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YIELD CURVE, INFLATION, EXCHANGE RATE AND THE NIGERIA'S FUTURE ECONOMIC GROWTH: A VAR APPROACH

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Abstract

This paper analysed the predictive ability of the yield curve on macroeconomic variable or real activity (GDP) using Vector autoregressive (VAR) model for Nigeria. A quarterly data was utilized for the period 2003q1 to 2023q4. One popular stylized fact in macroeconomics remains the forecasting ability of the term spread (yield curve) for future real activity (recessions). A vector autoregressive model was adopted for the data analysis. Four (4) different VAR equations were specified according to the total number of variables under study. The 4-variables are real GDP growth (RGDP_G), yield curve (YC), consumer price index (CPI) and exchange rate volatility index (EVIX). One major finding of the paper remains the observation of the yield curve's predictive ability on recessions. This was observed from the monetary policy tightening of the Central Bank of Nigeria (CBN), which leads to flattening of the yield curve as it reduces the net interest margin, reduced credit supply or loans supply or credit advancement and finally reduced economic activities (recession). Based on this, it has been recommended that both short-term and long-term interest rates be raised simultaneously to avoid flattening of the YC and in essence to avoid the spiral through the balance sheet monetary policy transmission mechanism.

Keywords: Consumer price index, exchange volatility index, monetary policy, real GDP growth, vector autoregressive, yield curve,

JEL Codes: E43, E31, F39, O47

1. Introduction

The relationships among the yield curve, exchange rate, inflation and economic growth have garnered significant attention in macroeconomic arena, particularly in developing economies such as Nigeria. The yield curve indicating the term structure of interest rates serves as an important tool for assessing market expectations about future interest rates and economic conditions. In advanced economies, an inverted yield curve is often a predictor of recessions. The predictive power of the yield curve in emerging markets like Nigeria remains an area requiring further investigation (Akpan & Umoh, 2020). The Nigeria's macroeconomic environment has been notably influenced by persistent inflationary pressures, coupled with volatile exchange rate movements and uneven economic growth patterns. The exchange rate

volatility, often driven by oil price fluctuations and capital flow dynamics, has had profound implications for inflation and economic growth (Adeniran, Yusuf, & Adeyemi, 2014). The depreciation of the naira, particularly in the aftermath of the 2016 economic recession in the country and the Covid-19 pandemic, has further generated inflationary pressures, eroding purchasing power and destabilizing investment outlooks. (Central Bank of Nigeria [CBN], 2022).

This paper tries to understand the link among the yield curve, exchange rate and the attendant consequence on the economic growth of the country. The yield curve represents the graphical relationship of the nominal yield-to-maturity (YTM) on bonds or short-term interest rates. There are other classes of yield curves from fixed income assets like the corporate bonds, high yield bonds and other bonds markets worldwide, Nigeria inclusive. The current levels of inflation rate, short-term interest rate and nominal exchange rate depreciation make studying their links important. The yield curves after being estimated can indicate a positive, negative (inverted) or inverted parabolic (lumped) slopes. It is used mainly to predict the future direction of the economy (growth or recession). For instance, a positive yield curve slope predicts economic growth and negative curve slope predicts recessionary possibility (Bauer & Rudebusch, 2020). In Nigeria, the yield curve can be seen to exhibit such movement as can be seen in Figure 1.1:

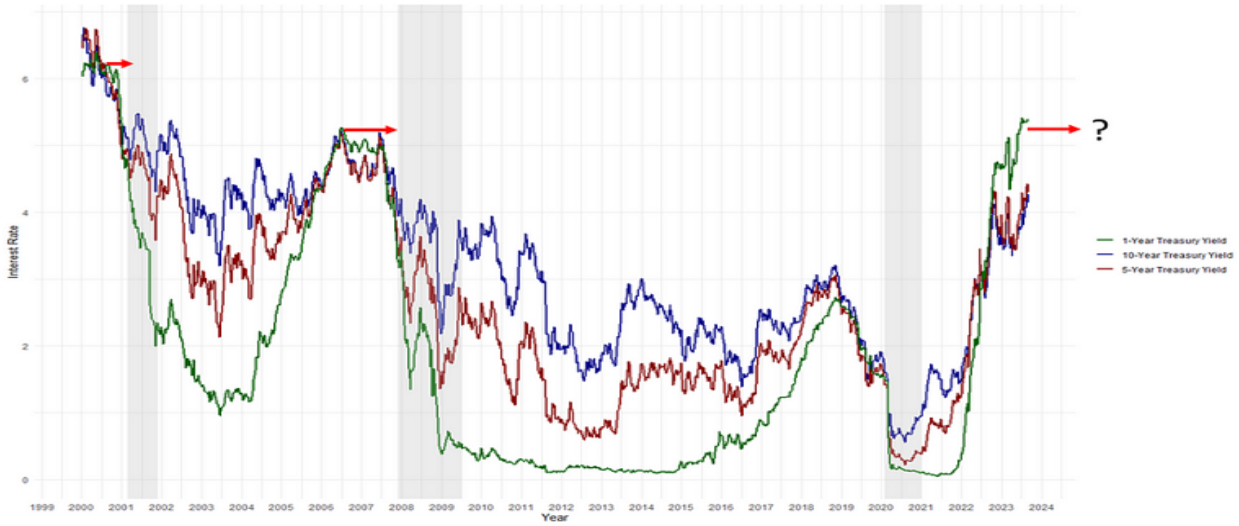

Figure 1.1: Nigeria's Yield Curve 1999 – 2023
Source: EFG International (2023).

From the Figure 1.1, the Nigeria's spread between the 3-month treasury bill and the 10-year treasury yield, commonly referred to as the yield curve spread was presented. The yield curve remains vital indicator in financial markets, particularly given the historical strength of its inversion predicting recessions in many countries across the World particularly the US economy (Bayaa & Qadan, 2024). An inversion of the spread signals that markets believe current policy may be too restrictive, potentially triggering an economic slowdown (recession) and vice-versa.

Attempts have however been made to link macroeconomic variables to the term structure of say, interest rates or exchange rates using dynamic macro models. But one could argue that both theoretical and empirical breakthrough, there exist limited agreement

about how macroeconomic information should be modelled into yield curve analysis. The neglected link in recent times between the macroeconomy and the yield curve remains time-varying long-run means of macro series and nominal exchange rates that this paper is trying to fill, using data from Nigeria. In most term structure works in finance, constant long-run means are observed but accounting for changes in the macro and finance variables are essential for modelling the term structure, measuring the bond risk premia and forecasting yields (Rudebusch & Swanson, 2012).

However, different approaches in measuring the yield curve and its impact on the macroeconomy have been utilized, starting with usually the regression-based approach, with different forecasting results. The other techniques used are probability models, specifically, discrete turning points. But the turning points most often than not are hard to predict the yield curve as predictor of recessions (Bordo & Haubrich, 2020).

2. Related Literature

In the whole of literature analyzing the predictive ability of the yield curve, two works are found to be the dominant ones; Harvey (2014) & Estrella and Hardouvelis (1991). Havey argued his work from a great deal of micro-founded theory of asset pricing. To many researchers, the use of Harvey model may came not as a surprise, especially by seeing how yield curve predicts recessions. His paper titled "The real term structure and consumption growth" tested the implication of the consumption-based capital-asset pricing model. But his variable was not output (to predict recessions) but per capita consumption and the real interest rate but his model ended being replicated to measure recessions by other researchers. Estrella and Hardouvelis (1991) on the other hand, focused on the empirical facts and were skeptical of the theoretical foundations to explain yield curve predictability of macroeconomic outcomes like recessions. Their work started by gathering the opinions of business economists and analysts that reported the US 1989 yield curve inversion to predict the period's recession. They further tried to assess how much extra information is in the term structure (the yield curve) above other variables. This was possible when they started predicting the cumulative percentage change in real GNP, thereby regressing it on the 10-year-3-month spread using quarterly averages (Haubrich, 2021).

In other similar studies, Guidolin and Thornton (2018) indicated that monetary level variables inclusion to term structure models increase to a greater extent their predictive abilities of recessions. Augustin, (2018) observed that the links among bond yields, uncertainty and global shocks. The term structure is also very important in predicting real activity like during Covid-19 pandemic bonds market disruptions, leading to liquidity crunches and finally affect real activity (Duffie, 2020; O'Hara & Zhou, 2021; Kargar et al., 2020). In the works of Cooper, Fuhrer and Olivei (2020), they examined the predictive aspect of the yield curve for the monetary policy and found that a yield curve inversion likely overstates the probability of a recession, especially when the neutral funds rate is accommodative. Bordo and Haubrich (2020) argued that using historical evidence on the low inflation levels and low interest rates environments in the late 1800s, the 1930s, the 1940s and the 2007/08 financial crisis, predicted recessions and seen in industrial production (IP) and real GDP. They further corroborated the use of quarterly data to produce strong evidence.

However, some studies apart from using yield curves for predictions, short rates are also added to aid in predicting real activities. For

instance, Liu and Moench (2016) indicate that using in-sample model and short rate in addition to yield curve may fail to explain recessions. Bauer and Mertens (2018) also added the natural level of real interest rates and found that it exerted little influence on recessionary predictions of the yield curve, especially in low rates periods of monetary regimes. These studies are important in trying to understand the low rates of short-term and long-term rates (the yield curve) in predicting real activities (Ramey & Zubairy, 2018; Sims & Wu, 2020).

In the works of Lenel, Piazzesi and Schneider (2019) indicated in their study that interest rate policy shocks spilled over to the rest of an economy through bank balance sheets. They argued that banks create money through holding of short-term securities, thereby producing safe ground yield for the short-term assets. Engstrom and Sharpe (2019) proposed a new spread and argued that it best takes into account upcoming movements in the short-term provided robust predictions compared to usual yield curve. They utilized the implied rate on a 3-month T-bill 6 quarters ahead less the rate on a current 3-month T-bill. According to them, if the spread is negative, it likely indicates an easing of monetary policy as the monetary authorities expect a recession. They also indicated evidence that the new spread provides better than the usual 10-year 2-year spread.

Further, in another strand of the existing literature, some studies investigated the influence of housing, banking and credit supply conditions on analyzing individual recession forecasting abilities. In the work of Favara et al. (2016) that corporate credit spreads like the excess bond premium (EBP) was found to predict recessions in the United States. Minghui and Liya (2018) and Chatterjee (2016) indicated that banks' economic outputs usually measured by bank liquidity creation (LC) forecast economic crises and recessions.

To conclude on the reviews, the reported literature on the relationships between macroeconomy and yield curve is important to understand what holds for Nigeria's data and to report the findings. Also limited or no study was observed in Nigeria on the relationship between the yield curve and economic output or GDP and also this study integrates as a control variable the relevance of exchange on the relationship.

3. Methodology

The links among real exchange rate, the slope of the yield curve, inflation rate (CPI) and real economic activity (real GDP growth) in Nigeria are investigated using a vector autoregression (VAR) model. A quarterly data of real GDP growth (RGDP_G) as a measure of real activity from the CBN statistical bulletin, the 10-year-3-month term bond spread or the yield curve (YC), the quarterly change in the Exchange Volatility Index (EVIX) as a measure of risk and the quarterly consumer price (CPI) as a measure of inflation are used for the study. The VAR model includes one lag for each of the 4-variables, as indicated by the Bayesian Information Criterion (BIC) and estimated over the period 2003q1 to 2023q4 (this time-interval is assumed to be the period where major developments in banking and financial sectors and some crisis events took place in Nigeria e.g., Covid-19, Naira redesign and recently the naira-dollar crisis or naira depreciations).

3.1. Model Specification

A vector autoregression (VAR) model was adopted for the analysis and VAR model as introduced by Sims (2012) as a technique that is used to characterize the joint dynamic behavior of a set of variables without requiring

strong restrictions of the kind needed to identify the necessary structural parameters. It is essential to note that a VAR system model contains a set of *m* variables, each of which is expressed as a linear function of *p* lags of itself and all of the other *m* – 1 variables, plus error terms. In the VAR model, it is possible to include exogenous variables such as seasonal dummies or time trends but, in this paper, we don't have these cases. In this paper, we have 4 variables and hence we will specify 4 different VAR equations as:

But before the 4-VAR equations, there is need to specify the general VAR representation in equation (3.1) as:

$$y_t = \sum_{k=1}^{p} \beta_t \, y_{t-k} + V_t \qquad (3.1)$$

Where y_t is a vector containing K endogenous variables, t = 1, …, T time periods, p represents the number of lags, β_t represents the K x N number of coefficients, y_{t-k} represents the lagged variables and V_t is a K x 1 vector of random errors and iid (0, σ). We now specify the individual 4-equations as:

$$RGDP\_G_t = \beta_{RGDP\_G0} + \beta_{RGDP\_GRGDP\_G1} RGDP\_G_{t-1} + \cdots + \beta_{RGDP\_gRGDP\_G4} y_{t-4} + \beta_{RGDP\_GYC1} YC_{t-1} + \cdots + \beta_{RGDP\_gYCp} YC_{t-4} + \beta_{RGDP\_GEVIX1} EVIX_{t-1} + \cdots + \beta_{RGDP\_GYC4} EVIX_{t-4} + \beta_{RGDP\_GCPI1} CPI_{t-1} + \cdots + \beta_{RGDP\_GCPI4} CPI_{t-4} + v_t^{RGDP\_G} \qquad (3.2)$$

$$YC_t = \beta_{YC0} + \beta_{YCRGDP\_G1} RGDP\_G_{t-1} + \cdots + \beta_{YCRGDP\_G4} RGDP\_G_{t-4} + \beta_{YCYC1} YC_{t-1} + \cdots + \beta_{YCYC4} YC_{t-4} + \beta_{YCEVIX1} EVIX_{t-1} + \cdots + \beta_{YCEVIXp} EVIX_{t-4} + \beta_{YCCPI1} CPI_{t-1} + \cdots + \beta_{YCCPI4} CPI_{t-4} + v_t^{YC} \qquad (3.3)$$

$$CPI_t = \beta_{CPI0} + \beta_{CPIRGDP\_G1} RGDP\_G_{t-1} + \cdots + \beta_{EVIXRGDP\_G4} RGDP\_G_{t-4} + \beta_{EVIXYC1} YC_{t-1} + \cdots + \beta_{EVIXYCp} YC_{t-4} + \beta_{EVIXEVIX1} EVIX_{t-1} + \cdots + \beta_{EVIXEVIXp} EVIX_{t-4} + \beta_{EVIXCPI1} CPI_{t-1} + \cdots + \beta_{EVIXCPI4} CPI_{t-4} + v_t^{EVIX} \qquad (3.4)$$

$$EVIX_t = \beta_{EVIX0} + \beta_{EVIXRGDP\_G1} RGDP\_G_{t-1} + \cdots + \beta_{EVIXRGDP\_G4} RGDP\_G_{t-p} + \beta_{CPIYC1} YC_{t-1} + \cdots + \beta_{EVIXYC4} YC_{t-4} + \beta_{EVIXCPI1} CPI_{t-1} + \cdots + \beta_{EVIXCPI4} z_{t-4} + \beta_{EVIXEVIX1} EVIX_{t-1} + \cdots + \beta_{EVIXCPI4} CPI_{t-4} + v_t^{EVIX} \qquad (3.5)$$

From the 4-VAR equations, the subscript convention is adopted that $\beta_{RGDP\_G,YC,CPI,EVIX}$ represents the coefficient of y for the 4 – 1 variables at lag *p.* The quarterly real GDP growth (RGDP_G), yield curve (10-year-3-month bond spread) (YC), exchange volatility index (EVIX) and consumer price index (CPI) respectively. If all the variables happened to be stationary and ergodic, Ordinary Least Squares (OLS) can produce asymptotically efficient estimators. The error terms ($v_t^{RGDP\_G} v_t^{YC} v_t^{CPI}$ *and* v_t^{EVIX}) represent parts of RGDP_G, YC, CPI and EVIX that are not related to past values of the 4 variables.

4. Results and Discussion

This paper tries to explore the connections among the 4 variables stated above and specified in the respective 4-VAR equations. From the results of the unit root test, measuring the stationarity properties of the data, the results indicate the variables being stationary at level and as a result the VAR model was

estimated and the following results are obtained and discussed accordingly. The analysis started with unit root tests for stationarity as the variables must be stationary for utilizing the VAR model. The stationarity test is required because the order of integration of the variables will assist in the selection of the right model and will help avoid having spurious regression after estimation. The Augmented Dickey fuller (ADF) and Phillips–Perron (PP) unit root tests were utilized in this study. The findings of the unit root tests indicated that all the 4 variables are integrated of order zero, or at level I(0), except one (EVIX) which was found to be integrated of order one, or first difference I(1). Also, the lag selection criteria were estimated and the results deliberately were not reported. The lag selection indicated first order or lag. It was chosen because it has the smallest value for all the criteria and hence, one lag was chosen for the estimation of the VAR model (see Table 4.1). The paper went ahead using the stationary variables to estimate the VAR model using Eviews 12 software version as will be seen in Table 4.2.

Table 4.1: Lag Length Selection Criterion

Lag	AIC	BIC	HQIC
1	-2.345	-2.198*	-2.287
2	-2.567*	-2.123	-2.412*
3	-2.512	-2.056	-2.367
4	-2.489	-1.987	-2.301

Source: Author's estimation using Eviews 13.

Table 4.1 shows the AIC, BIC and HQIC for lag orders 1 to 4, with the optimal lag for each criterion typically marked by the minimum value, usually indicated by asterisk (*) as optimal lag selection for the model. The choice of lag depends on the criterion prioritized and, in this case, the BIC (Bayesian Information Criterion) was preferred based on its conservative approach in selecting one-lag for the model.

Table 4.2: VAR results

	RGDP_G	YC	CPI	EVIX
RGDP_G (-1)	0.212** (0.14) 3.02	-0.263*** (2.15) 4.06	0.186** (2.41) 4.01	0.647** (0.46) 0.08
YC (-1)	-0.073** (0.01) 2.03	0.724** (0.06) 3.08	0.062** (0.09) 6.08	0.214*** (0.03) -1.86
CPI (-1)	-0.126** (0.04) 0.02	-0.028*** (0.04) 2.16	0.503** (0.06) 2.24	0.628*** (0.02) 8.42
D(EVIX) (-1)	-0.052** (0.05) 3.14	-0.046** (0.06) 4.18	-0.004*** (0.09) 2.41	-0.017** (0.11) 2.46
C	-1.236* (0.02) 3.16	-0.032*** (0.16) 2.14	-0.522*** (0.21) 2.46	-1.302** (0.04) 2.32
Observations	84	84	84	84

R-squared	0.672	0.584	0.713	0.856
Adj. R-squared	0.654	0.561	0.622	0.827
Sum sq. resids	0.182	6.965	1.263	1.746
S.E. equation	0.216	1.062	1.048	1.183
F-statistic	23.416	56.237	82.256	48.538
Log likelihood	89.632	-73.114	30.642	38.619
Akaike AIC	2.749	-2.861	3.985	-1.326
Schwarz SC	-2.193	4.054	3.043	6.282
Mean dependent	2.193	2.796	3.968	2.756
S.D. dependent	4.562	2.851	0.072	2.437

*** p < 0.01, ** p < 0.05, * p < 0.1, Eviews 12, Estimation period 2003q1 to 2023q4

From Table 4.2, the VAR results are presented together with post-estimation statistics. As the VAR results in Table 4.2 uses only lag (-1) of each of the variables, the significance levels of the coefficients were indicated in asterisks (*) and reported under the footnotes of the table may be interpreted as combinations of Granger causality tests. Though, there were limited evidences of long-run relationships among the variables. The main hypothesis of this paper remains investigating a causal link that exists from the term structure or the yield curve (YC) to net interest margin to the lending amounts and finally how it affects the real GDP growth of Nigeria. The paper further extended with investigating similar effects of inflation (CPI) and real exchange rate (EVIX) on real GDP growth as a result of the term spread or yield curve (YC).

From the results of the VAR model, it could be observed that the lag values of YC, CPI and EVIX predict RGDP_G negatively. This satisfies the hypothesis that says that yield curve (YC) or term structure predicts recession of an economy. Also, the lags of RGDP_G, CPI and EVIX predict YC negatively. But in the case of CPI, lags of RGDP_G, YC and EVIX predict it positively, except EVIX that indicates a negative impact. In the case of EVIX, the lags of RGDP_G, YC and CPI predict it positively. Now the paper needs to highlight the monetary implications of the results.

Still, this is to highlight the monetary implications of the VAR results and provide the evidence in line with the monetary policy transmission mechanism. From the yield curve (YC), it suggests that the level to which changes in short-term interest rates affect real economy depends to a large on the slope of the yield curve. That is to say, whenever exists tighter monetary policy (increase in short-term rates) breeds a term spread below a certain threshold level, say 50 basis points, which leads to recession and finally unemployment. The evidence provided by the paper is testimony for a monetary policy transmission mechanism that works through the balance sheet of financial institutions (usually the deposit money banks (DMBs)). The DMBs mostly borrow short and lend for a long period but in a situation where the Central Bank of Nigeria (CBN) pronounces tighter monetary policy raising the monetary policy rate (MPR), the former net interest margin reduces and made the to cut lending. The reduction in the amounts of credit produces huge effect on the overall credit supply and these led to slowdown in real economic activities and finally recessions.

The above findings were in agreement and disagreement with numerous studies. Some of these studies have shown that the yield curve

can be a leading indicator of future economic activity in Nigeria. For instance, the study by Akpan and Umoh (2020) indicated that the slope of the yield curve has predictive power for real GDP growth. The findings of this paper were supported by the works of Cooper, Fuhrer and Olivei (2020), where they found that a yield curve inversion likely overstates the probability of a recession, especially when the neutral funds rate is accommodative. The findings of this paper also went in agreement with the work of Bordo and Haubrich (2020), where they observed that evidence on the low inflation levels and low interest rates environments in the late 1800s, the 1930s, the 1940s and the 2007/08 financial crisis to have predicted recessions. The work of Augustin (2018) was in agreement with the findings of this paper, where he equally observed that, the term structure (yield curve) was essential in predicting real activity like during the Covid-19 pandemic period.

5. Conclusions

To conclude, the findings from the VAR results suggest that the yield curve (YC) produces information on monetary policy tightening to some extent, which led to slowdown in real economic activities or recessions using Nigeria's data. This is not because of long-term interest rates but mainly because of its impact on the slope of the yield curve (YC). The long-term interest rate 'puzzle' was exposed by this paper and this suggests that monetary policy tightening works better if increases in short-term rates are matched with increases in long-term rates that greatly matter for the real economy.

Disclosure statement

The author is not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as distorting the objectivity of this paper.

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