Article

Signal Extraction from the Bond Market and Inflation Forecasting in Nigeria

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Abstract
The study seeks to examine the bond market information content and its implications for forecasting inflation in Nigeria and the influence bond market is having in predicting monetary policy outcome. The study is predicated on the premises that are enunciated in the Expectations Theory of Term Structure. The theory suggests that interest rates and prices are driven by expectations. ARIMA model was estimated using monthly data on inflation rate and government bond for the period of 2006-2019. The study finds that: is a significant relationship between Signal Extraction from bond market and inflation forecasting in Nigeria and that inflation is more likely to move upward; the influence of bond market in prediction of monetary policy outcome is not accurate; and the bond market cannot provide useful information for monetary policy and has no significant role to play in the monetary policy. From these findings, the study recommends that before deciding on operational target variables that will affect individual welfare, monetary authorities should first identify the source of current economic shocks in the economy.

Keywords
Inflation rate, bond market, ARIMA
JEL Classification: E37 &F17

Introduction

Monetary policy has a significant impact on the economy of any country. It is one of the contemporary tools utilized by governments to regulate the economic well-being of citizens Economists are typically interested in the economic well-being of the population, and they prefer to determine the status

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of individuals in the country using monetary measures, such as expenditure or income-based measurements. In this sense, the Central Bank has a dual mandate: it must promote both price stability and economic growth (CBN, 2013). The Central Bank's future course influences market expectations in part. Monetary policy can thus only be effective if they are adept at coordinating market expectations (Jeffery, Stephen and Hyun, 2003).

As a result, inflation expectations have a significant influence on present inflation. It is unsurprising that central banks carefully monitor private actors' inflation expectations, providing useful indicators of rising price stability risk (Coffinet, Mesonnier and Lang, 2009). So, it is vital for monetary policy authorities and regulators to be aware of what these expectations are and aim towards them. A good inflation prediction must reflect inflation forecasts, because monetary policy is one of the ways that the actual economy is affected. In contrast to current inflation, future inflation has received a lot of attention among scholars and speculators, as monetary policies have a large impact on the economy. In other words, a change in monetary policy takes time to fully impact the actual economy. As a result, the CBN requires information from the bond market. The bond market is a financial market with various maturities that also serve as an information source that provides reliable estimates of inflation and the state of the economy (Nimark, 2008). Asset prices incorporate more detailed and up-to-date macroeconomic information than is currently available to policymakers or the general public (Soderlind and Svesson, 1996). This is because securities are sold on a daily basis and so reflect daily market participants' expectations. In theory, asset value data may be connected to the fact that rates of various maturities contain a risk premium or expected inflation. Hence, the yield curve's structure may extract this sort of information, which is crucial for predicting inflation. The yield curve is so named because it combines forecasts and private-sector opinions on the economy's future prospects (Goodfriend, 1998). The yield curve's information relates to its ability to predict future inflation swings and economic prospects. To obtain suitable results, the yield curve should be simulated along with other economic factors (Goodfriend, 1998).

Monetary policy action in Nigeria commenced with the establishment of the Central Bank of Nigeria. The Central Bank Act of 1958 primarily requires monetary policies to be developed and adopted. After its foundation in 1960, the monetary policy instruments of the Central Bank may, in order to achieve its economic policy objectives, be split into two – indirect (quantitative) and direct (qualitative) instruments. While indirect approaches are frequently employed in advanced economies, the direct method prevails in less advanced economies such as Nigeria (Gandolfo, 2016). Both techniques are meant to

alter bank credit systems' costs and availability that affect the overall demand through supplies, money costs and credit availability (Gandolfo, 2016).

To provide a more complete picture, a quick examination of the term interest rate structure (income curve) demonstrates the relationship between yields for various maturity loans. Because of its forecasting powers, it has been a source of concern for both political and economic analysts, and it is frequently a helpful indication of monetary policy position. This forecasting ability arises from the decision-making process of profit-seeking investors, which includes the formulation of future inflation and interest-rate expectations (Goodfriend, 1998).

And, by extension, the term structure's predictive power would be effective if expectations were reasonable. Throughout the first six months of 2013, inflation was tied to a single digit, but bond rates rose to two digits (CBN, 2013). In May 2013, the inflation rate was 9%, but the 10-year bond yield was 11.8 percent higher than the 2.8 percentage point inflation rate. Although inflation is decreasing, rising debt yields suggest that market participants believe the current rate is unsustainable in the short run due to underlying economic factors such as currency rates and capital inflows. Accordingly, the yield curve would be more responsive to the policy direction and the economic fundamentals of stock market dynamics.

The CBN invests significant efforts in forecasting and calculating the underlying state of the economy by collecting information to ensure this rate. The bond market matches this criterion since it provides information about participants' expectations of inflation. Thus, it is crucial for monetary policy to extract such information. Forecasts from influential central banks may cause private actors to stop building their own information sets and instead refer to the central bank's information (Hubert, 2012). It is on this basis that this study seeks to analyse the bond market information content and its implication for forecasting inflation in Nigeria.

The study's goal is to improve inflation prediction by including data from asset returns and shaping it with other variables to provide a more reliable inflation forecast. Given the importance of the link between monetary policy and asset prices, obtaining accurate estimates of asset price inflationary effect is critical. It is critical to emphasize that the goal of this study is not to outperform other prediction models and sources of information contained on the bonds market, but rather to serve as an instrument set that the CBN may utilize throughout the monetary policy process.

Literature Review

Essentially, there are four theoretical approaches to inflation forecasting concerning bond market: the expectation theory of the term structure, the segmented markets theory of the term structure, the liquidity premium theory of the term structure, and the preferred habitat theory of the term structure (van-Binsbergen and Koijen, 2017).

According to the expectations theory of the term structure, the long-term rate is a weighted average of short-term or expected short-term interest rates. If future short rates remain constant, the long rate will equal the short rate (plus a constant risk premium). If future short rates rise, the current long rate will outperform the current short rate and the constant risk premium, resulting in the same projected return. As a result, the shape of the yield curve reflects market expectations for future short-term interest rates. According to the theory of expectations, securities of varying maturities replace one another (exact or anticipated). The theory holds that the expected holding period of financial instruments with distinct terms cannot be replaced in the segmented market theory. The supply and demand of short and long-term instruments in the markets is therefore mainly autonomously decided. Future investors determine in advance if short-term or long-term instruments are required. If investors want to liquidate their holdings, they prefer short-term instruments to long-term ones. The short-term instruments market will thus have a higher demand. Increased instrument demand involves higher prices and lower profits. This is why short-term rates tend to be lower than long-term yields. This concept explains the preponderance of normal yield curves. This explanation, however, does not explain why yields in both markets do not move at the same time (i.e., upward and downward shifts in the curve (Lumenlearning, 2021).

Long-term interest rates, according to the theory, do not just represent investors' future interest rates; they also include a long-term bond premium, known as a term or liquidity premium, since investors prefer short-term bonds over long-term bonds. Investors are rewarded for the increased risk, or price instability, of having their money tethered for a longer period of time. Long-term premium rates are often higher than short-term returns, and the yield curve slopes upward. Long-term returns grow not just as a result of the liquidity benefit, but also as a result of the risk premium added by the risk of default from holding security over the long term (Lumen learning, 2021).

The expectations theory argues that the long-term interest rate is an average of both current and projected short-term rates, according to van-Binsbergen and Koijen (2017). For example, a five-year bond maturity rate is the current and projected average short-term rate for the next five years (van-Binsbergen and Koijen, 2017). The concept is founded on the circumstances of asset-market equilibrium. The holding-period return on the asset is the return rate obtained via the acquisition, retention, and sale of the asset over a period of time. Short-term and long-term bonds must have the same anticipated return on holding length under the criteria of return on asset market balance. The condition of rates of return is that the various assets are close substitutes: investors would invest wherever the expected rates of return are high (van-Binsbergen and Koijen, 2017).

Several studies have examined both inflation forecasting and bond market in developed and developing countries. Some of the studies are reviewed in this section. According to Hong, Sraer and Yu (2017), the liquidity premium theory of interest rates predicts that the Treasury yield curve moves with inflation uncertainty as investors seek higher risk premiums to hold long-term bonds. The study discovered the reverse when it used the dispersion of inflation forecasts to evaluate uncertainty. Because long-term bond prices change more with inflation than short-term bond prices, investors disagree and speculate more on long-maturity payoffs with higher uncertainty. Shorting frictions, as measured by Treasury loan costs, cause long maturities to become overvalued and the yield curve to flatten.

Zhang and Guo (2018) analyse the role of inflation-indexed bond in optimal management of defined contribution pension plan during the decumulation phase. The plan aims to maximize the expected constant relative risk aversion (CRRA) utility from the terminal real wealth by investing the fund in a financial market consisting of an inflation-indexed bond, an ordinary zero coupon bond and a risk-free asset. Zhang and Guo (2018) derive the optimal investment strategy in closed-form using the dynamic programming approach by solving the related Hamilton-Jacobi-Bellman (HJB) equation. The results reveal that, with any level of the parameters, an inflation-indexed bond has significant advantage to hedge inflation risk.

Lartey, Li, Lartey and Boadi (2019) used the piecewise cubic Hermite technique, the piecewise cubic spline method (with not-a-knot end condition), the Nelson–Siegel–Svensson method, and the variable roughness penalty approach to simulate the zero-coupon, par, and forward yield curves for the Nigerian bond market. The piecewise cubic Hermite technique was found to be extremely suitable for generating the Nigerian par and zero-coupon yield curves in the study. As a result, the piecewise cubic Hermite technique is recommended by the research for creating the Nigerian zero-coupon yield curve, followed by the Nelson–Siegel–Svensson method.

Lally (2020) used standard root mean square error (RMSE) forecasting accuracy tests to determine the best method for estimating expected future inflation in Australia. The study concluded that the Australian Policy makers should estimate expected inflation over the next five years rather than the next ten. Market prices (break-even rates and swap prices) are likely to be biased estimators of expected future inflation, to varying degrees over time. Fu (2007) also extracted information on inflation expectations, the real interest rate, and various risk premiums by exploring the underlying common factors among the actual inflation, University of Michigan consumer survey inflation forecast, yields on U.S. nominal Treasury bonds, and particularly, yields on Treasury Inflation Protected Securities (TIPS). The study concluded that there is a significant liquidity risk premium on TIPS, which leads to inflation expectations that are generally higher than the inflation compensation measure

at the 10-year horizon by using the autoregressive of order 2, (AR(2)) time series model in the one-step-ahead forecast of inflation.

Nkwede (2020) investigated the macroeconomic determinants of bond market development in Nigeria to address the long-standing research question of whether bond market development in emerging markets is driven by macroeconomic or institutional factors. The study used ordinary least square regression techniques to analyse time series data generated over a 32-year period. According to the study, the exchange rate, interest rate, inflation rate, and banking sector development all have a negative and significant impact on the capitalization of the Nigerian bond market. As a result, the study provided strong evidence as robust macroeconomic determinants and drivers of bond market development on the growth of the Nigerian economy from 1986–2018 using the co-integration bounds test approach. According to the study, corporate bonds and the value of bonds traded were the major variables that increased the depth of Nigeria's bond market development.

The review of theoretical literature reveals that, inflation forecasting and bond market in particular may affect growth in different ways: it may enhance growth through significant positive impact, hinder growth through negative impact and may not even affect growth. This implies that there is no unanimity in theoretical literature as to the direction or extent of signal the inflation forecasting and the bond market can affect the economy. The contradictory proposition of the theoretical literature has also been confirmed by empirical literature on inflation-bond market nexus. Some of the studies reported positive signals on growth, some others reported negative signals in forecasting the economy.

In Nigeria, some studies such as Lartey, Li, Lartey and Boadi (2019), Nkwede (2020) have examined the determinants of bond market development with a particular focus on inflation. Our study deviates from this line of thought since the main objective of the study is to unravel the existence of signal extraction of inflation and bond market and the effect of such signal on economic performance. The study, therefore, contributes to the literature on inflation forecasting and bond market nexus to see how their signal extraction will affect economic growth in Nigeria to arrive at a country-specific policy guide on how the economy can achieve sustained and inclusive economic growth in Nigeria.

Theoretical Framework and Methodology

Theoretical Framework

This study employs expectation theory. The expectation theory of the term structure regards expected future rates as the major determinant of the present structure of inflation rate. According to the theory, buyers do not prefer bonds of one maturity over the other. So, they will not hold any quantity of bond if its expected returns are less than that of another bond with a different maturity. This is because bonds of various maturities are believed to be perfect substitutes. The difference between long-term and short-term bonds is simply the interest rate risk attached to holding bonds of different maturity. Interestingly, the theory explicitly assumes away interest rate risk. Therefore, when expectations are high, it signals an increase in future rates and the reverse is the case when expectations are low. In recent years, there has been a growing recognition of the importance of expectations about the future stance of monetary policy in improving monetary policy effectiveness in stabilizing inflation and output (Sadaoui and Ramos-Francia, 2008). This is tied to the fact that expectations act as a major component for setting prices and wages, consumption, savings and investment decisions. Thus, there is the need for the monetary authority to know what such expectations are and target them in a way that is consistent with its target level.

Model Specification

Drawing from the work of Uzuke *et al.* (2016), and in line with the objective of this study, the appropriate forecasting technique, that is, autoregressive (AR) and moving average (MA) are specified in equations 1 and 2

$$X_t = \mu + \sum_{z=1}^{p} \emptyset_p X_{t-p} + \varepsilon_t \quad (1)$$

where X is the variable to forecast. Therefore, equation 1 says that variable X at time *t* is predicted by its previous values and the unobservable factors captured by the error term, ε_t. This is explicitly stated in equation 2

$$X_t = \mathrm{a} + \emptyset_1 X_{t-1} + \emptyset_2 X_{t-2} + \emptyset_3 X_{t-3} + \ldots + \emptyset_p X_{t-p} + \varepsilon_t \quad (2)$$

The error term, ε_t is assumed to be an independently and identically distributed (i.i.d) random variable and assumed to be normally distributed. The term a, is constant while *p* denotes the order of autoregressive term, defining how many previous values the current value is related to. Equation 1 assumes that past values of X can be used to predict its present value. In some cases, past values of the error is used and this is called moving average model. This is specified in equation 3.

$$X_t = b + \sum_{j=0}^{q} \emptyset_q \varepsilon_{t-q} \quad (3)$$

$$X_t = \mathrm{b} + \varepsilon_t + \emptyset_1 \varepsilon_{t-1} + \varepsilon_2 X_{t-2} + \emptyset_3 X_{t-3} + \ldots + \emptyset_q X_{t-q} \quad (4)$$

The error (or noise) term in this equation ε_t is the one step ahead forecasting error is expressed as a function of previous forecasting errors. Equation 3 suggests that the value of X at any point in time is a weighted moving average of the past forecast error. It shows that MA (q) models make forecast based on the error made in the past, and so one can learn from the error made in the past to improve current forecast. The usual practice in Economics and in forecasting circle is to assume that information from both the lags of X and past errors can be used to predict the current value of X. In this regard, a suitable model will be the combination of AR(p) in equation 1 and MA(q) in equation 3 to form ARMA(p,q). The ARMA(p,q) forecast model is specified in equation 5.

$$X_t = c + \sum_{z=1}^{p} \theta_p X_{t-p} + \sum_{j=0}^{q} \theta_q \varepsilon_{t-q} \quad (5)$$

where $c = a+b$. in the spirit of equations 2 and 4, the ARMA(p,q) can be explicitly specified in equation 6

$$X_t = c + \emptyset_1 X_{t-1} + \emptyset_2 X_{t-2} + \emptyset_3 X_{t-3} + \ldots + \emptyset_p X_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_2 + \theta_3 \varepsilon_{t-3} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (6)$$

In statistics, ARIMA (p, d, q) model is used to estimate a forecast which is typically applied to time series data for forecasting. Given a time series $X_{t-1}\ X_{t-2},\ \ldots,\ X_2\ X_1$. The ARIMA model is a tool for understanding and, perhaps, predicting future values in the series. ARIMA is an extension of the ARMA, by incorporating the differenced values (level of integration) of X model in the ARMA. Hence, ARIMA consists of three parts: an Autoregressive (AR) part, a Moving Average (MA) part and the Differencing part (I). The model is usually referred to as ARIMA (p, d, q) where p is the order of the autoregressive part, d is the order of differencing and q is the order of the moving average part.0 From equation 6, the nature of the series can be predicted. The following interpretation is given to the outcome from equation 6. If we have ARIMA(0,0,0), the model is predicted to be white noise. If it is ARIMA(0,1,0) with no constant (*c*), the series is said to exhibit random walk, and with constant , it exhibits random walk with drift. If the model follows ARIMA(p,0,0), it exhibits autoregressive and while ARIMA(0,0,q) is the case of moving average. Now, it the model follows ARIMA(p.d.,q) like ARIMA(1,1,1) then the model exhibits random walk autoregressive moving average of order 1. That is the series can be predicted with both immediate past values of the variable which is stationary at first difference and the asynchronous error term.

Forecasting $X_{t-1}\ X_{t-2},\ \ldots,\ X_2\ X_1$ using ARIMA consist of the following steps: model identification, parameter estimation, and diagnostics. Model identification is the first step of these processes. The data would be examined to check for the most appropriate class of ARIMA processes by selecting the order of the consecutive and seasonal differencing, required in making the series stationary, as well as specifying the order of the regular and seasonal autoregressive and moving average model necessary to adequately represent the time series model. The Autocorrelation Function (ACF) and the Partial Autocorrelation function (PACF) are the most important elements of time series analysis and forecasting. The ACF measures the amount of linear dependence between observations in a time series that are separated by l*ags*. The PACF plots help to determine how many autoregressive terms necessary to reveal one or more of the following characteristics: time lag where high correlations appear, seasonality of the series trend either in the mean level or in the variance of the series.

It must be recalled that the objective of this study is to predict inflationary spiral and bonds market in Nigeria. Following equation 6, variable X is replaced with inflation rate and 3-month government bonds (proxy for bonds market) respectively. Thus equations 7 and 8 specify ARIMA(p,d,q) for inflation rate and government bonds respectively.

ARIMA(p,d,q) for predicting inflation rate

$$INF_t = c + \emptyset_1 INF_{t-1} + \emptyset_2 INF_{t-2} + \emptyset_3 INF_{t-3} + \ldots + \emptyset_p INF_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_2 + \theta_3 \varepsilon_{t-3} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (7)$$

ARIMA(p,d,q) for predicting bonds market

$$GBOND_t = c + \emptyset_1 GBOND_{t-1} + \emptyset_2 GBOND_{t-2} + \emptyset_3 GBOND_{t-3} + \ldots + \emptyset_p IGBOND_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_2 + \theta_3 \varepsilon_{t-3} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (8)$$

Where INF and GBOND represents inflation rate and 3-month government bond respectively. If equations 7 and 8 follow ARIMA(0,0,0), it means that both inflation rate and government bond exhibit white noise, in which case, the current inflation rate and government bond are not influenced by previous happening in the economy. In this regard, only current information dictates the value of the current inflation rate and bond price, no more no less. If the model follows ARIMA(0,1,0). It indicates that inflation rate and government bond exhibit random walk if there is no constant or random walk with drift if it contains constant. What it means is that either inflation rate or government bond cannot be straightforwardly predicted, because inherent in the series is inertia, which needs to be demystified. If the model follows ARIMA(p,0,0) or ARIMA(0,0,q) then it is either that the prediction of inflation rate and government bond relies on past values of the respective variables in the case of the former, or past unobserved factors (the error terms). A special case is where any of the variables (inflation rate or government bonds) follows

ARIMA(p,d,q). In this case, the prediction of future values becomes a little beat complex because not only that the variables follow random walk, but also both previous values of the variables and the error terms are to be predicted. What this study, therefore, seeks to achieve is to unravel to nature of forecasting ability of inflation and government bonds in Nigeria utilizing the ARIMA(p,d,q) model.

Sources of Data and Definition of Variable

Data for inflation rate and government bonds were extracted from the online databank (financial sector and real sector) made available by the Central Bank of Nigeria (CBN). The data can be obtained from statistics.cbn.gov.ng/cbn-onlinestats/DataBrowser.aspx. The inflation rate is defined and computed as the year-on-year percentage change in the consumer price index on a monthly basis using November 2009 as the base year (see the above link). For the bonds market, 3-month government treasury bill is employed because it is most issued and most dynamic bond. Data on these variables are obtained from January 2008 to July 2020 as data availability permits.

Results and Discussion

Descriptive Statistics

Table 1 shows that on average inflation rate is 12.2 percent, while maximum and minimum monthly inflation rate is 18.72 percent and 7.7 respectively. The standard deviation of inflation rate within the time period of the research is 2.99 percent. Also, on average, Nigeria's government bond is 12.52 percent. The maximum and minimum rate of a government bond is 16.68 and 4.15 which implies that the growth of government bond has been positive and above 10 percent.

Table 1: **Summary of the Descriptive Statistics**

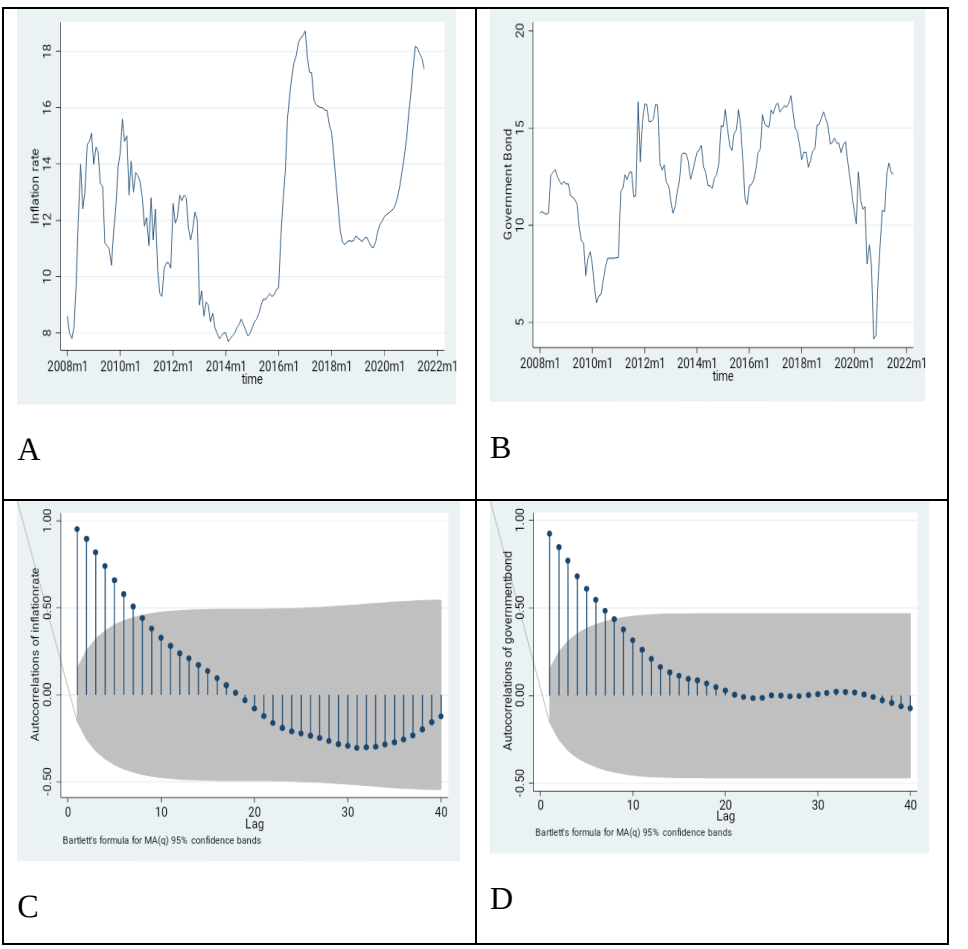
	Mean	Max	Min	Std. Dev.	Obs
Inflation rate	12.20123	18.72	7.7	2.986379	163
Government bond	12.51969	16.68	4.15	2.675255	163

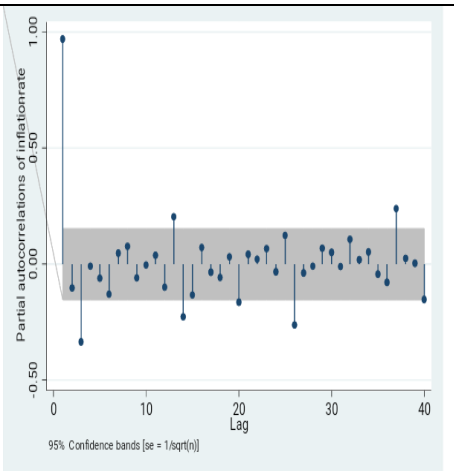
The Stationarity of the Series

Since the prime objective of this study is to examine the bond market information content and its implication for forecasting inflation in Nigeria, the

study empirically identifies the appropriate model that will best forecast these variables. The preliminary step in this analysis is concerned with identifying the required lags for AR and MA process since the study employed time series data. For this purpose, the analysis employed correlograms which is the plot of ACFs and PACFs against their respective lag length. However, the PAC measures correlation between (time series) observations that are *k* time periods apart after controlling for correlations at intermediate lags (that is, lags that is less than *k*). Basically, the PACF measures marginal impact. On this note, the study applies the plot of the series to visualize the stationarity or otherwise of unit root in the level and first difference of each of the variables, using the correlogram test calculated with ACF and PACF. This is a well-accepted test statistic to check the stationarity of the series. The results are presented in Figure 1.

Figure 1: **The Result of Stationarity Test**





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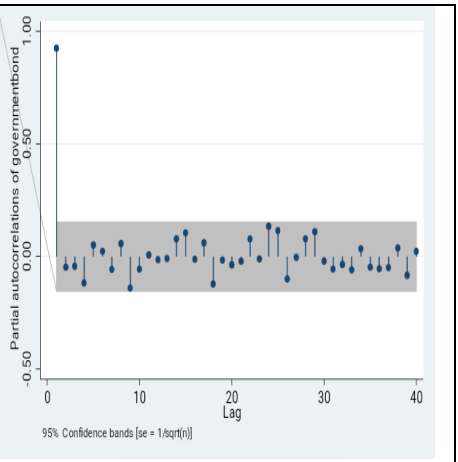

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Figure 1a and 1b show that the two series are stationary at level. This implies that the series are mean reverting after experiencing a major shock. They have a constant mean even though overtime, their variances are not constant. Figures 1c and 1b show the autocorrelation for both series respectively. The ACF tails off having shown significant spike in lag 1 to 7 on both series and every other thing shows no autocorrelation. This is also an indicator of a stationary series. The PACF of the series cuts of at lag 1 or 3 for figure 5 and at lag 1 for figure 6.

Therefore, to find the ARIMA pattern for the series, the pattern of the ACF and PACF from their associated correlogram will have to be considered. From the result in Figures 1c and 1f, PACF displays a sharp cut-off while the ACF decays more slowly. The inflation rate and government bond series are an AR process. This is because the ACF shows a significant spike at lags 1 to 7 and no correlation with other lags while the PACF shows a positive 1st lag and a set of exponential decays. Implying that autocorrelation pattern is explained more easily by adding AR terms than by adding MA terms. Hence, lags 1, 3, 13, 14, 26, and 37 are all statistically significant for inflation rate. While only 1st lag is statistically significant for government bond. It is worth noting that, parsimonious model gives better forecast than over-parameterized models. The model with the smallest number of parameters to be estimated is better.

Test for Appropriate Models

Having satisfied that all the individual series of consideration are stationary, the study further estimates the tentative models to know the appropriate model that best describes the forecast. The tentative models are: ARIMA (1,0,1); (1,0,2); (1,0,3); (3,0,1); (3,0,2); (3,0,3) for inflation rate and ARIMA (1,0,1); (1,0,2); (1,0,3); (2,0,1); (2,0,2); (2,0,3) for government bond.

Table 2: **Model selection criterion (Inflation rate)**

Inflation rate	ARIMA (1,0,1)	**ARIMA (1,0,2)**	ARIMA (1,0,3)	ARIMA (3,0,1)	ARIMA (3,0,2)	ARIMA (3,0,3)
Significant Coefficient	1	**3**	3	2	2	2
$Sigma^2$ (volatility)	.76	**.73**	.73	.72	0.72	.71
Log-likelihood	-189.21	**-180.97**	-180.83	-179.23	-178.87	-178.07
AIC	386.42	**371.95**	373.67	370.45	371.74	372.15
SBIC	398.80	**387.42**	392.23	389.01	393.40	396.90

Table 3: Model selection criterion (Government Bond)

Government Bond	**ARIMA (1,0,1)**	ARIMA (1,0,2)	ARIMA (1,0,3)	ARIMA (2,0,1)	ARIMA (2,0,2)	ARIMA (2,0,3)
Significant Coefficient	**1**	1	1	3	3	0
$Sigma^2$ (volatility)	**1.01**	1.01	.998	1.01	1.01	.997
Log-likelihood	**-233.23**	-233.13	-231.92	-232.70	-232.68	-231.92
AIC	**474.46**	476.26	475.86	475.39	477.35	477.84
SBIC	**486.83**	491.73	494.42	490.86	495.91	499.49

From Tables 2 and 3, the most appropriate model is selected based on most significant coefficients, lowest volatility, highest log likelihood, and lowest AIC and SBIC. Out of all, ARIMA (1,0,2) qualifies for most ideal model for inflation forecast while ARIMA (1,0,1) qualifies for government bond forecast.

ARIMA Model Estimation Result

Table 4: The Results of the appropriate ARIMA models

MODEL →	Inflation Rate	Government Bond
	Sigma	
	0.728***	1.006***
	(0.0288)	(0.0304)
	ARMA	
ar-1	0.946***	0.915***
	(0.0412)	(0.0308)
ma-1	0.124*	0.0485
	(0.0698)	(0.0602)
ma-2	0.303***	
	(0.0546)	
Constant	12.36***	12.42***
	(1.325)	(0.992)
Observations	163	163

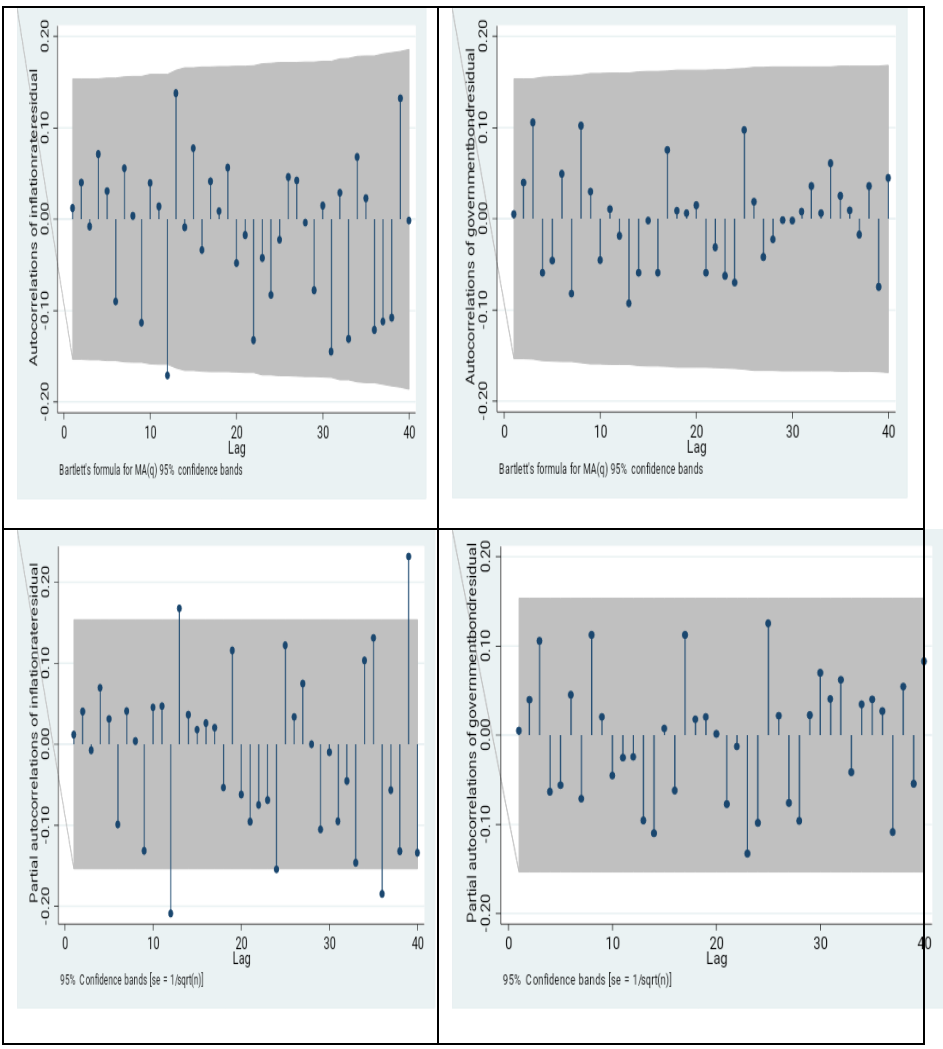
Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

From the result in table 4, both models are highly volatile as inflation and government bond exert 0.728 and 1.006 respectively. The sigma results that their speed of adjustment to restore equilibrium is fast. Model for inflation rate forecast reveals that the first lag of inflation rate can positively predict its future occurrence. Also, the past realization of the first and second lag have positive and significant influence on the inflation rate. In the same vein, model for government bond shows that the first lag value of government bond positively and significantly influences current values of government bond in Nigeria.

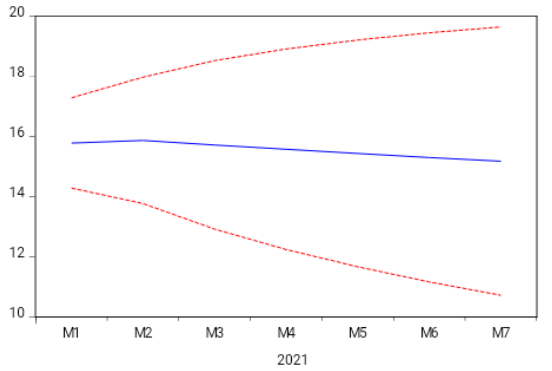
Diagnostic Test

The model is checked to ensure that it is not overfitting and capturing random noise. An ideal model should have errors that resemble white noise. Besides, the residuals of the model are inspected to confirm that there is no additional structure. Finally, a suitable model is selected.

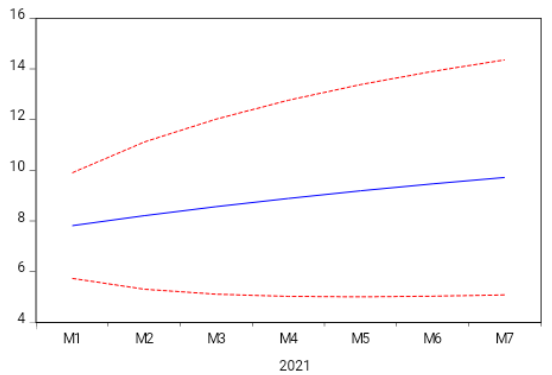
Figure 2: Residual result checking



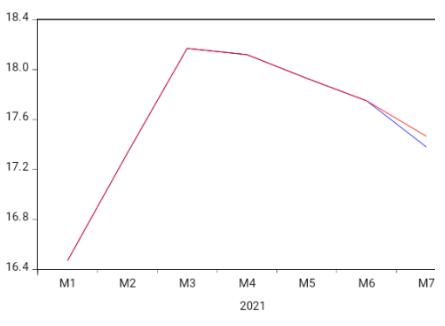
From the result of ACF in Figure 2, the correlogram is flat and lags are within the 95 percent confidence interval indicating that there is no uncaptured information in bond market. The result of the correlogram of the PACF for the residual is not so flat in inflation rate because it is still showing some significance at lags 12, 13, 35 and 39 for inflation rate residual. So, the forecast made with ARIMA (1,0,2) for inflation rate can then be accepted as significant and ARIMA (1,0,1) made for government bond is considered an accurate forecast. However, because parsimony is the fundamental idea, then the ARIMA (1,0,2) and ARIMA (1,0,1) models are most ideal to be used for forecasting inflation rate and government bond respectively.

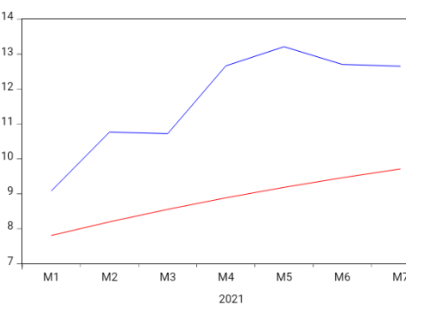


Forecast: INFLATION_F	
Actual: INFLATION_RATE	
Forecast sample: 2021M01 2021	
Included observations: 7	
Root Mean Squared Error	2.1
Mean Absolute Error	2.0
Mean Abs. Percent Error	11.
Theil Inequality Coefficient	0.0
Bias Proportion	0.9
Variance Proportion	0.0
Covariance Proportion	0.0
Theil U2 Coefficient	4.2
Symmetric MAPE	12.



Forecast: GOVERNMENTF	
Actual: GOVERNMENT_BOND	
Forecast sample: 2021M01 2021	
Included observations: 7	
Root Mean Squared Error	2.9
Mean Absolute Error	2.8
Mean Abs. Percent Error	23.
Theil Inequality Coefficient	0.1
Bias Proportion	0.9
Variance Proportion	0.0
Covariance Proportion	0.0
Theil U2 Coefficient	2.5
Symmetric MAPE	27.





The inflation rate forecast of the modified sample size further reveals that the prediction from the 1st month to the 6th is exert prediction while there is a slight deviation in predicting the 7th month. Therefore, forecasters are more likely experience forecast accurately for future inflation rate and more accurate decision will be made. The government bond forecast of the modified sample

size further reveals that the prediction from the 1st month to the 7th shows a large deviation. Therefore, the prediction of this variable is not exact hence, more evaluation will be needed to predict accurately the variability in the series in future years.

Hence, analysing signal extraction from the bond market and inflation forecasting in Nigeria, findings indicate that there are significant relationships between these variables. Inflation, therefore, is more likely to move upward. Consequently, information from the past period can be used to improve inflation forecast. However, the influence of bond market in prediction of monetary policy outcome is not accurate. The bond market cannot provide useful information for monetary policy and has no significant role to play in the monetary policy.

Conclusion and Policy Recommendations

The economy of Nigeria is defined by many variables of which inflation contributes significantly to the economy and thus has a great effect on its growth rate. Therefore, the research examined the bond market information content and its implication for forecasting inflation rate in Nigeria. Monthly data spanning January, 2008 to July, 2020 were extracted to test the ability of the expectation theory to predict inflation rate through the bond market. The theory regards expected future rates as the major determinant of the present nature of inflation rate to extract signal from the bond market and inflation forecasting. For this purpose, the analysis employed ARIMA(p,d,q) model alongside correlograms to know the appropriate model to best estimate the variables. From the result the tentative result for inflation rate is ARIMA (1,0,1); (1,0,2); (1,0,3); (3,0,1); (3,0,2); (3,0,3) while that of government bonds is ARIMA (1,0,1); (1,0,2); (1,0,3); (2,0,1); (2,0,2); (2,0,3). From these tentative results, the appropriate model selected by AIC is ARIMA (1,0,2) for inflation rate and ARIMA (1,0,1) for government bond. From the estimation, their past values were accurately significant.

The result suggests that the first lag of inflation rate positively predicted its future occurrence. Also, the past realization of the first and second lags has positive influence on the current inflation rate. Further, bond market shows that the first lag value of government bond is highly significant and has a positive influence on the current status of bond market in Nigeria. As a result of the outcome, there exists a positive effect of money supply on inflation control in Nigeria. Therefore, the natural outcome is that increased money supply leads to the persistent rise in price level (inflation) which would be followed by a proportional rise in the cost of living of citizenry within the economy. The findings in this study lend credence to the findings of others such as Fu (2007) and Hong *et al.* (2017) who discovered the reverse when they used the dispersion of inflation forecasts to evaluate uncertainty. Because the long-term bond prices change more with inflation than short-term bond prices, investors disagree and speculate more on long-maturity payoffs with higher uncertainty.

Furthermore, long-term inflation expectations are typically steady, inflation risk is inevitable and so, policy makers need to forecast the economic outcome more appropriately.

In conclusion, inflation expectations have a great influence on actual inflation. Unsurprisingly, central banks monitor closely inflation expectations of private agents, as they provide useful signals of emerging risks to price stability. Information from the past period can be used to improve inflation forecast and the influence of bond market in prediction of monetary policy outcome is not accurate, hence, bond market cannot provide useful information for monetary policy and has no significant role to play in the monetary policy. This result, therefore, is in-line with the view of increasing the information set available to the CBN to forecast future inflation. There is the global recognition of the importance of expectations in the conduct of monetary policy. This is partly because of the recognition that expectations of inflation by the private sector form a component of actual inflation. Expected inflation is increasingly found to be a useful input in inflation forecast models for monetary policy.

Following the results, some policy implications and recommendations can be drawn. First, before deciding on operational target variables that will affect individual welfare and make a significant contribution to the course of economic growth, monetary authorities should identify the source of current economic shocks in the economy. Greater attention should be paide on how to control inflation in the year 2021 and beyond because there is more likely to be an upward trend of inflation which could likely increase cost of living of the people. Monetary authorities should pursue a program of low-inflation monetary policy and stabilize demand to permanently boost the status of the underprivileged by streamlining its relevant monetary policy instruments. Improved financial systems, and the existence of a strong institution in the activities of bond market can be effectively applied to ensure the right access for low-inflation rate in the economy. Also, activities in the bond market should be monitored so as to adopt the best strategy to boost the market and when this is done, investment would increase accordingly.

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