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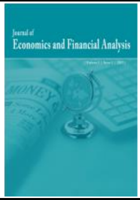

# Bond Indices Maturities and Changing Macroeconomic Conditions: Evidence from South Africa

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## Abstract

*This paper examines the effect of macroeconomic variables on government bond yields of different maturities under two regimes in South Africa. The study employs a Two-Stage Markov regime-switching model to analyze monthly time series data from March 2009 to October 2022. It attempts to explain variations in 1-3 year, 3-7 year, 7-12 year and +12 year government bond yields with six independent variables such as inflation, real GDP, real short-term interest rates, real long-term interest rates, real money supply, and the real Rand/Dollar exchange rate.*

*As a result, the study finds that the performance of government bond yields varies with market conditions, as per the adaptive market hypothesis (AMH). More specifically, the returns of the 1-3 year bond index are influenced by real GDP in a bull regime, while the performance of the 3-7 year government bond yield is affected by real GDP in a bear market condition. Additionally, the inflation growth rate influences the performance of the 7-12 year government bond yield in a bull market regime, but not in a bear regime.*

*It also documents that the bear market conditions prevail among selected bond index returns, with the 12-year government bond yield staying in a bull state for 12 months, while the 7-12 year government bond yield stays the longest in a bear state (19 months). These findings demonstrate that the South African bond market is affected by changing conditions. Therefore, the interaction between the macroeconomy and bond performance is better explained by AMH, and there is potential for improved explanatory power through the use of nonlinear modeling techniques.*

**Keywords:** *Two-Stage Markov Regime Switching Model; JSE; Adaptive Market Hypothesis; Bond Returns; GDP; Inflation Rate; Interest Rate.*

**JEL Classification:** *G11, G12.*

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## 1. Introduction & Literature

A review of the South African (SA) debt market's market capitalisation and liquidity rates suggests it is the largest market in Africa and one of the most liquid markets among emerging economies worldwide (Muzindutsi & Obalade, 2020). The liquidity of the SA bond market provides a vital role in the SA economy, serving as a financing vehicle for various projects. One of these financing vehicles is the issuance of government bonds, which constitute more than 77 percent of all trade instruments on the bond exchange (Mosteanu, 2017). This issuance of government bonds is usually considered for financing the SA infrastructure and includes zero-coupon, fixed-rate, inflation-linked, local currency and foreign currency bonds. The efficiency of the bond market allows for economic stability and reduces foreign risk. The SA bond market topped the rankings of the 46 markets worldwide in 2021, as positive returns were earned by investors engaging in debt trading (Karunungan & Kondo, 2021). The favorable ranking of the SA bond market indicates that potential policy adjustments by the South African Reserve Bank (SARB) may not significantly impact the volatility of the market as the substantial coupon payments, will serve to mitigate the effects of the price adjustments. Therefore, it shows a growing trend among investors who are increasingly considering bonds as an attractive alternative investment. Bonds offer the potential to earn returns at par with or surpassing inflation rates, all while providing a shield against the pronounced volatility often witnessed in aggregate stock markets. (Campbell, 2019).

Despite the limited volatility of the bond market, unlike the stock market, some factors, such as macroeconomic variables, affect the bond market's performance, pricing and yields (Gupta & Modise, 2013). These factors positively or negatively affect a country's economy and may be manipulated by the domestic reserve bank to ensure economic stability. As with the economy, when macroeconomic factors such as inflation, money supply, interest rates, gross domestic product (GDP), and exchange rates fluctuate and deviate from their fundamental value, the overall performance of the bond market is affected (Fredericks, 2014; Utama & Agesy, 2016; Manu & Sarkar, 2017). Accordingly, positive economic growth (increase in GDP and money supply, ceteris paribus) results in elevated levels of demand, which causes bond prices to decrease and yields to increase, contributing to positive returns earned by investors. Consequently, negative economic growth (increase in inflation and interest rates, ceteris paribus) reduces demand and causes bond prices to decrease which results in yields increasing, reducing investor returns (Mosteanu, 2017). This relationship is characterized by a linear effect such that if one macroeconomic variable deviate from its fundamental value, it can either positively or negatively affect bond market pricing and yields, as there is an inverse relationship between bond yields and macroeconomic variables.

According to the Efficient Market Hypothesis (EMH), bond markets reflect information about individual bonds efficiently; as such, there should be a linear relationship between government bond yields and macroeconomic factors (Fama, 1965). However, the Adaptive Market Hypothesis (AMH) suggests that investors do not always act rationally. When such occurs, bond yields deviate from their fundamental value without restoring to equilibrium (Lo, 2009). Consequently, bond markets are not efficient as proposed by EMH, and the occurrence of efficiency and inefficiency tends to alternate with bull and bear markets in what is known as a nonlinear relationship. It is evident from the academic front that there is no consensus on the relationship between macroeconomic variables and bond yields, especially under changing market conditions, as Fredericks (2014), Utama and Agesy (2016), Manu and Sarkar (2017) advocate for a linear relationship, but Muzindutsi and Obalade (2020), Obalade, Khumalo, Maistry, Naidoo, Thwala and Muzindusi (2023) advocate for a nonlinear relationship, at the relationship evolves over time. This is because the studies that advocate for the linear relationship are relatively old. The response of bond market prices/yields to changes in macroeconomic factors under changing/switching market conditions has not been thoroughly investigated as the majority of scholars consider government bond indices and not bond indices at varying maturities. especially in the case of SA and other emerging economies with high levels of macroeconomic uncertainty. The growing popularity of AMH justifies an investigation of this relationship in the context of changing market conditions. This study analysed the effect of macroeconomic variables on JSE government bond yields of varying maturities in the presence of bull and bear market conditions. More specifically, this study compared the levels of bull and bear market conditions across different maturities of the JSE government bond yields. It evaluated how the overall JSE government bond yields respond to the changes in macroeconomic factors in bullish and bearish market conditions. Moreover, the EMH and AMH were tested to determine if the SA bond market is efficient, as there is no consensus among scholars regarding the efficiency of the SA bond market.

## 2. Literature Review

It is noted in the academic literature that at least two key theoretical explanations exist for bond market yields/prices and macroeconomic variables. These theories include the efficient market hypothesis (EMH) and the adaptive market hypothesis (AMH). EMH, coined by Fama (1965), suggests that financial markets efficiently reflect information about individual bonds/or the bond market as a whole. This hypothesis is related to the concept of random walk, which characterises subsequent price changes as random deviations from previous prices (Malkiel, 2003). The efficient market hypothesis is based on the view that new information is incorporated into security prices without a lag and that the new information received determines the level of efficiency. Therefore, there are three assumptions of EMH: a weak-form efficient market, a semi-strong-form efficient market and a strong-form efficient market (Malkiel, 2003). Of the three versions of EMH, the semi-strong form efficient market illustrates that macroeconomic fundamentals did not allow for the prediction of bond prices/yields; hence, a linear relationship existed between macroeconomic factors and bond prices/yields. However, the weak-form efficient version illustrates that macroeconomic fundamentals can be used to predict bond prices/yields. If such is true, then there also should exist a nonlinear relationship between bond prices/yields and the macroeconomy (Yen & Lee, 2008). This essentially implies that bond prices/yields are predictable from past prices, and fundamental analysis can be used to earn excess returns. EMH dominated the literature for decades (Atanasov, Pirinksy & Wang, 2018). However, AMH is a competing theory that has contributed to the dissipation of EMH.

The basis of the AMH involves a revolutionary outlook of behavioural economics, including principles such as competition, reproduction, mutation and natural selection (Ghazani & Ebrahimi, 2019). The argument proposed by AMH is that the occurrence of efficiency and inefficiency tends to alternate with bull and bear markets in what is known as changing market conditions (Obalade & Muzindutsi, 2018). AMH, thus, shows that bond markets' alternating efficiency and inefficiency are the key attributes of changing market conditions (Lo, 2004). As such, AMH implies that macroeconomic variables should have an alternating effect under a bullish and bearish market. The impact of macroeconomic variables on bond prices/yields in an upper market condition is not expected to be the same in a lower market condition, as the bond market performs differently under each market condition. As a result, market participants could earn excess returns as markets are not always efficient due to various market participants' behaviour and changing market conditions.

Several critics of AMH raised the question that it is rather abstract and qualitative (See, Zhou & Lee, 2013; Urquhart & McGroarty, 2016). However, these academics fail to understand that AMH contains three astonishing yet concrete implications concerning financial activities (Lo, 2004). The first is that if a relationship exists between risk and reward, it is improbable that it remains constant over time. The second implication contradicts EMH, which proposed that arbitrage opportunities exist as time varies. The third implication is also seen to be contrary to EMH. It implies that under AMH, investment strategies may fall for a period as the environment becomes more favourable for market participants, and it returns to profitability (Lo, 2004). These implications explain the adapting relationship between bond markets and macroeconomic variables, as the relationship between macroeconomic fundamentals and bond market returns must be nonlinear.

It is evident from the review of empirical evidence that many studies have considered the macroeconomy and bond prices/yields. Accordingly, these studies factored in the symmetrical effect as proposed by EMH. For example, Chowdhury, Bayar and Kilic (2013) examined the impact of macroeconomic factors on emerging market bond prices/yields. Using the panel regression model, the authors find a negative relationship between inflation and bond yields and a positive relationship between gross domestic product (GDP) and bond yields. Fredericks (2014) also examined macroeconomic factors' effect on bond yields. However, the panel regression model findings suggest that exchange rates, interest rates and GDP positively influence the Kenyan bond market. The findings were confirmed by a study conducted by Utama and Agesy (2016), as they found that exchange rates and interest rates positively influence SA bond yields. Despite the confirmed findings, Ngabirano (2016) found that inflation, interest, and exchange rates do not significantly impact South African (SA) bond performance.

Ameer (2007) used the vector autoregressive model (VAR) to determine the influence of selected macroeconomic variables on the Malaysian bond market. The model's findings suggested a bivariate relationship exists between bond yields and inflation, money supply, interest rates and GDP. Zhou (2020) also examined the effect of macroeconomic factors on bond yields. Using the Auto-regressive distributed lag (ARDL) model, the study found that inflation, exchange rate, money supply, and GDP negatively affect SA bond market performance. Ahwireng-Obeng (2020) confirmed these findings as inflation, exchange rate, money supply, and GDP had a negative impact on SA bond market performance.

Despite the large amounts of empirical evidence surrounding the symmetrical relationship between macroeconomy and bond index prices/yields, limited studies have considered the asymmetrical influence of macroeconomy on bond index prices/yields since the formation of AMH both internationally and domestically. Muzindutsi and Obalade (2020) examined the effect of country risk changes on the SA bond market under bull and bear market conditions. Using the Two-state Markov model, they find that bond yields stay longer in a bullish regime, and country risk has no significant effects on government bond yields under changing market conditions. Similarly, Obalade et al. (2023) used the Two-state Markov regime model. However, they examined the effect of macroeconomic variables on JSE bond index prices/yields. The study's findings indicate that corporate bonds are influenced by inflation, exchange rate and GDP in a bull and bear market regime. However, the bull regime's exchange and interest rates only affect the government bond index yield.

The review of existing literature demonstrates a research gap surrounding the effect of macroeconomic variables on bond index prices/yields under changing market conditions in emerging markets. Studies have examined the symmetrical effect (See, Fredericks, 2014; Utama & Agesy, 2016; Ameer, 2007). However, these studies do not consider regime changes. There is a need for more studies to be considered which factor in the asymmetrical effect as only Muzindutsi and Obalade (2020) and Obalade et al. (2023) considered such in the South African context. However, Muzindutsi and Obalade's (2020) study focuses on country risk effects on SA government bond yields. Hence, the study does not provide definitive conclusions surrounding the impact of macroeconomic factors on government bond yields and the overall bond market of South Africa. Moreover, Obalade et al.'s. (2023) study is limited to three bond indices (all-bond index, corporate bond index and government bond index), The study centred around bond indices, not government bond yields of varying maturities. Hence, it is important to understand how different bond maturities respond to macroeconomic variables under changing market conditions as investors consider riskless investments to enhance their portfolio return. To bridge the research gap, the study examines the effect of macroeconomic variables on government bond yields of varying maturities under changing market conditions.

## 3. Data and Methodology

### 3.1. Data Collection and Sampling

The study used a monthly time series data set covering 2009/03 to 2022/10. The sample period filters the effects of the 2008/2009 global financial crises and Covid-19, which plays a crucial role in the choice of modelling adopted in this study, the Markov-Switching regime model. The variables included in the sample are the monthly closing yields for South African government bond indices (1–3-year bond index, 3-7 year bond index, 7-12 year bond index and over 12-year bond index). The variables were considered in relation to empirical evidence, as most studies consider bond index returns and did not focus on government bond yields of varying maturities (Obalade et al., 2023). It is, therefore, important to understand how government bonds of different maturities respond to the SA macroeconomy, as most investors consider these riskless investments to minimize portfolio volatility. All these government bond variables were obtained from the IRSS. Real macroeconomic variables were obtained from the South African Reserve Bank (SARB) and Statistics South Africa (StatsSA). Empirical literature was used to select the variables, and only those macroeconomic variables that contribute significantly to the SA economy were considered. It consisted of the inflation (CPI) rate, gross domestic product (GDP), short-term interest rate, long-term interest rate, Money Supply (M2) and Rand/Dollar exchange rate. GDP is not available monthly. As a result, it is converted from quarterly to monthly data using the quadratic average interpolation approach, as done by Dlamini (2017).

### 3.2. Empirical Model Specification

To determine the impact of macroeconomic factors on government bond yields under changing market conditions, the study relied on the regime-switching model, which allows for the parameters to switch with the economy's state. In this model, the JSE bond yield returns ($I_t$) are assumed to follow a process governed by an unobservable state variable $C_t$. The occurrence of a regime is divided into *N* states in period *t* when $C_t = N$, where *N* = 1,2,3…., *N*. The Markov regime-switching model of the conditional mean permits each regime with an alternate regression model. The model is specified as follows:

$$\mathrm{I}_t = \mu_{ct} + \alpha_{0ict}\Delta CPI + \alpha_{1ict}\Delta M2 + \alpha_{2ict}\Delta STI + \alpha_{3ict}\Delta \mathrm{LTI} + \alpha_{4ict}\Delta \mathrm{GDP} + \alpha_{5ict}\Delta EXR + \varepsilon_{c_{t,}} \quad (1)$$

Where $\varepsilon_{c_{t,}}$ i. i. $d$ $(0, \sigma^2_{c_{t,}})$, $\mathrm{I}_t$ refers to the SA government bond yields of varying maturities, $\mu_{ct}$ is the state-dependent intercept (mean), $\sigma^2_{c_{t,}}$ is the regime-dependent variance of the returns, and $C_t$ = 1,2 illustrates two regimes, namely bull (1) and bear (2) regimes, where the macroeconomic variables contain state-dependent coefficients. $\Delta CPI$ is the change in the SA inflation rate, $\Delta M2$ is the change in the SA real money supply rate, $\Delta STI$ is the change in SA short-term real interest rate, $\Delta\mathrm{LTI}$ is the change in SA long-term real interest rate, $\Delta\mathrm{GDP}$ is the change in real gross domestic product and, $\Delta EXR$ is the change in the real Rand/Dollar exchange rate.

Each regime is given to follow a first-order Markov process demonstrated by the transition probability matrix. Under the first-order Markov process, the possibility of being in a specific regime is dependent on the most recent state, which is demonstrated as follows:

$$Prob(\, C_t = j \mid C_{t-1} = i\,) = Prob_{ij}(t) \quad (2)$$

Where $ij$ is the probability of switching from a regime denoted as $i$ in a period denoted $t-1$ to a regime *j* in a specific period ($t$) where the probability is given to be constant for all periods so that $Prob(t)$= $Prob_{ij}$. Hence, the matrix for a two-regime model is given by:

$$Prob\ [C_t = 1 \mid C_{t-1} = 1] = Prob\ 11 \quad (3)$$

$$Prob\ [C_t = 2 \mid C_{t-1} = 1] = 1 - Prob\ 11 \quad (4)$$

$$Prob\ [C_t\ =\ 2|\ C_{t-1}\ =\ 2]\ =\ Prob\ 22 \quad (5)$$

$$Prob\ [C_t\ =\ 1|\ C_{t-1}\ =\ 2]\ =\ 1 - Prob\ 22 \quad (5)$$

Where $Prob_{11}$ is the probability that the government bond yield is at state one (bullish state) at $t-1$ and remains there at time $t$, $Prob_{21}$ is the probability that the returns are at state one (bullish state) at $t-1$ and move to state two (bearish state) at time $t$. $Prob_{22}$ is the probability that the government bond yield is at state two (bearish state) at time $t-1$ and remains there at time $t$, $Prob_{12}$ is the probability that the government bond yield is at state two (bearish state) at $t-1$ and moves to state one (bullish state) at time $t$ (Brooks, 2019). The probability of staying in each regime is generated and compared across the different JSE government bond yields. A logit model is followed when the probability of changing from regime $i$ to $j$. Hence, the transition matrix rows above contain a complete set of conditional probabilities. A new logit model is determined for each row of the transition matrix:

$$Prob_n(G_{t-1}, d_i) = \frac{\exp(G'_{t-1}, d_{ij})}{\sum_{s=1}^{N} \exp(G'_{t-1}, d_{is})} \quad (7)$$

Where j = 1, …, N and i = 1, …, N with the normalisations $d_{iN}$ = 0. Markov regime-switching models are normally and generally specified with constant probabilities so that $G_{t-1}$ contains only a constant. Therefore, the estimates from equation 3 to 6 identify bull and bear states and provide the total number of months each JSE government bond yield stayed in bull and bear regimes. The transition probabilities and the constant's expected duration of each regime are compared across the JSE government bond yields of different maturity to identify how each bond yield of different maturities shifts between bull and bear regimes.

## 4. Results and Analysis

### 4.1. Descriptive Statistics

Table 1 depicts the common sample descriptive statistics of the JSE government bond yield and SA real macroeconomic variables. The JSE government bond yield attained all negative average monthly returns. It is evident that the 3-7 year government bond yield attains the highest average return for the sample period, whereas the over 12-year government bond yield demonstrates the lowest average returns. It is evident that the JSE government bond yields behave differently when faced with different macroeconomic conditions. Hence, the findings of varying effects among the JSE government bond yields. This suggests that market cycles effect the function of yields. Moreover, all the JSE government bond yields, except for the 7-12 year government bond yield distribution, are positively skewed. The JSE government bond yields distribution is leptokurtic. Thus, the JSE government bond yield has no standard bell curve as the returns peak and flattens. The Jarque-Bera test of normality confirms this. The real money supply growth rate has the highest average growth, and the inflation growth rate has the lowest average growth for the sample period. The inflation growth rate attains the highest maximum, minimum and standard deviation values, whereas the real money supply growth rate is lowest within this context. All variables except inflation and real short-term interest growth rates were positively skewed. Moreover, only the real exchange growth rate indicates a kurtosis of less than three. The Jarque-Bera test of normality confirms this as the null hypothesis is not rejected at a 1 percent level of significance.

**Table 1.** Descriptive Statistics

| | Mean | Median | Max. | Min. | Std.Dev. | Skewness | Kurtosis | Jarque-Bera | Obs. |
|---|---|---|---|---|---|---|---|---|---|
| *1-3 Year* | -0.1404 | -0.2479 | 25.3657 | -21.2878 | 7.1189 | 0.2755 | 4.8252 | 24.84*** | 164 |
| *3-7 Year* | -0.0056 | 0.0985 | 24.9204 | -22.7424 | 7.2464 | 0.1951 | 4.7085 | 20.98*** | 164 |
| *7-12 Year* | -0.0135 | 0.0558 | 8.3653 | -12.4807 | 2.3011 | -0.8438 | 8.7062 | 241.96*** | 164 |
| *+12 Year* | -0.1045 | -0.2784 | 26.0548 | -21.2092 | 7.4351 | 0.3069 | 4.4364 | 16.67*** | 164 |
| *ALBI* | -0.0656 | -0.1339 | 25.4487 | -21.7945 | 7.3047 | 0.2928 | 4.5609 | 18.99*** | 164 |
| *ΔCPI* | -0.1289 | 0.0000 | 20.0000 | -21.2121 | 5.3077 | -0.1084 | 6.2411 | 72.11*** | 164 |
| *ΔM2* | 0.5599 | 0.4262 | 6.2862 | -3.0828 | 1.3629 | 0.5689 | 4.0465 | 16.33*** | 164 |
| *ΔSTI* | -0.1477 | -0.0119 | 13.7301 | -24.2032 | 3.9548 | -1.4899 | 12.3884 | 662.98*** | 164 |
| *ΔLTI* | 0.2607 | -0.0376 | 17.7352 | -10.1201 | 3.2851 | 1.1530 | 9.093 | 290.02*** | 164 |
| *ΔGDP* | 0.5295 | 0.4890 | 24.3533 | -20.0638 | 2.7857 | 1.4099 | 51.9996 | 16460.88*** | 164 |
| *ΔEXR* | 0.4222 | -0.0805 | 11.9500 | -9.7128 | 3.4729 | 0.3376 | 3.589 | 5.486*** | 164 |

**Notes:** The *, **, and *** indicates significance levels of 10%, 5%,and 1% respectively.

### 4.2. Correlation Analysis

Table 2 suggests a significant negative association between inflation growth rate and 1-3 year government bond yield, 3-7 year government bond yield, over 12-year government bond yield and the All-Bond Index yield. A significant positive association exists between real long-term interest rates and 7-12 year government bond yield. In addition, the 1-3 year government bond yield, 3-7 year government bond yield, and all bond yields have a significant negative association with the real GDP growth rate. These findings align with empirical literature as there is an inverse relationship between government bond yields and macroeconomic variables. No significant relationship exists between the real money supply growth rate, real short-term growth rate, real exchange rate and the JSE bond indices yields.

**Table 2.** Correlation Analysis of JSE Bond Indices Returns and Macroeconomic Factors

| | 1-3 Years | 3-7 Years | 7-12 Years | +12 Years | ALBI |
|---|---|---|---|---|---|
| Δ***CPI*** | -0.6647*** | -0.6579*** | 0.0245 | -0.6288*** | -0.6469*** |
| Δ***M2*** | 0.1217 | 0.1166 | 0.0081 | 0.0919 | 0.1067 |
| Δ***STI*** | -0.0435 | -0.0008 | 0.1203 | 0.0415 | 0.0249 |
| Δ***LTI*** | -0.0334 | 0.0124 | 0.1376* | 0.0376 | 0.0288 |
| Δ***GDP*** | -0.1468** | -0.1354* | -0.0311 | -0.1265 | -0.1307* |
| Δ***EXR*** | 0.0368 | 0.0503 | 0.0409 | 0.0380 | 0.0418 |

**Note:** The correlation coefficient test is estimated using the ordinary method with probability test statistics. ***, ** and *indicate a 1%, 5% and 10% significance level, respectively.

### 4.3. Unit Roots Results

Table 3 shows the test statistic of the ADF and KPSS tests. The ADF test is more negative than the critical values at a 1 percent significance level. Thus, rejecting the null hypothesis that the JSE government bond yields and real macroeconomic variables contain a unit root in favour of the alternative hypothesis that the JSE government bond yields and macroeconomic variables are stationary. The stationarity test of KPSS confirms the findings of the unit root tests for all indices and real macroeconomic variables. The breakpoint unit root test confirms the stationarity of the JSE government bond yields and real macroeconomic variables in the presence of structural breaks. The null hypothesis of a unit root is rejected in favour of the alternative hypothesis of stationarity, as the test statistic is more negative than the critical values at a 1 percent significance level. The study concludes that the government bond yields and real macroeconomic variables are stationary in levels and structural breaks.

**Table 3.** Unit Roots Results

| | ADF | KPSS | ADF' | | ADF | KPSS | ADF' |
|---|---|---|---|---|---|---|---|
| ***1-3 Years*** | -12.54*** | 0.12*** | -20.50*** | ***ΔCPI*** | -11.51*** | 0.22*** | -12.79*** |
| ***3-7 Years*** | -12.03*** | 0.21*** | -19.94*** | ***ΔM2*** | -7.12*** | 0.18*** | -13.88*** |
| ***7-12 Years*** | -14.89*** | 0.17*** | -16.05*** | ***ΔSTI*** | -6.16*** | 0.18*** | -10.93*** |
| ***+12 Years*** | -11.09*** | 0.30*** | -19.27*** | ***ΔLTI*** | -10.83*** | 0.15*** | -11.91*** |
| ***ALBI*** | -11.73*** | 0.31*** | -19.59*** | ***ΔGDP*** | -5.28*** | 0.22*** | -10.10*** |
| | | | | ***ΔEXR*** | -9.57*** | 0.20*** | -10.24*** |

**Notes:** The *, ***, ** and * indicate a 1%, 5% and 10% significance level, respectively. The LM critical values of the KPPS test are 1% = 0.739, 5% = 0.463, and 10% = 0.347. The ADF and KPSS estimates derived with Unit Root Test levels, whule ADF' estimates are Break Point Unit Root Test in levels.

A significant requirement by the Markov regime-switching model of conditional mean with constant transition probabilities is the presence of stationarity with structural breaks in the data series. The model assumes that the transition probabilities are constant throughout time (Hamilton, 1989). The model is biased towards estimations with nonstationary data with structural breaks as it does not cater for the nonstationary series' break periods. Given that the data series was stationary in the presence of structural breaks, the study proceeds by estimating the Markov regime-switching model of conditional mean with constant transition probabilities.

### 4.4. Empirical Findings: Markov Regime-Switching Model Results

Table 4 estimates the Markov regime-switching model with constant transition probabilities. The findings demonstrate that the inflation growth rate has a significant positive effect on the 7-12 year government bond yield in a bull market condition and a significant negative effect on 1-3 year government bond yield and 3-7 year government bond yield, over 12-year government bond yield and the ALBI government bond index in a bullish market condition. In the bear market condition, the inflation growth rate significantly negatively affects all government bond yields except for the 7-12 year government bond. The real money supply growth rate significantly positively affects 7-12 year government bond yields in a bearish market condition but has no significant effect on government bond yields in a bullish market condition. The real short-term interest growth rate has a significant positive impact on over 7-12 year government bond yields in a bull regime but no significant effect on government bond yields in a bear market regime. The real long-term interest growth rate does not significantly affect government bond yields in a bull and bear market condition. The real GDP growth rate has a significantly positive (negative) effect on 1-3 year government bond yield and over 12-year government bond yield (7-12 year government bond yield) in a bull market condition. The real GDP growth rate positively affects 3-7 year government bond yield and the ALBI government bond index in a bear market condition. The real effective growth rate does not significantly affect the JSE government bond yields in a bull or bear regime.

**Table 4.** Markov Regime-Switching Model of Conditional Mean

| Variables | 1-3 Years | 3-7 Years | 7-12 Years | + 12 Years | ALBI |
|---|---|---|---|---|---|
| **Regime 1:** Bull Market Condition | | | | | |
| $\mu$ | -3.2104** | -0.8936 | -2.2077 | -0.6182 | -0.5593 |
| $\alpha^0$ | -0.8330*** | -0.8258*** | 0.5413** | -0.8569*** | -0.8960*** |
| $\alpha^1$ | 1.1735 | 0.8802 | 1.1454 | 0.2899 | 0.5551 |
| $\alpha^2$ | 0.9501 | 0.1843 | 0.5698** | 0.1503 | 0.4334 |
| $\alpha^3$ | -0.6822 | -0.0460 | 0.1086 | 0.0489 | 0.1959 |
| $\alpha^4$ | 2.2988* | -0.1222 | -0.7357* | 0.8911** | -0.1302 |
| $\alpha^5$ | 0.2400 | 0.002 | 0.3350 | -0.2349 | 0.1651 |
| $\sigma^2$ | 1.9581*** | 1.9284*** | 1.0230*** | 1.29990*** | 2.0528*** |
| ***Transition Probabilities and Expected Duration Probabilities*** | | | | | |
| $P_{11}$ | 0.5007 | 0.8316 | 0.6313 | 0.9183 | 0.8232 |
| $T_{11}$ | 2.0028 | 5.9371 | 2.7123 | 12.243 | 5.6561 |
| **Regime 2:** Bear Market Condition | | | | | |
| $\mu$ | 0.4316 | -0.3427 | 0.1601 | -0.3933 | -0.5485 |
| $\alpha^0$ | -1.0211*** | -1.0270*** | -0.0202 | -0.9145*** | -0.9063*** |
| $\alpha^1$ | -0.0464 | 0.0544 | -0.2157* | 0.6520 | 0.3893 |
| $\alpha^2$ | -0.0378 | -0.0111 | 0.0410 | 0.5907 | 0.1503 |
| $\alpha^3$ | -0.0438 | -0.1482 | -0.0284 | 0.1576 | -0.0243 |
| $\alpha^4$ | -0.1071 | 0.9315*** | 0.0287 | -0.1289 | 0.8605** |
| $\alpha^5$ | -0.1016 | -0.0031 | -0.0092 | 0.3146 | -0.1814 |
| $\sigma^2$ | 0.9648*** | 0.7256*** | 0.4774*** | 2.1003*** | 1.1871*** |
| ***Transition Probabilities and Expected Duration Probabilities*** | | | | | |
| $P_{22}$ | 0.7522 | 0.8217 | 0.9483 | 0.8061 | 0.9072 |
| $T_{22}$ | 4.0362 | 5.6114 | 19.346 | 5.1587 | 10.7797 |

It is evident from the table above that the over 12 year government bond yield stayed the longest in a bull market condition (12 months), followed by 3-7 year government bond yield (5.9 months), ALBI government bond index (5.5 months), 7-12 year government bond yield (2.7 months) and 1-3 year government bond yield (2 months). However, 7-12 year government bond yield stayed the longest in bear market conditions (19 months), followed by ALBI government bond index (10 months), 3-7-year government bond yield (5.6 months), over 12 year government bond yield (5.1 months) and 1-3-year government bond yield (4 months). Hence, there are longer bear market periods than bull market periods, which is confirmed by the transition probabilities ($P_{11}$ and $P_{22}$).

## 5. Discussion of the Results

It is evident from the review of empirical evidence that one study in the South African context has considered the effect of real macroeconomic variables on bond performance under changing market conditions - that is, Obalade et al. (2023). Hence, the results will be compared to that of the current study. This study finds inflation growth rate and real GDP growth rate have an alternating effect on government bond yields in a bear and bull market regime. However, the findings do not align with Obalade et al. (2023), as they find that inflation and real GDP growth rates have no significant effect on the government bond index returns under both regimes. This suggests that inflation and real GDP growth rates should not influence the bond market's performance under changing market conditions despite the current study finding the opposite. The deviations in results can be attributed to Obalade et al. (2023) using a single bond index as a proxy for government bonds in SA instead of using different forms of government bonds, as presented in this study. A single bond index fails to reflect the various responses by other bonds of varying maturities. The analysis of the SA bond market must consider different bond maturities as it provides a more accurate understanding of the SA bond market when it is faced with changing market conditions. Thus, the findings of Obalade et al. (2023) are isolated to that of the government bond index as opposed to the individual government bonds comprising the various government bond yields of varying maturities.

It is seen that real macroeconomic variables have an alternating effect on each JSE government bond yield. In some cases, the real macroeconomic variables significantly impact JSE government bond yields in a bear regime and have an insignificant effect in a bull regime and vice versa. Thus, the JSE government bond yields present alternating efficiency and inefficiency. Similar findings were found by Obalade et al. (2023), as the authors found real interest rates to influence government bonds in a bull regime significantly but not in a bear regime. The explanation is attributed to the assumption that real macroeconomic variables' effect on bond markets is regime-dependent; the alternating efficiency effect varies according to regimes. It varies as the performance of bond markets under each regime is known; in an upper market condition, bond market yields increase, whereas bond market yields decrease in a lower market condition (Davies, 2013). Bond markets do not follow a random walk process as yields of the individual government bond are known to investors, contrary to EMH (Obalade & Muzindutsi, 2018; 2019). Research has revealed that there are longer bearish market periods than bull market periods among JSE government bond yields due to the state of the SA economy and lower economic growth. Moreover, it is found that emerging bond markets are more prone to financial market shocks more specifically interest rate cuts by the South African Reserve Bank (SARB). This assumes that the yields are negative and decreasing over time for the relevant JSE government bond yields. Such decreasing and negative yields do not favour investors, as negative yields generate negative returns. It does not attract investors' participation and decreases the contribution to the financial sector and, in turn, the SA economy. The finding is illuminating as studies by Guidolin (2016) and Maheu and McCurdy, and Song (2012) found a higher presence of a bull market condition among sectors of financial markets. Hence, it is evident that the SA bond market behaves differently from other bond markets, as which makes the SA bond market unique and economy dependent.

## 6. Conclusion

The study investigated the regime-switching effect of macroeconomic variables on JSE government bond yields under the AMH framework. The study found that macroeconomic factors affect the JSE government bond yields differently under changing market conditions. The bearish market condition is most persistent among the JSE government bond yields. The findings suggested that the response of the JSE government bond yields to changes in the real effective exchange rate, inflation, short-term and long-term interest rates, and industrial production is subject to adaptive market behaviour. Implying that the SA bond market is not always efficient as proposed by the EMH, as different bond maturities depicted varying responses to macroeconomic conditions. Hence, the SA bond market is not always efficient as the SA bond market changes with market conditions, consistent with the AMH. As a result, the study's alternating efficiency effect under changing market conditions suggests that the AMH explains macroeconomic variables' effect on JSE government bond yields and could be better modelled by nonlinear models. Policymakers should consider that the effect of macroeconomic variables on JSE government bond yields varies with regimes and develop appropriate policies. Investors should consider the switching responses of JSE government bond yields to changes in macroeconomic conditions in their investment decisions. Moreover, portfolio rebalancing should be considered when market conditions switch from bull and bear regimes. Hence, hedging of macroeconomic exposure should be aligned with changing conditions.

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