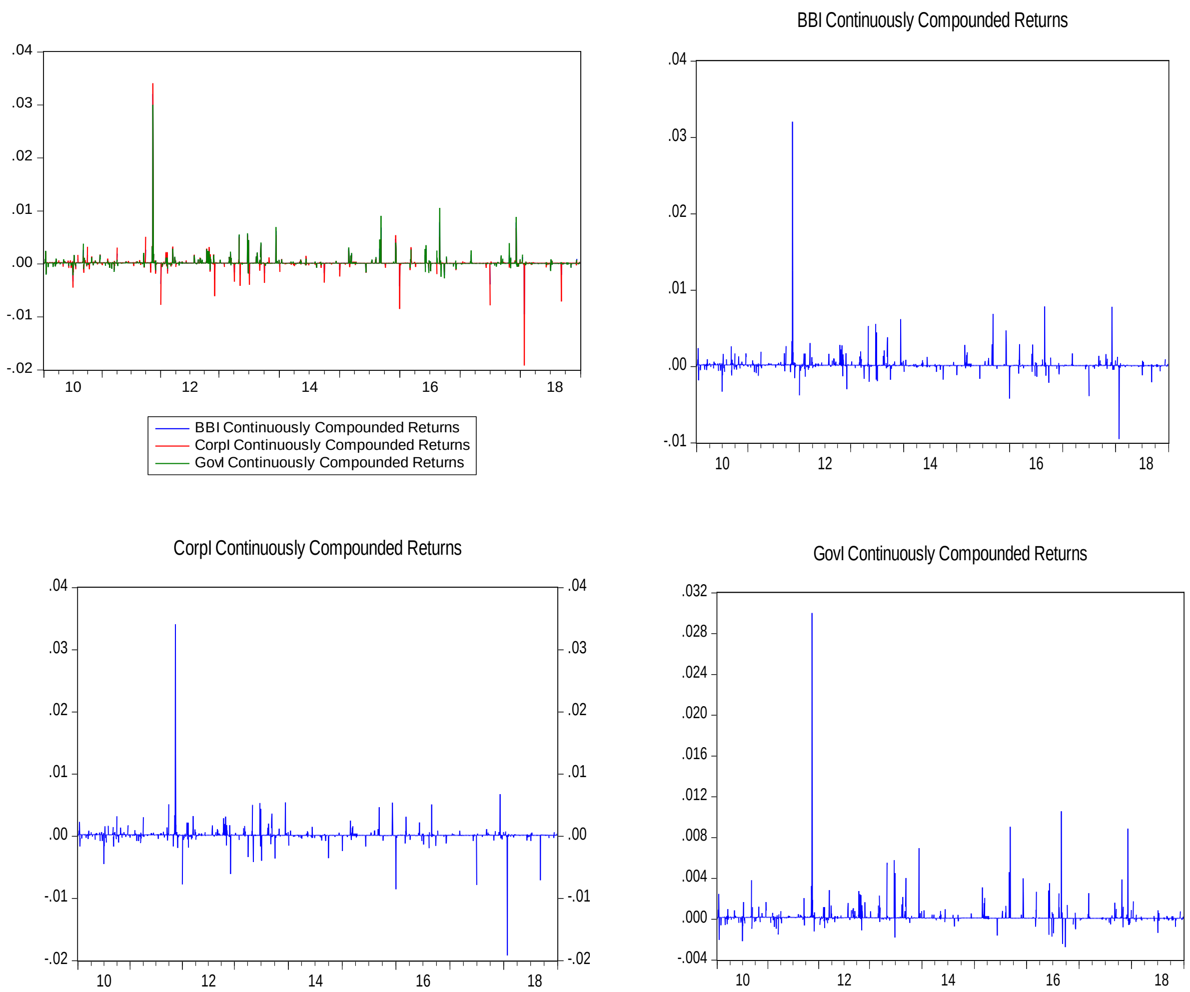
Table 3: Descriptive Statistics

	BBI Returns	CORPI Returns	GOVI Returns
Mean	0.0002	0.000199	0.000203
Median	0.000132	0.000163	0.000114
Maximum	0.032061	0.034089	0.030027
Minimum	-0.009491	-0.019163	-0.002731
Std. Dev.	0.000917	0.001065	0.000877
Skewness	19.77669	11.72355	20.42274
Kurtosis	659.0343	508.7801	612.1203
Jarque-Bera	41718735	24760424	35996208
Probability	0.000000	0.000000	0.000000
Sum	0.464163	0.461423	0.469579
Sum Sq. Dev.	0.001947	0.002629	0.001784
Observations	2318	2318	2318

Evidence from Table 3 reveals that the distribution of the bond returns does not follow a normal curve. The skewness statistic, which is a measure of the dataset's symmetry, is non-zero for all the three return series. A non-zero skewness statistic shows that the bond return series is not normally distributed because a normal distribution has a skewness value of zero. In addition, the kurtosis value which is measure of all the tails in the distribution of the dataset, are all greater than three. The bond return distribution is therefore described as a leptokurtic because kurtosis statistics with very high figures above three indicate that the data has a large number of outliers (extreme points). Most of the statistical tests generally require the data used for testing to be normally distributed (Moustafa (2004) and Mollah (2007)). Normality test presented above means that the Botswana bond index returns are non-normal and hence violate the condition of random walk hypothesis which assumes a normal distribution. This descriptive statistics therefore provides preliminary ground for rejection of the random walk behaviour governing Botswana's bond returns.

Below we present also the graphical view of how the returns meander over time.

Figure 1: Graphical depiction and analysis of the data



Graphical depiction of the three bond return series generally indicate that there are observed volatilities in Botswana's bond returns. There are period of observed low volatilities followed by low volatilities and high volatilities followed by high volatilities. This therefore suggests that the bond returns can be easily predicted in Botswana. Furthermore, the three series tend to trend together overtime and hence there is an observable trend. Graphical observation is however a subjective approach and it therefore can be challenged. Nonetheless, it provides us with preliminary conclusion to suggest there is a deterministic chaotic process governing Botswana's bond returns. Next we employ more robust statistical approach to check for deterministic process in the three bond return series.

EMPIRICAL RESULTS AND DISCUSSION

Unit Root Tests

The results of the two unit root tests that were employ are presented in this section. In all the cases we perform the tests on level data and select lag length by minimizing the Schwartz Information criterion (SIC) and also selected the bandwidth using Bartlett kernels where applicable. We start with the results of the ADF which we discuss below followed by the presentation of the KPSS test results.

Augmented Dickey-Fuller (ADF) test results

Under the ADF test, the null hypothesis is that there is a unit root observed in the data hence the data is non-stationary and the alternate hypothesis is that the time series is stationary. Failing to reject the null hypothesis means that bond returns follow a random walk and alternatively, rejecting the null hypothesis implies that bond returns do not follow a random walk.

The results of the ADF which were performed on level data are presented in table 4 below and the ADF model was run with both constant and a trend term included in the model. Both the trend and constant terms are included because as observed earlier in the graphical representation of the data there was an observed trend followed by each of the three returns series under investigation. Moreover, descriptive statistics of the return series as also demonstrated earlier as well as the graphical representation suggests that the mean values for the three returns series is constant.

The results of the ADF as presented in table 4 below show that we reject the null hypothesis of a unit root with 99% confidence or at a 1% significance level for all indices using absolute values. Consequently, this indicates that the bond return series had no presence of a unit root and are stationary hence proving that the bond returns do not follow a random walk.

Kwiatkowski-Philips-Schmidt-Shin (KPSS) test results

KPSS similar to the ADF, is used to determine if a time series is stationary or non-stationary. This test is used to alleviate the Type I error associated with the ADF test hence used to confirm the results of the ADF test. KPSS tests the null hypothesis of a unit root in a reverse fashion, thus the null hypothesis is that the data is stationary and there is no unit root. The results of KPSS test for all the return series are presented in Table 4 and in all the cases we fail to reject the null hypothesis of no unit root at 5% level of significance indicating that the bond return data is stationary.

Table 4: The Results of Unit Root test

Series	Test	Test Statistic	Probability
BBI Returns	ADF	-38.1625	0.0000
	KPSS	0.045724	Stationary
CorpI Returns	ADF	-39.6787	0.0000
	KPSS	0.034383	Stationary
GorvI Return	ADF	-38.4897	0.0000
	KPSS	0.065059	Stationary

	Critical Values	
	ADF	**KPSS**
1% level	-3.962	0.216
5% level	-3.41174	0.146
10%level	-3.12776	0.119

In sum both the ADF and the KPSS test collectively declare the returns of Botswana's bond market to be stationary and hence predictable therefore dismissing the possibility of a stochastic process followed by the bond returns. These results of a stationary data series are useful in performing our next statistical test which is the GARCH. One of the prerequisite of a GARCH model is that the time series data should be stationary. More detailed discussions of the GARCH approach are covered next.

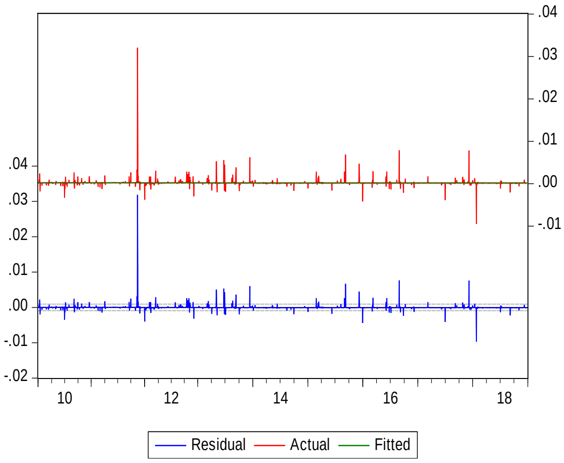
General Autoregressive Conditional Heteroscedasticity (GARCH)

The GARCH model is used to model and measure volatility in a time series data. We therefore use this model to check for volatility in the returns of Botswana's Bond market. As indicated earlier under unit root tests, one of the prerequisite to run the GARCH model is that the return series should be stationary. If the series is not stationary then it has to be made stationary by taking the first derivative of the series or second derivative until the series is stationary. In our case though our unit root tests, both the ADF and KPSS test declared our three bond return series (BBI, GorvI and CorpI) to be level stationary and this therefore gives us the platform to model volatility using the GARCH model.

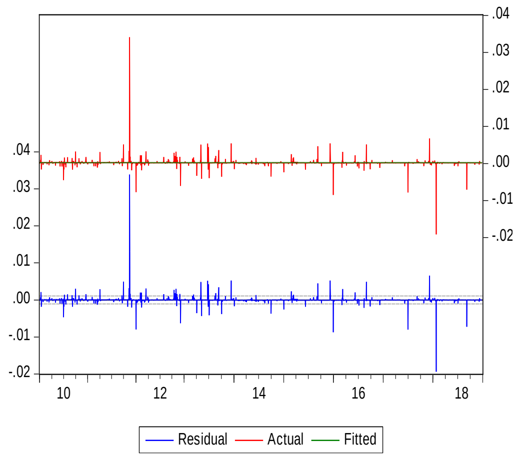
Apart from stationarity as a condition needed to perform GARCH and any related ARCH family models, the residual of the model has to exhibit volatility clustering as well and the model should also have an ARCH effect. ARCH effect is a time series that exhibit conditional heteroscedasticity or autocorrelation in the squared series. To check for volatility clustering we plot the residuals of our three models were plotted and observe their behaviour over time and to check the model for ARCH effect the heteroskedasticity test is run. Below is a graphical depiction of the residual of the three return series model.

Figure 2: Plots of Residual Series

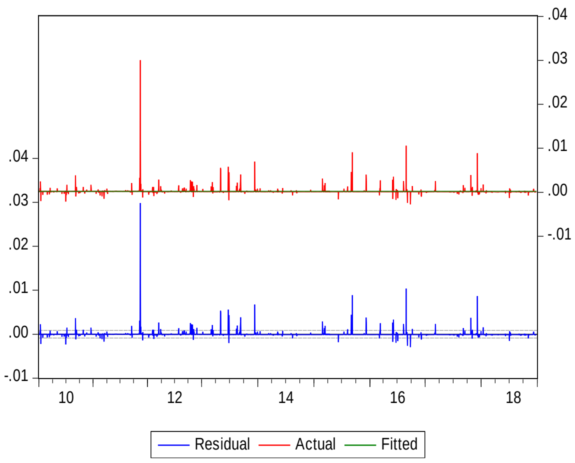
BBI Returns



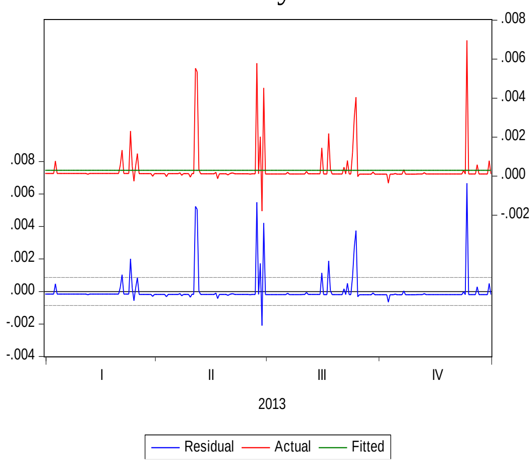
CorpI Returns



GorvI Returns



GorvI Returns-one year extract



The above residual plot of our bond return models indicates that there is volatility clustering in all the three return data series as observed by patches of period of prolonged low volatility and patches of prolonged high volatility within each residual series. One year extract of the GorvI index for 2013 sure more clearly the volatility clustering's (2013 was chosen randomly to improve pictorial view). This therefore means that the second condition needed to run ARCH family test is satisfied. The last condition that needs to be satisfied is presence of ARCH effect in the model and to check this we ran the heteroskedasticity test for each bond return model was run and the results are presented below.

Table 5: Heteroskedacticity Test

Heteroskedasticity Test: ARCH Test Results for BBI Returns Model			
F-statistic	48.80295	Prob. F(1,2319)	0.0000
Obs*R-squared	47.83829	Prob. Chi-Square(1)	0.0000

Heteroskedasticity Test: ARCH Test Results for CorpI Returns Model			
F-statistic	38.99288	Prob. F(1,2319)	0.0000
Obs*R-squared	38.38115	Prob. Chi-Square(1)	0.0000

Heteroskedasticity Test: ARCH Test Results for GorvI Returns Model			
F-statistic	48.48592	Prob. F(1,2314)	0.0000
Obs*R-squared	47.53187	Prob. Chi-Square(1)	0.0000

The null hypothesis under the heteroskedasticity test is that there is no ARCH effect (H_0= No ARCH effect) and this is tested against an alternative hypothesis of ARCH effect (H_1= There is ARCH effect). The results presented in Table 5 above show that the observed R-squared values for BBI, CorpI and GorvI returns are 47.838, 38.381 and 47.53 respectively and their associated P-Values are all zero and hence significantly less that 5%. We therefore reject the null hypothesis of no ARCH effect in favour of the alternative hypothesis suggesting that there is ARCH effect.

In sum we have seen that all the conditions needed to run any ARCH family model which are stationary data; exhibition of clustering volatilities and presence of ARCH effect have been satisfied. We therefore proceed to run GARCH model to check for volatilities and long memory properties of our bond return series.

Next, we check which of the ARCH model between ARCH (Autoregressive Conditional Heteroscedasticity), GARCH (Generalised Autoregressive Conditional Heteroscedasticity), TARCH (Threshold Autoregressive Conditional Heteroscedasticity) and EGARCH (Exponential Generalised Autoregressive Conditional Heteroscedasticity) will be best for our data and to do that we run all these models and observe the absolute values of their Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC). The model with the lower AIC and SIC is the model to use. Below we present summary of the AIC and SIC for all our bond / models in table 5.

Table 6: Akaike & Schwarz Information Criterion values for selected ARCH models

BBI Returns

Model	AIC	SIC
ARCH (5,0)	-12.0259	-12.0086
GARCH(1,1)	**-11.9312**	**-11.9213**
EGARCH	-12.0475	-12.0352
TARCH	-12.0397	-12.0273
	CorpI Returns	
Model	**AIC**	**SIC**
ARCH (5,0)	-11.6016	-11.5842
GARCH(1,1)	**-11.3227**	**-11.3128**
EGARCH	-11.7163	-11.7039
TARCH	-11.4141	-11.4017
	GorvI Returns	
Model	**AIC**	**SIC**
ARCH (5,0)	-12.1441	-12.1268
GARCH(1,1)	**-12.0638**	**-12.0539**
EGARCH	-12.0994	-12.087
TARCH	-12.1169	-12.1045

As can be observed from the above table 6, for all bond returns, the model with the smallest absolute values of AIC and SIC is the GARCH(1,1) model. This means that to measure volatility in Botswana's bond returns the best fitted model from the ARCH family models is GARCH(1,1). Note however that all the AIC and SIC values are almost similar and negative, this means that all these models are actually best suited as the information loss is significantly low when each of these models is run. We however, proceed to run the GARCH model as a model of our choice and present the results below. Before the presentation of the results of the GARCH(1,1) model it is necessary to perform diagnostic test on the residuals of the model to check how best the model is fitted. The three residual diagnostic tests that are run are the Autocorrelation test, the ARCH LM test to check for heteroskedasticity and lastly the Residual Normality test to check if the residuals are normally distributed. We start with the presentation of Autocorrelation test results in the tables below.

Table 7: Correlogram of BBI Returns

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*

| |	| |	1	-0.006	-0.006	0.0958	0.757
| |	| |	2	-0.006	-0.006	0.1847	0.912
| |	| |	3	0.006	0.006	0.2751	0.965
| |	| |	4	-0.004	-0.004	0.3118	0.989
| |	| |	5	-0.002	-0.002	0.3259	0.997
| |	| |	6	-0.006	-0.006	0.4047	0.999
| |	| |	7	-0.007	-0.007	0.5103	0.999
| |	| |	8	0.000	-0.000	0.5103	1.000
| |	| |	9	-0.006	-0.006	0.5981	1.000
| |	| |	10	-0.003	-0.003	0.6241	1.000
| |	| |	11	-0.002	-0.002	0.6326	1.000
| |	| |	12	-0.006	-0.006	0.7183	1.000
| |	| |	13	-0.006	-0.007	0.8150	1.000
| |	| |	14	-0.006	-0.006	0.9037	1.000
| |	| |	15	-0.007	-0.007	1.0094	1.000
| |	| |	16	-0.006	-0.007	1.1080	1.000
| |	| |	17	0.013	0.013	1.5224	1.000
| |	| |	18	-0.004	-0.004	1.5679	1.000
| |	| |	19	-0.007	-0.007	1.6796	1.000
| |	| |	20	0.008	0.007	1.8186	1.000

*Probabilities may not be valid for this equation specification.

Table 8: Correlogram of CorpI Returns

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
| |	| |	1	-0.004	-0.004	0.0292	0.864
| |	| |	2	-0.003	-0.003	0.0557	0.973
| |	| |	3	0.001	0.001	0.0600	0.996
| |	| |	4	-0.003	-0.003	0.0755	0.999
| |	| |	5	-0.003	-0.003	0.0999	1.000
| |	| |	6	-0.004	-0.004	0.1302	1.000
| |	| |	7	-0.004	-0.004	0.1597	1.000
| |	| |	8	-0.002	-0.002	0.1670	1.000
| |	| |	9	-0.004	-0.004	0.1978	1.000
| |	| |	10	-0.001	-0.001	0.2004	1.000
| |	| |	11	-0.002	-0.002	0.2064	1.000
| |	| |	12	-0.003	-0.003	0.2262	1.000
| |	| |	13	-0.004	-0.004	0.2574	1.000
| |	| |	14	-0.003	-0.004	0.2851	1.000
| |	| |	15	-0.004	-0.004	0.3152	1.000
| |	| |	16	-0.003	-0.004	0.3424	1.000
| |	| |	17	0.010	0.009	0.5550	1.000
| |	| |	18	-0.003	-0.003	0.5753	1.000
| |	| |	19	-0.004	-0.004	0.6049	1.000
| |	| |	20	-0.003	-0.003	0.6219	1.000

*Probabilities may not be valid for this equation specification.

Table 9: Correlogram of GorvI Returns

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*

1	-0.005	-0.005	0.0521	0.820
2	-0.005	-0.005	0.1042	0.949
3	0.004	0.004	0.1434	0.986
4	-0.003	-0.003	0.1658	0.997
5	0.001	0.001	0.1669	0.999
6	-0.000	-0.000	0.1672	1.000
7	-0.005	-0.005	0.2275	1.000
8	-0.004	-0.004	0.2641	1.000
9	-0.004	-0.004	0.2981	1.000
10	-0.004	-0.004	0.3361	1.000
11	-0.003	-0.003	0.3523	1.000
12	0.019	0.019	1.2352	1.000
13	-0.004	-0.004	1.2794	1.000
14	-0.004	-0.004	1.3254	1.000
15	-0.005	-0.005	1.3810	1.000
16	-0.004	-0.004	1.4218	1.000
17	-0.003	-0.003	1.4440	1.000
18	-0.005	-0.005	1.4918	1.000
19	-0.005	-0.005	1.5535	1.000
20	0.031	0.031	3.8140	1.000

*Probabilities may not be valid for this equation specification.

There null hypothesis under Autocorrelation test is that there is no serial correlation and the alternative is that there is serial correlation. Looking at the results presented above, we fail to reject the null for all the residual of the three returns series because almost all p-values are more than 5% suggesting that there is no serial correlation. The absence of serial correlation suggests that the estimated variances of the regression coefficients in our model will not be biased, leading to reliable hypothesis testing. This means that one of the conditions that need to be satisfied for the models to be best fit is satisfied. The other two conditions that needs to be satisfied is that there should be no ARCH effect in the residuals and there residuals should be normally distributed. Next is to check for the presence of ARCH effect by running the ARCH LM test.

Table 10: Results of the ARCH LM Test

Heteroskedasticity Test: ARCH for BBI Residuals			
F-statistic	0.095517	Prob. F(1,2319)	0.7573
Obs*R-squared	0.095596	Prob. Chi-Square(1)	0.7572
Heteroskedasticity Test: ARCH for CorpI Residuals			
F-statistic	0.029112	Prob. F(1,2319)	0.8645
Obs*R-squared	0.029137	Prob. Chi-Square(1)	0.8645
Heteroskedasticity Test: ARCH for GorvI Residuals			
F-statistic	0.051929	Prob. F(1,2319)	0.8198
Obs*R-squared	0.051973	Prob. Chi-Square(1)	0.8197

The Null hypothesis under ARCH LM test is that there is no ARCH effect in the residuals. With all P-values of more than 5%, we fail to reject the null hypothesis for for all the residual of the three returns series suggesting that there is no ARCH effect. This therefor means the second condition of no ARCH effect in the residuals is also satisfied. So far, the two necessary conditions of no correlation and no ARCH effect have been satisfied and we now look at the last condition of normal distributions followed by the residuals.

Figure 3:BBI Residuals Normality test Results

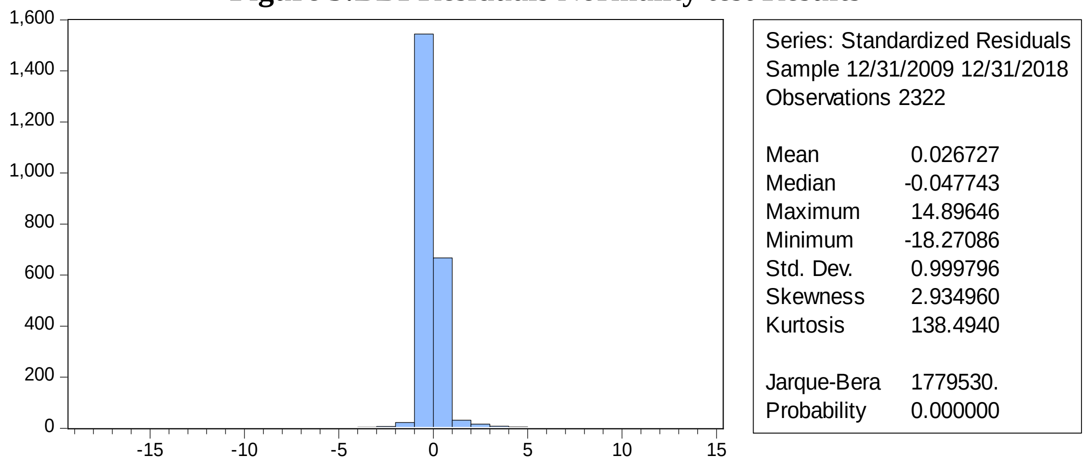


Figure 4:CorpI Residuals Normality test Results

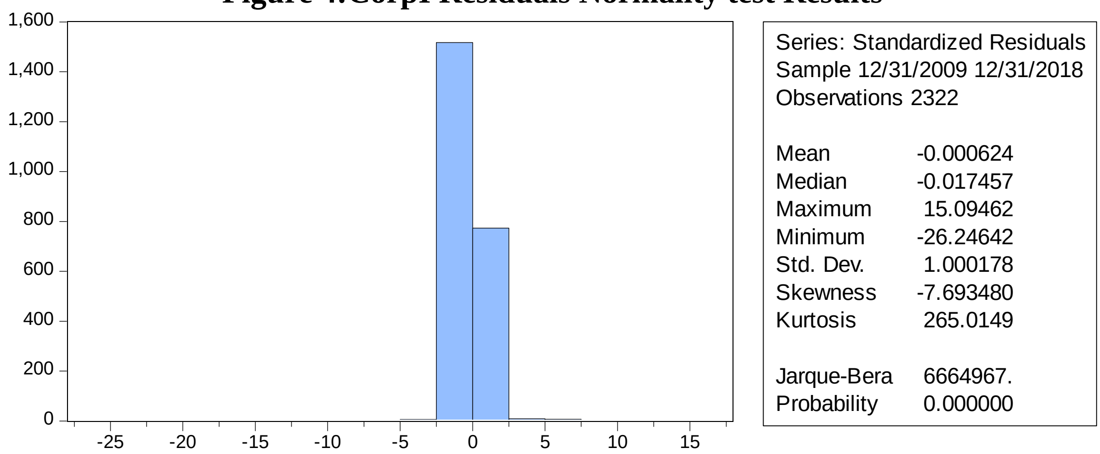
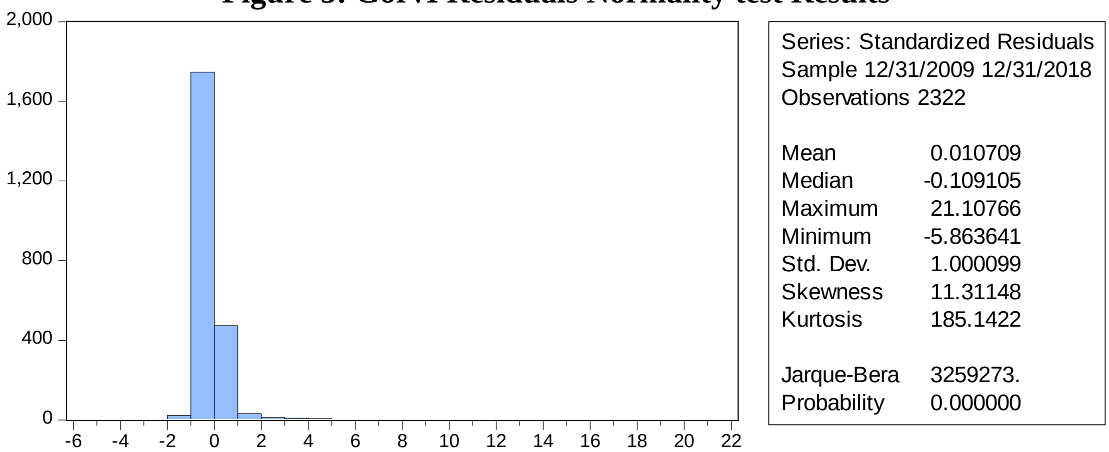


Figure 5: GorvI Residuals Normality test Results



The normality test results as presented above in figure 3 to 4 shows that the residual for all our three bond return series are not normally distributed as shown by skewness values which are higher than zero and kurtosis values in excess of 3. Furthermore the Jargue-Bera values far exceed the normal value of at most 6 suggesting that indeed the residuals are not normally distributed. This therefore means that the third condition of a normal distribution which should be satisfied to make our GARCH model to be reliable is not satisfied. However as has been noted in previous literature, the absence of normality in the residuals does not render tests virtually inconsequential especially in sample sizes that are significantly large, (Brooks, 2009). We can therefore still rely on our GARCH model as best suited for the data because the two most important conditions of no serial correlation and no ARCH effect are satisfied. The results of the GARCH model are presented in the table below.

Table 11: Results of the GARCH model

GARCH(1,1) BBI Returns				**GARCH(1,1) CorpI Returns**			
	Param	Value	Prob.		Param	Value	Prob.
Constant	μ	0.000000154	0.0000	Constant	μ	0.000000313	0.0000
Arch term	α_0	1.066388	0.0000	Arch term	α_0	1.043347	0.0000
Garch term	β_1	0.414901	0.0000	Garch term	β_1	0.402469	0.0000

GARCH(1,1) GorvI Returns			
	Param	Value	Prob.
Constant	μ	0.000000142	0.0000
Arch term	α_0	1.241318	0.0000
Garch term	β_1	0.388133	0.0000

Recall that earlier that the GARCH model was presented as follows:

$$h_t=\omega+\alpha_0\varepsilon^2_{t-1}+\beta_1 h_{t-1}$$

Where, h_t is the volatility of our respective bond returns, ω is the constant term, α denotes the alpha coefficient of the ARCH term, β is the alpha coefficient of the GARCH term , ε^2_{t-1} = ARCH term and h_{t-1} = GARCH term. Both ε^2_{t-1} and h_{t-1} are endogenous variables that can affect the volatility of our respective bond returns.

The results of our GARCH model presented in Table 11 above reveal that for all the three bond return series under investigation both the ARCH and GARCH terms are significant in affecting the volatility of the Botswana bond returns. These results means that past volatilities have an impact on future volatilities of Botswana Bond returns and hence declaring the returns of Botswana's bond market to be inefficient in the weak form.

In summary all the tests that were performed in this study which include the Unit root tests (ADF and KPSS) and the GARCH model uniformly reject the random walk hypothesis suggesting that there is existence of long property memory in the bond return series. This exhibition of non-stochastic process means that the bond returns follow a deterministic chaotic process which opens a room for exploitation of these inefficiencies by investors.

These results mean that though the Botswana bond market is still at an infancy stage in terms of its developments, the efforts to development the market which were geared to improve the operation and efficiency of the market has to date failed to improve the efficiency of the market at least up to the year 2018. Future tests of weak form efficiency in the bond market may need to be done to check if the efforts made to improve the efficiency might not have a coincidental but a lagging impact which might be seen later in the future.

CONCLUSION

This paper examined the efficiency of Botswana's bond market by testing the GovI, CorpI and BBI daily returns using a variety of statistical techniques. Initially we showed the descriptive statistics of the data from which the skewness and kurtosis statistics immediately suggested that the bond indices returns are not weak-form efficient as they did not follow a normal distribution. A non-normal distribution of our three return series provided us with a preliminary suggestion that the random walk condition is violated and hence the bond market might be inefficient in the weak form. See Moustafa (2004) and Mollah (2007) on the importance of a normal distribution as a necessary condition for the random walk model and hence efficiency.

Nonetheless, three other statistical tests were performed to verify the efficiency of the bond market. Based on the results of the ADF test, KPSS test, and the GARCH model, the overall results suggest that Botswana's bond returns are predictable and hence violate the conditions of weak-form market efficiency. These results are consistent with the results expected from an emerging market because empirical evidence does show that emerging bond markets tend not to be weak-form efficient. Research conducted by Bhat (2017) on India's bond market and Thupayagale (2012) on Mexico, Hong Kong and South Africa bond markets does confirm that emerging bond markets tend to be weak-form inefficient.

One would however have expected the bond market to show signs of efficiency due to the developments that have been introduced in the market by relevant parties including the Botswana Stock Exchange, Botswana Bond Market Association and the Bank of Botswana amongst others. With the introduction of the neutral bond indices, ATS and bonds being dematerialised into the BSE CSD, such developments were expected to improve the efficiency of the bond market. Even though improved efficiency was expected, Thupayagale (2014) in his research on Kenya's bond market reforms suggested that the introductions of ATS did not significantly improve the efficiency of the bond market. Therefore, it should not be a surprise that the ATS did not significantly improve the efficiency of Botswana's bond market and the same could be the case with all the other development introduced to date.

There are on-going discussions to centralise into one platform for BSE and Bank of Botswana, bond trading and settlement in the ATS and CSD which potentially could make the market more efficient by improving information dissemination, transparency and liquidity. Other expected development is the introduction of separate debt listing requirement which are currently not available as such but used to be bundled together with Equity listing rules in one book. Introduction of infrastructure bonds, retail bonds and green bonds would be other exciting developments if they could be introduced in the market. Once these developments have been effected there is possibility that the efficiency of the market will improve. As such research on this topic regarding the local bond markets will continue in further as these developments unfold to check if the efficiency of the market has improved. Furthermore, other exogenous variables like bond and equity returns of other markets that trade with Botswana will be introduced in the statistical models that were employed in this research to check their impact.

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