SIGNAL EXTRACTION FROM THE BOND MARKET AND INFLATION FORECASTING IN NIGERIA

BY

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BEING A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE (M.sc) IN ECONOMICS.

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Declaration

I declare that this M.sc. Thesis entitled, *"Signal Extraction from the Bond Market and Inflation Forecasting in Nigeria"* has been carried out by me in the Department of Economics. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other university.

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CERTIFICATION

This thesis titled, *"Signal Extraction from the Bond Market and Inflation Forecasting in Nigeria"* by Ejiroghene Daniel, MUDIARE meets the regulations governing the award of the degree of Master of Science in Economics of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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Dedication

This thesis is dedicated to the Almighty God and my parents, Prof. and Dr. Mrs Mudiare.

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Abstract

There is the global recognition of the importance of expectations in the conduct of monetary policy, which can be attributed to the growth of financial markets, and the fact that economic fundamentals are driven, by expectations of the market agents. In an ever changing economic and financial environment, the CBN would require all the information it can get to respond to these changes in accordance with its policy objectives. Some of such information can be sourced from the bond market. The study seeks to examine the extent to which the information on private sector expectations of inflation which is contained in the yield curve that can improve inflation forecast. This would consequently increase the information set available to the CBN to forecast future inflation. The study is predicated on the premises that are enunciated in the Expectations Theory of Term Structure of Interest Rates. The theory suggests that interest rates and prices are driven by expectations.VAR model was estimated using quarterly data on security prices, inflation, MPR, and exchange rate for the period of 2006-2013. The study finds that: (i) there is information about private sector expectation embedded in the yield curves (ii) the proxy for expectation (treasury bills with 90 days maturity) has a significant effect on inflation in Nigeria (iii) the yield spread can indeed improve inflation forecast in Nigeria. The study concludes that the information embedded in the prices of securities can improve inflation forecast and monetary policy in Nigeria. From these findings, the study recommends that CBN should increase effectiveness and efficiency of monetary policy through the inclusion of the yield curve in modeling inflation in Nigeria. Furthermore, government in collaboration with the Central Bank of Nigeria should take effective measures to improve liquidity in the bond market which often disrupt the information signals found in security prices.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Monetary policy plays an important role in the economy of every nation. In this regard, the Central Bank of Nigeria (CBN) is conferred with the dual mandate to pursue both price stability and economic growth. Therefore, the CBN has to formulate monetary policy in such a way that is consistent with the attainment of these goals. Monetary policy over the years has been evolving in the face of changing economic realities both domestically and internationally. The CBN came up with a number of monetary policy regimes and instruments in consonance with its objectives. The introduction of Structural Adjustment Program (SAP) led to a remarkable change in monetary policy instruments given the introduction of a market based interest rate regime. By 1993, indirect instruments (market based instruments such as Open Market Operation, Liquidity Ratio and cash reserves) emerged to guide the course of monetary policy in Nigeria. In 2006, the CBN adopted the Monetary Policy Rate (MPR) which is an overnight interest rate to replace the Minimum Rediscount Rate (CBN, 2011; Dintimi et al, 2011). In recent times, the CBN recognized that achieving stable prices would require a continuous reassessment and evaluation of its monetary policy framework to enable it respond to the ever changing economic and financial environment (CBN, 2011). This is anchored on the premise that monetary policy is a tool for enhancing a stable macroeconomic environment and a sound financial system that would promote economic growth.

Recent literature on the theory of monetary policy point to the fact that the success of monetary policy does not depend solely on the effective control of short-term interest rates, but also on the Central Bank's ability to shape market expectation of how interest rates and inflation are likely to evolve overtime (Brand, Buncic and Turunen, , 2008). This was attributed to the fact that financial markets have grown globally and prices are driven by expectations of market agents. In a world governed by the rational expectation paradigm, economic agents are forward looking and form their expectations efficiently and homogeneously using all information available including precise knowledge of the economy (ECB, 2009). Such information about the functioning of the economy and the stance of monetary policy has been acknowledged as the principal drivers of interest rates and asset prices. Market expectations are shaped in part by the future course of actions of the Central Bank. Therefore monetary policy can only be effective if it is effective in coordinating market expectations (Jeffery, Stephen and Hyun, 2003). Thus, the CBN must coordinate private agents' expectations in a way that is consistent with its inflation target. To do this, the central bank makes public its forecast and stance on monetary policy.

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 (Coffinet, Mesonnier, and Lang, 2009). Therefore, knowing what such expectations are and targeting it, is an important input of monetary policy. A good forecast of inflation must capture inflation expectations because it is one of the channels through which monetary policy affects the real economy. Information on private sector expectations can be sourced from central bank surveys and financial instruments (ECB, 2011). Monitoring information regarding inflation expectations, as reflected in surveys or financial

markets, for instance, has been part of the policy process at many central banks (Orphanides and John, 2003).

In pursuit of its objectives, the CBN therefore cannot conduct a successful proactive monetary policy that is capable of predicting the future path of inflation and the state of the economy without gathering accurate and credible information about the economy. Much emphasis is placed on future inflation as opposed to current inflation because monetary policy affects the economy with lags. In other words, a monetary policy change takes a certain amount of time to have full effect on the real economy. For this reason, the CBN requires information some of which can be obtained from the bond market. The bonds market is the market for debts of various maturities and serves as a source of information that provides efficient estimates of inflation and the state of the economy (Nimark, 2008). Asset prices embody more accurate and up to date macroeconomic information than what is currently published or directly available to policy makers (Soderlind and Svesson, 1996). The reason being that securities are sold on a daily basis and so reflect market participants' expectations on day-to-day bases. On theoretical grounds, the information contained in asset prices can be tied to the fact that yields of various maturities contain a premium for risk or expected inflation. Therefore, this kind of information which is useful in the forecast of inflation can be extracted from the shape of the yield curve. This is because the yield curve embeds private sector expectations of inflation and their views on the future outlook of the economy. Information in the yield curve refers to the ability of its slope to predict future changes in inflation and future outlook of the economy. To get accurate results, the yield curve should be modeled alongside other economic indicators (Goodfriend, 1998). This is because volatility and uncertainty do exist in the bond market, and so observing the term structure or the yields on securities in such situations would be uninformative. Basically, the

information embedded in asset prices cannot be ignored because it plays an important role in the transmission mechanism of monetary policy. Changes in the official rates affect asset prices and consequently inflation. A change in the official rate will alters the value of existing wealth, if such alteration is positive; it leads to an increase in demand and puts pressure on output and thus inflation. The ability of the CBN to extract information from the bonds market and its potential role in forecasting inflation and the state of the economy have a strong bearing on the performance of monetary policy/control of inflation and therefore requires an empirical investigation.

1.2 Statement of Problem

The term structure of interest rates (yield curve) shows the relationship between yields of different maturities for different maturity loans. It has been an issue of concern both to policy makers and economic forecasters because of its predictive abilities and is often a useful indicator of the stance of monetary policy. This forecasting potentials result from the decision making process of profit seeking investors, which involves the formulation of expectations about future inflation and interest rates (Hurley, 1990). The fear for heightened inflations induces investors to demand for higher nominal yields. Such fears (inflation scare) could cause higher inflation expectations and signal a loss of confidence in the Central Bank's commitment to low level of inflation (Goodfriend, 1998). At this point the shape of the yield curve would slope upwards indicating higher inflation expectations and disbelief in the monetary authority. The result is that credibility level of the Central Bank at this point would be very low. Economic theory suggests that if markets are efficient, it should be possible to extract the aggregates of these expectations of inflation and interest rates from observable term structure data (Hurley, 1990). However, it then follows that such expectations must be rational for the forecasting power to be effective.

And by extension, if expectations are rational, the predictive power of the term structure would also be effective. Inflation figures in the past six months of 2013 have been pegged at a single digit, while bond yields have climb to double digits (CBN, 2013). Back in may 2013, the rate of inflation stood at 9%, however the yield on a 10-year bond was 11.8% which exceeds the inflation rate by 2.8% points. Despite the decline in inflation, the rising bond yields suggest that market participants' view this rate as unsustainable in the short-run due to unbalanced fundamentals in the economy like exchange rate and capital inflow. Accordingly, the yield curve would be more responsive to the policy direction and these economic fundamentals.

The CBN like any other central bank relies on inflation forecast and any information it can gather to make policy decisions. Nevertheless the CBN in its quest to formulate optimal policies is limited by the fact that it operates under an atmosphere of imperfect knowledge (Uncertainty). This can make it difficult for the CBN to come up with the desired interest rate that is consistent with the target level of inflation. The CBN devotes a lot of resources to forecasting and estimating the underlying state of the economy by gathering information that can shed light on this rate. The bonds market fits this profile because it contains information about participants' expectations on inflation. So, extracting such information would be an important input for monetary policy. Influential central banks' forecasts may lead private agents to stop forming their specific information sets and refer to the central bank's information (Hubert, 2012).

This study seeks to empirically examine the extent to which the information on private sector expectations of inflation which is contained in the yield curve that can help forecast inflation. This is with the view of increasing the information set available to the CBN to forecast future inflation.

1.3 Research Questions

Arising from the above research problems, this study seeks to answer the following questions

i. Is there any information in the bond market about the private sector inflation expectations?
ii. Can such information be used to improve inflation forecast?
iii. What is the implication of this information for policy?

1.4 Objective of the Study

The broad objective of the study is to examine the bond market information content and its implication for forecasting inflation in Nigeria. The specific objectives include;

i. To examine the information content of the bond market by plotting the yield curve from 2006 to 2013.
ii. To examine if such information can be used to improve the forecasting power of inflation models.
iii. To investigate the implication of this information for monetary policy.

1.5 Research Hypothesis

The research hypotheses to be tested in this study are;

$H_0$1: The bond market does not contain information on inflation expectations.

$H_0$2: The bond market cannot provide useful information for forecasting inflation.

$H_0$3: The bond market has no useful role to play in the policy arena.

1.6 Significance of the Study

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 this reason the CBN in 2009 through its statistical department began the conduct of surveys on inflation expectation using a small sample size of 1400 from the country's total population of over 140 million (CBN, 2012). Such results results obtained may not truly reflect the expectations of Nigerians. This also prompted the CBN (2010) in its study on inflation forecasting to call for further research that will capture the term structure of interest rate (the yield curve) and unemployment. And so this study will compliment the CBN surveys; by taking advantage of the information contained in yields of market instruments on inflation expectations. Secondly, the study seeks to improve inflation forecast by using information obtained from asset yield and modeling it alongside other variables to obtain a more reliable inflation forecast result. As the relationship between monetary policy and asset prices is critical, obtaining reliable estimates on the likely effect of asset prices (or yields) on inflation would be a paramount step to policy decision making. It is important to note, that this study does not seek to show the superiority of the information content of the bonds market over other forecasting models and information sources, but to serve as a part of the tool kit for which the CBN can exploit in the monetary policy process.

1.7 Scope of the Study

This study will cover the period of 2006-2013. The choice of this period is derived from the fact that monetary authority introduced a new framework for monetary policy through its introduction of the monetary policy rate (MPR). The ultimate goal of this framework was to achieve a stable value of the domestic currency through stability in short-term interest rates around an operating target (MPR). More so, this study adds new depth to the understanding of how assets of different maturity affect the level of inflation, since it explicitly reflects market participants' expectations.

1.8 Organization of the Study

This study is organized into five chapters. Chapter one contains the general introduction which includes; the background to the study, statement of problem, research questions, and objectives of the study, research hypothesis, and significance of the study, scope and limitation of the study. Chapter two contains with the review of literature; this consists of conceptual literature, theoretical literature, empirical and other relevant literature that could help the study. Chapter three is on the methodology and it contains; the theoretical and analytical framework, estimation method, model specification and source of data. Chapter four presents and analyses the empirical results as well draws implications from the findings. Finally, chapter five presents the summary, conclusion and recommendations of the study. References and appendices form the finishing part of this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literatures in related area. It seeks to establish a rationale for the use of information contained in asset prices as an additional tool for monetary policy formulation. The chapter also provides the appropriate theoretical basis and other literature that explains the role of the bond market in achieving CBN's macroeconomic objectives.

2.2 Conceptual Literature

2.2.1 Concept of Bond Market

Bond markets are central to the development of an efficient economic system. A developed bond market also plays an important role in improving the efficiency of overall economic management through expanding the range of opportunities of available to financing large scale projects, contributing to better allocation of capital, providing a non-inflationary source of finance for government and facilitating public debt management, and contributing to promote sustainable economic growth (Silva, 2008). Basically, the bond market is simply a financial market where bonds (treasury bills and treasury bonds) are bought and sold and are used to raise capital by government and corporations to finance medium to long-term projects (DMO,2013) According to Turner (2003), the strategic value of the bond market can be tied to the following:

i. The market helps to make financial markets more complete by generating market interest rates that reflect the opportunity cost of funds at a wide range of maturities. This is essential for efficient investment and financing decisions. The absence of such markets constrains investment possibilities.

ii. A second reason is that the development of bond markets can avoid concentrating intermediation on banks. It is better to spread some corporate risk in capital markets, rather than concentrating all corporate risk in the banking system.

iii. Furthermore, a liquid debt markets help the operation of monetary policy. A well functioning money market is essential for the smooth transmission of policy moves in a framework that is increasingly reliant on indirect instruments of control.

iv. The government is not left out; the bond market also helps governments to structure the debt management by providing an alternative channel for mobilizing funding, thus reducing the need for government to finance its deficits from banks and other financial institutions.

As obtainable in most financial markets, the Nigerian bond market is divided into the primary and secondary segments. Investors can buy only from the primary market while they buy and sell in the secondary market. The level of activities in these markets are influenced by several macroeconomic aggregates like level of money supply, market yield, market expectations as well as fiscal and monetary policies. Following a restructuring of the domestic debt markets, the Debt Management Office (DMO), which was originally established in 2000 to centrally coordinate the management of Nigeria's debt, started the issuance of longer tenured bonds in 2003 which resuscitated the bond market while CBN issue short-term bonds and also was mandated to act as the Issuing House and the Registrar in the primary market.

It is important to note that bonds are not only issued by the federal government but also by the state government and corporate organizations like banks to raise money to finance huge or capital intensive projects. However the most active player in the bond market in Nigeria is the federal government as it controls 94% of the bond market (Vetiva capital management, 2010).

2.2.2 Primary Market

The primary market is a market for new issues of bond securities and financial products. The securities are sold by the DMO and the CBN directly to investors via the primary dealers. Primary dealers' primary market function include taking up, marketing and distributing fresh issues of FGN securities. Other principal participants in the market are the DMBs, and discount houses. The primary market auction is conducted monthly usually on the third Wednesday of each month in accordance with released quarterly auction calendars. The auction calendars are usually issued before each quarter. The annual auction calendar stipulates the total amount to be offered for the year, tenor and frequency of issuances. The considerations are settled on the Friday of the same week on a Delivery Vs Payment basis. Investors would provide funding via their primary dealer and their bond accounts with the Central Securities Clearing System (CSCS) of the Nigeria Stock Exchange (NSE) would be credited. The auction is done using a single clearance yield or rate i.e. the single price auction system and successful bidders are allotted bonds at the clearance yield. The coupons on the bond are paid semi-annually and the coupons are fixed.

2.2.3 Secondary Market

The secondary market, is the financial market in which previously issued financial instruments such as treasury bills, and treasury bonds are bought and sold. In other words, it is a market for trading of existing securities. The secondary bond market has been experiencing a massive resurgence as the market has become very active. Although all FGN bonds are listed on the Nigerian Stock Exchange to facilitate retail market trade, almost all the trades are done over-the-counter (OTC). The Primary Dealership System has encouraged significant activities in the secondary market as all primary dealers are obliged to give 2-way quotes on different FGN bond maturities to their clients and other primary dealers upon request.

2.2.4 Instruments in the Nigerian Bond Market

2.2.4.1 Nigerian Treasury bills (NTBs)

Nigerian Treasury Bills are short-term debt instruments that mature in one year or less. This instrument is issued by the CBN on behalf of the federal government, to raise money to finance government projects and also as a means of mopping out excess liquidity in the economy. The bills also double as monetary policy instruments, which the CBN uses to control the liquidity level in the banking system through OMO. They are often regarded as the most liquid and marketable instruments due to its ease of access, affordability and safety.

2.2.4.2 FGN Bonds

They are long term debt instruments with maturity greater than one year (3years, 5years, 7years, 10years and 20years), issued on behalf of the FGN by DMO and are backed by the full faith and credit of the Nigerian Federal Government. The purpose of this instrument is to enable government to finance its deficits and meet up with its developmental obligations. They are issued at par and at coupon rate, and interest is paid periodically.

2.2.5 Trend Analysis of the Bond Market

Since the re-structuring of the FGN Bond market in 2003, there has been an overwhelming demand for government bonds because of government commitment to meeting its obligations and the low level of risk attached to holding government bonds. By 2006, the volume of trade in the market had increased tremendously due to the introduction of the Primary Dealers/Market Makers (PDMM) in 2006, playing an active role in the issuance, sale and marketing of FGN Bonds. This increase continued till 2007. However 2008, the global financial crises impacted negatively on the market. But, in 2009 the market began to record significant growth as a result of an increase in demand for credit by government to finance budget deficits for both new and abandoned long-term infrastructure projects and facilitate national development.

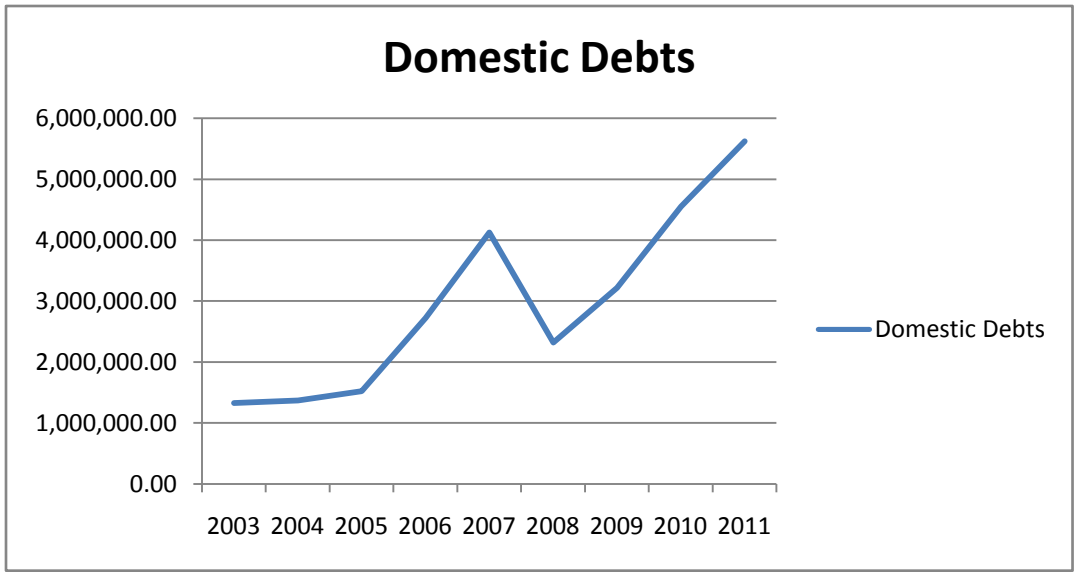


Fig 2.1: Trend of Domestic debts size

2.2.6 Signal Extraction

Signal extraction refers to the use of information contained in the yields of financial assets for policy purposes. The slope of the yield curve signals or informs policy makers of people's expectations about future inflation. And so the monetary authority can adjust short term rates in a way that is consistent with their target inflation

2.2.7 Monetary Policy

Monetary policy is the direct or indirect use of monetary instruments (money supply or interest rates) by the monetary authority (CBN), to achieve macroeconomic stability (Ezema, 2009). The efficacy of monetary policy is not only dependent on its transmission mechanism but also on the ability of the CBN to predict future outcomes of inflation. This is because monetary policy affects the economy with a lag and central bank's forecast plays an important role in

implementing monetary policy. Some central banks consider inflation forecast as an intermediate target of monetary policy (CBN, 2010).

Monetary policy operates in an ever changing environment and thus understanding the inflation dynamics requires forecasting models that are capable of predicting price shocks and its effect on macroeconomic variables. Inflation targets must be forward-looking in such a way that the monetary authority is able to preempt rising inflation. Inflation forecast are based on empirical studies of the relationship between the rate of inflation and several economic aggregates that are believed to influence inflation. In Nigeria, efforts were made to develop a suite of models for inflation forecasting; these models which range from trend, autoregressive integrated moving average (ARIMA), money gap, open economy, Philip curve models, VAR to VECM (CBN, 2010). Given the policy lag, it makes sense that policy decisions should be based on expected future conditions when the policy was first made (Orphanides and John, 2003). Expectations in this regards, is crucial in determining the ability of the monetary authority to forecast future inflation rates. This is because economic agents, both households and firms have an incentive to make their economic decisions (consumption and investments) in a way that optimally takes into account the likely future developments of economic variables relevant to such decisions (Iklagu, 2001).

Inflation expectations have a great influence actual inflation because expectations act as a major component of setting prices and wages in the economy. Therefore if such inflation expectations are known, the central bank can target it in a way that is consistent with its target level of inflation. The Expectation theory asserts that the yield curve is an indicator of inflation expectations. The yield curve slopes upwards when inflation expectations are high and slopes downwards when inflation expectations low. Thus, if expectations are unbiased, then changes in

the yield curve will provide leading information on actual changes in inflation (Fung and Chapple, 1994). Basically, inflation expectations provide the link between policy instruments used by the CBN and the inflation target (Iklaga, 2001).

Central banks use different avenues to generate information on inflation expectations. Iklaga (2001) outline these channels as follows:

i. Surveys of the results of inflation forecasts made by professional researchers.
ii. Surveys of inflation expectations of households, managers, trade union officials.
iii. Indicators of inflation expectations derived from financial market data, above all long-ter bond yields and the difference between such yields and yields of index-linked gilts.
iv. In addition, the results of wage settlements can be used as very important indicators of inflationary expectations and of future cost pressure.

Conversely this study is concerned with the third point mentioned above; inflation expectations derived from financial market. CBN in 2009 designed a framework for undertaken on a regular basis expectation surveys of households and businesses across the six geo-political zones. The main purpose of these surveys is to generate data that could provide information useful to policy makers over both short run and long run horizons. However the sample size used for this purpose is usually small and as such, surveys conducted might not be a true representation of the inflation expectations of the Nigerian populace. The bond market can provide information that would enrich the data base on inflation expectations in Nigeria. Therefore as long as financial instruments contain information that can predict future rates of inflation, CBN can use such information in formulating monetary policy.

2.2.8 Concept of the Yield Curve/ Term Structure of Interest Rate

The yield curve has become one of the most popular leading indicators of economic activity, as there is substantial evidence of systematic association between changes in its slope and the future state of the economy (Chauvet and Senyuz, 2012). The yield curve (also called the term structure of interest rates) is a graphical representation of instruments with various maturities and it shows the returns for instruments with different maturities but having the same risk structure (Central bank of Egypt, 2010).Yield curve can be upward sloping, lumped and downward sloping and the shape is often taken to be an indication of whether interest rates and/ or inflation are expected to rise or fall (Hurley, 1990). Basically, the shape of the yield curve reflects market expectation of participants and also the likely course of future monetary policy. According to the Central Bank of Egypt (2010), the various shapes of the yield curve are as follows:

i. The yield curve has usually been "normal", meaning that yields rise as maturity lengthens (i.e., the slope of the yield curve is positive). The steepness of the yield curve stems from the investors' expectations that the economy would grow in the future and, importantly, for this growth to be associated with a greater expectation that inflation will rise in the future rather than fall. This expectation of higher inflation leads to expectations that the central bank will tighten monetary policy by raising short term interest rates in the future to slow economic growth and dampen inflationary pressure. It also creates a need for a risk premium associated with uncertainty about the future rate of inflation and the risk this poses upon the future value of cash flows. Investors price these risks into the yield curve by demanding higher yields for maturities further into the future.

ii. On the other hand, a flat yield curve is observed when all maturities have similar yields, whereas a humped curve results when short-term and long-term yields are equal and medium-term yields are higher than those of the short-term and long-term. A flat curve sends signals of uncertainty in the economy. This mixed signal can revert back to a normal curve or could later result into an inverted curve.

iii. There is also the possibility of having an inverted yield curve when long-term yields fall below short-term yields. Under this abnormal and conflicting situation, long-term investors will settle for lower yields in this case, if they think the economy will slow or even decline in the future. An inverted curve may indicate a worsening economic situation in the future. In addition to potentially signaling an economic decline, inverted yield curves also imply that the market believes inflation will remain low. This is because, even if there is a recession, a low bond yield will still be offset by low inflation

2.3 Theoretical Literature

This section reviews the various theories of the term structure of interest rates

2.3.1 The Expectation Theory of the Term Structure

The expectation theory of the term structure can be attributed to Irvin fisher and was improved by hicks in his treaties on value and capital. The theory suggests that there exist a relationship between short-term rates and long-term rates. This is because the long-term rates are simply averages of the current and expected future short-term rates. Therefore, monetary policy affects long-term rates by directly influencing short term rates and by altering market expectations about future short term rates (Roley & Sellon, 1995).

According to the theory, the interest rate on any security contains two elements; information about financial market's expectation about monetary policy over the life time of the security and a term premium to compensate for risk (Kozicki & Sellon, 2005). In other words, the long-term bond rates is determined by average short-term rates and a premium for risk which is usually equal to zero (α=0). This can be formally expressed in an equation as follows;

$$I_t = \frac{1}{n}(i_t + i^e_{t+1} + i^e_{t+2} + \ldots + i^e_{t+n-1}) \quad \ldots\ldots (1)$$

Where I_t and i_t are the long-term and short-term rates respectively. i^e_{t+1}, i^e_{t+2} express the future path of short-term rates. This equation expresses the fact that the long-run rates are driven by expectations of future short-term rates. Such expectations of future rise in short term rate are tied to the fact that market participants expect inflation to rise in the future. In simpler term, the current yield on a 3-year bond will equal the averages of three rates; the current 1-year rate, the expected future 1-year rate, and the expected 1-year rate two years in the future. Similarly, the current yield on a 20-year bond will equal the averages of the current 1-year rate and a series of 19 expected 1-year rates.

Jhingan (2004) opined that the difference in yields on securities of different maturities is due to the fact that the market expects the interest rates of different securities to be the same over an equal period of time. For instance, suppose a 1-year bond is currently trading with an annual yield of 5% and market participants expect a new 1-year bond issued a year from now to yield 7%. In this case, under expectation theory the current yield on a 2-year bond will be 6% which is the average of the current and expected future 1-year bond. If the assumption of perfect substitution does not hold, investors will arbitrage away any differences. In other words, investors will buy and sell securities in such a way that they would make profit without incurring

any risk. Therefore, both short-term and long-term securities would have no effect on their yields. This will imply that investors would have no problems with the composition of their investment portfolio (whether or not it favors the acquisition of short-term or long-term securities).

Fisher's hypothesis (which is also referred to as Fisher's effect) provides a clear explanation of the expectation theory. The hypothesis suggests that there is a link between market interest rates and expected inflation. This is represented in a simple equation as;

$$R = r - \pi^e \quad \text{..... (2)}$$

This means that the real interest rate (R) is equal to the nominal interest rate (r) minus expected inflation. If (R) is assumed to be constant, (r) must rise for when (π^e) rises. Thus the Fisher's effect states that there will be one for one adjustment of the nominal interest rates to inflation expectations. For instance, if we assume that inflation is expected to rise from a constant level say 5% to a higher say 10% per year. Interest rates are expected to catch up with the higher level of inflation rate by raising 5 points a year from the initial level. The fisher's effect is evidence that in the long run pure monetary developments will have no effect on the country's relative prices which is consistent with the study of Walsh (2010).

Adao and Luis (1997) argued that if the expectation theory is valid, information about the future path of short-term rates can be drawn from the yield curve as the forward short-term rates are in fact advanced indicators of macroeconomic variables (inflation, employment and growth). Hence, when the yield curve slopes downwards (negatively sloped), it indicates low inflation expectations of private agents and consequently a fall in future short-term rates. And when the yield curve slopes upwards (positively sloped), it indicates a rise in inflation expectations of

private agents and thus a rise in future short-term rates. A third case scenario may arise; in this case, the yield curve becomes horizontal, indicating that market participant's expectations of inflation and future short-term rates are normal (to neither rise nor fall). Basically, private sector inflation expectations affect the shape of the yield curve. Basically, if expected inflation rises, the market interest rate must rise to preserve the required real returns (Garner, 1987).

Government's altering of short-term and long-term rates through varying their supply would have no effect on the structure of interest rate. Therefore, for policy to be effective, monetary authority must find a way to alter the inflation expectations of market participants.

2.3.2 The Segmented Markets Theory of the Term Structure

The segmented market theory can be attributed to Culbertson and is also regarded as an institutional theory. The theory suggests that yields of different maturities are determined independent of one another. The interest rates of short-term securities are determined by the demand and supply of short-term securities while long-term rates are determined by the demand and supply of long-term securities. In other words, short-term and long-term rates are determined in separate markets so short-term securities cannot be substituted for securities of longer maturity. The market segmentation theory suggest that inefficiency in the general equilibrium of the partially non-communicating interest rates markets, ranked by maturity, and is not completely eliminated by inter-market arbitrage as suppose by the expectation theory (Sutthisit&Cornelis, 2006). The theory can be presented in mathematical for as follows;

$$R_t = [(1 + r_1)(1 + E_0\{r_2\} + L_2 + E_2)(1 + E_0\{r_3\} + L_3 + E_3) \dots\dots (1 + E_0\{r_t\} + L_t + E_t)]^{\frac{1}{t}} - 1 \quad \text{..... (3)}$$

Where E_t expresses the market inefficiency cost for term t, L_t is the liquidity risk premium, r_t expresses the interest rate at term t.

The slope of the yield curve can be viewed as an imbalance between the demand and supply for yields of different maturity. This position and the shape of the yield curve is independent of the factors that determine the demand and supply for both short-term and long-term bonds; the state of the economy determines the position of the supply curve, and the rates on government securities determines the position of the corporate bond demand curve (Stafford et-al, 2003). Based on the market segmentation theory; an upward sloping curve indicates that supply is greater than demand for short-term securities (SS>SD) and therefore, short-term rates would be lower than long-term rates. This would put pressure on the supply of long-term securities. On the other hand, if demand exceeds supply for long-term securities (LD>LS), the short-term rates would be higher than the long-term rates. In this case the yield curve would slope downward. It is important to note that investors are risk averse and would naturally demand more of short-term bonds which are less risky relative to long-term bonds. Long-term bonds would ultimately have lower prices and high interest rates.

Basically, since interest rates in one segment of the market have no impact on any other portion of the market, Garner (1987) argued that the yield curve would be on likely to contain much useful information regarding expectations of future inflation.

2.3.3 The Liquidity Premium Theory of the Term Structure

The liquidity premium theory is an extension of the expectation theory because it not only attaches the same importance to the expected future rates of interest and inflation, but also includes the role and influence of risk preference of market participants. The theory explicitly states that the interest rate on long-term bond would equal an average of short-term interest rates expected to occur over the life of the long-term bond plus a liquidity premium that responds to

demand and supply conditions (San et-al, 2012). In other words, yields of longer maturities reflect not only the expectation of market participants of future inflation, but also a premium for risk. This premium is always positive and grows as the term to maturity increases.

The theory also regards bonds of different maturities as substitutes (like the expectation theory) but not as perfect substitutes. This implies that the expected returns on a bond, does not affect the expected returns on another bond of different maturity, thus allowing investors choose one bond maturity over another. The basic idea that underlies the theory is that investors prefer short-term securities because they are associated with less risk, while bonds of higher maturity are associated with high risk. Therefore, holders of long-term bonds must be paid a premium to induce them to hold such securities. Basically, higher interest rates on longer term securities are determined by two components; the expectation component and the liquidity premium component (Jhingan, 2004). For this reason, interest rates on longer term securities would be higher than that on short term securities because of the liquidity premium component.

The liquidity premium theory is written in mathematical form as follows;

$$I_{nt} = \frac{(i_t + i^e_{t+1} + i^e_{t+2} + \ldots + i^e_{t+(n-1)})}{n} + I_{nt} \qquad \text{.......................(4)}$$

Where I_{nt} is the liquidity term premium for n-period bond at time t, which is always positive and rises with the term to maturity of the bond, n.

The yield curve implied by the liquidity premium theory is always above the yield curve implied by the expectation theory because of the premium component. Basically, the theory is quite different from the expectation theory because it factors in the risk components associated with investing in securities of different maturities.

2.3.4 The Preferred Habitat Theory of the Term Structure

The preferred habitat theory of the term structure was developed by Modigliani &Sutch (1966). The theory is a combination of both the expectation and segmented market theories. The theory suggests that investors have preference for bonds of one maturity (preferred habitat) over another and are chosen according to their expected yields (Jhingan, 2004). But investors may be willing to buy securities outside their habitat if they are duly compensated or enticed by the risk premium. The risk premium is a reward which induces investors to purchase securities with different terms to maturity than their preferred term. These investors are likely to prefer the habitat of short-term bonds over that of longer-term bonds; they would only hold longer-term bonds if they have high expected returns (McElhattan, 1975). The preferred habitat theory can be expressed in mathematical form as;

$$R_n = \alpha_n + \frac{r+E_{1r}+E_{2r}+\cdots+E_{n-1r}}{n} \quad \text{.....(5)}$$

Where α_n is a term premium of a security with a term to maturity of n years, R_n is the yield on securities, r is the interest rate, E_{tr} is the expected interest rate on one-year security in year . This equation shows that the interest rate on n-period security equals an average of the one-year rates that are expected to prevail during the life of the long-term security plus the term premium required to induce investors to hold n-period security. It is important to note that implicit in interest rates are market agents expectations of future inflation which consequently affects the shape of the yield curve.

The theory further asserts that investors choose securities on the basis of; expected yield on securities and his preference for a security with a particular maturity (Jhingan, 2004). Thus, an investor must be compensated for purchasing undesirable securities with a term premium. The

preferred habitat theory explains the shape of the yield curve in a better dimension as opposed to the other theories;

i. The yield curve slopes upward when the term premium is positive, and when there are expectations of inflation and short-term rates to rise by a large amount.

ii. The yield curve would be horizontal when the term premium is positive and short-term rates and inflation expectations are likely to rise by a small amount.

iii. The yield curve would slope downwards when the term premium is positive and short-term rates and inflation expectations are expected to fall by a large amount.

2.4 Empirical Literature

Several attempts have been made by scholars especially in developed countries to provide empirical evidence concerning the information content of the bond market. But only few related literature have been carried out in Nigeria. In this section, we provide empirical evidence on not only the role of the bond market in formulating monetary policy, but also on its ability to forecast the state of the economy (business cycle)

Mishkin (1990) examined the information content in long term securities about future inflation in the United States. Using regression analysis, the result indicated that there was substantial information in longer term securities about future inflation. His conclusion was that the slope of the yield curve has a great deal of predictive power. A similar study was conducted by Hurley (1990) use Irish data from 1971 to 1989. The study anchored on the rational expectation theory and Fisher's parity hypothesis suggests that the slope of the yield curve lacks information about future inflation rates.

Bernanke and Woodford (1997) evaluated the role of inflation forecasting in monetary policy. The study focused on the existence and uniqueness of rational expectation equilibria when the Central Bank uses private sector forecast (professional forecasts or those implicit in asset prices) as a guide for policy action. Ina dynamic model which incorporates both sluggish price adjustments shock and shocks to aggregate demand and supply, the study reveals that economies with a more general forecast based policy rule are particularly susceptible to indeterminacy of rational expectation equilibria. The conclusion of the study was that; although private sector forecast contains information that is useful to the central bank, the monetary authority must rely on an explicit structural model of the economy to guide their policy decisions.

Jorion and Mishkin (1991) undertook a multi-country study of the term structure of interest rate over a long horizon. Using data set of 1-5 years on Britain, West Germany and Switzerland for the period 1973-1989, the study found that the term structure of interest did have a significant forecasting ability for future changes in inflation over a long horizon. However, the ability of the term structure to forecast future changes using a 1-year interest rate was somewhat weak. Mishkin (1989) conducted a similar study of OECD countries over a short horizon (for maturities of twelve months or less) for the period of 1973-1986. Employing the seemingly unrelated regression (SUR) estimates of a system of equations, the study showed that for a majority of the countries in the sample, the term structure did not have a great deal of information about the future course of inflation.

Ang et-al (2007) used a non-arbitrage term structure model to together with both nominal bond yield and inflation data to efficiently identify the term structure of real rates and inflation risk premium. The decomposition of nominal yields into real yields and inflation components at

various horizons indicates the variations in inflation compensation- expected inflation and inflation risk premia. The study suggested that inflation risk compensation is the main determinant of nominal interest rate spread over a long horizon.

Doh (2011) examined the information contained in the yield curve about the Federal Reserve's implicit inflation target. The data employed macro and Treasury bond data for the period 1960-2004, in a dynamic structural general equilibrium model (DSGE). Also, the Bayesian estimation technique combined prior information on the model's parameters with the likelihood generated by the sample to capture the common trend for both interest rates and inflation. Findings of the study indicated that the yield curve provides rich information about long horizon inflation expectations which are essential for monetary policy analysis.

Estrella et-al (2000) took a different approach by focusing how stable is the predictive power of the yield curve. The study considered continuous models which predict growth of inflation and binary models which predict recession or inflationary pressure. Using recent econometric technique for break testing (both known break points and unknown break points) to examine whether the empirical relationships are in fact stable, the study revealed that for both the U.S and Germany, the models that predict real activities were more stable than those that predict inflation over time.

Dewatcher (2009) estimated an encompassing macro-finance model that allowed for time variations in equilibrium real rates, miss-pricing and learning dynamics. The study employed various data sets in GDP, inflation and yields of various maturities for the period 1960-2006. The findings of the study confirmed the relevance of the inflation scarce hypothesis.

Other empirical studies focused on the applicability and validity of the expectation hypothesis of the term structure. Most of these studies validated the expectation hypothesis. For instance the Mitchell-Innes (2006) who studied the relationship between expected inflation rates and nominal interest rates to determine the extent to which the Expectation hypothesis holds in South Africa. The study employed data on 3 months banker's acceptance rate and 10 years government bonds as proxies for both short-term and long-term rates for the period 2000-2005. Using both Granger Causality and Johansen's co-integration test, he established that a long-run co-integrating relationship exists between long-run rates and expected inflation. The study therefore validated the expectation hypothesis. In a similar study, Smant (2010) provided evidence in support of the expectation hypothesis in the Netherlands. Taking into account the weaknesses of perfect foresight error of the expectation hypothesis and the coefficient bias caused by the term premium and forecast errors, the expectation theory fits the term structure data.

Liau and Yang (2009) found a different result in his study of Taiwan. The main intention of the study was to investigate the expectation hypothesis of the term structure using yields of various maturities. The Generalized Method of Moments (GMM) technique suggested that the expectation hypothesis of the term spread is not applicable at all rates. Moreover, the empirical result is valid for both sub-periods as well as the whole period.

Guthrie et-al (1999) tested the rational expectation theory of the term structure using daily records, weekly and monthly observations on New Zealand's interest rates. The study provides further evidence on the validity of the expectation theory of both short and long horizons.

Guidolin and Thornton (2008) analyzed the expectation hypothesis by focusing on its tenets- the predictability of future short-term rates. Employing interest rate forecasting models and random walk forecast model together with data on treasury bills, the study indicated that the future short term rates are not predictable to any significant level.

The information content of the bond as stated earlier is not only limited to forecasting inflation but also the state of the economy. Some studies have focused on the growth perspective, others the changes in business cycle, while others the changes in consumption patterns in the economy. Various studies carried out in this regards exploited the Consumption Capital Asset Pricing model (CCAPM), non-linear multivariate dynamic factor model, probit model and so on.

Ferreira et-al (2003) employed a flexible linear version of the CCAPM to show the extra ordinary capacity of the yield spread to forecast consumption growth. Using data from Euro and non-Euro states for the period 1993-2002, the findings of the study showed that the yield spread in Europe contains extremely useful information that can be employed to forecast future growth. A similar study was carried out by Harvey (1998) on the term structure and consumption growth. Employing the Generalized Method of Moments technique, the study provided evidence that the expected real term structure contains information that can be used to forecast consumption growth.

Dominguez and Novales (1997) used a general equilibrium asset pricing model to examine the predictive power of the term structure. The result of their study shows the ability of the term structure to predict growth over a short horizon in Spain. The study stressed the need to further research over a long horizon.

Nimark (2008) in his study on monetary policy with signal extraction from the bond market used a general equilibrium model of monetary policy. This model presented a coherent framework within which any information about the state of the economy contained in the term structure is quantified in a general equilibrium setting. Data on GDP, treasury bills and inflation were used together with a Bayesian estimation technique over the period of 1982-2005. The result suggested that there is some information in the U.S term structure that allows the Federal Reserve to respond to shocks in a timely manner. Most of the information in the term structure about the state of the economy could be found in yields with maturity of less than one year. Longer maturity bond are uninformative about the state of the economy.

Estrella and Mishkin (1995) examined the performance of various financial variables as predictors of subsequent U.S recession. Series such as interest rates and spreads, stock prices, currencies and monetary aggregates were evaluated in comparison with other financial and non-financial indicators. Using probit model and the yield curve spreads the results show that the yield spread can play a useful role in macroeconomic predictions. Ang et-al (2003) presented a flexible arbitrage free model in his study on the yield curve and GDP. Using data from 1964 to 2001, the study showed that short rates have more predictive power about GDP growth than long rates.

Chauvet and Senyuz (2012) proposed an econometric model of a joint dynamic relationship between the yield curve and the economy to predict business cycle. The proposed non-linear multivariate dynamic factor model takes into account not only the term spread but also information extracted from the level and curvature factor of the yield curve and macroeconomic variables. Using data for the period 1971-2007, the result indicated strong interrelationship between the bond market and business cycle. Hamilton and Kim (1999) revisits

the term spread's usefulness in predicting GDP growth. The study decomposed the term spread into; the effects of expected future changes in short rates and the effects of the term premium. Using a GARCH-X model, the study reveals that both components of the term spread are significant in explaining GDP growth.

Kozicki (1997) studied the predictive power of the yield spread for both inflation and growth. Her study covered countries like Australia, Canada, and France among others. Estimation results obtained using data over a period of 1970-1996 showed that the term spread has maximum predictive power for real growth over the next year or so; whereas, a maximum predictive power for inflation is at a much longer horizon of about three years.

Mehl (2006) investigated the extent to which the yield curve in emerging economies predicted inflation and growth. A sample of fourteen (14) emerging economies was used for the analysis. Regression analysis and granger causality test were carried out and the results suggested that the yield curve contained information in almost all countries, even after controlling for inflation and growth persistence at both short and long forecast horizon.

Hillebrand et-al (2011) used a Nelson-Siegel yield curve factor model to forecast growth and inflation. Data on inflation, output and Treasury bill of different maturity were used to test the model. The result indicated that the yield curve has predictive power in macroeconomic variable for both in and out of sample forecasting especially at long horizons.

Some studies in Nigeria shed light on the role of securities in influencing macroeconomic variables/outcomes. For example, the study of Teriba (2006), which focused on the information content of the interest rates spread for a period of 1987- 1995. Using random walk and spread models, his study reveals that the term structure spread does predict real activity

(real GDP), real gross domestic capital formation as well as consumer spending in Nigeria. Anyanwu and Oruh (2011), in their study of the term structure of Treasury bill rate, aimed at obtaining an appropriate yield curve that could be used to price any security that depends on the Nigeria Treasury bill rate. Using Cox, Ingersol and Ross Model and the stochastic differential equation (SDE), the interest rate process was simulated using the Milstein numerical scheme. The study reveals that the yield curves obtained are hump-shaped initially, before leveling out as the time to maturity lengthens.

Furthermore, the study of Ikoku (2010) examines the causal relationship among market prices, real GDP and the index of industrial production using data for the period 1984-2008. Granger causality test indicated a bi-directional causality between the stock prices and GDP. Out of sample forecast constructed with structural ARIMA and VEC model indicates that stock markets contain information that can be used to improve the accuracy of GDP forecast and enhance the conduct of macroeconomic policy in Nigeria. Omotor (2010) tried to establish the link between stock prices and inflation. The study investigates this relationship using monthly and quarterly data on Nigeria for the period 1985-2008. Granger causality and Co-integration test indicated that a positive relationship exists between inflation and stock prices. The policy implication of the study is that stock market returns may provide and effect hedge against inflation in Nigeria.

Ogbonna (2013) examined the causal link between interest rates and inflation in Nigeria using quarterly data on Nigeria for the periods of 1970 – 2012. Maximum likelihood method of co-integration, in ADL models was used to determine the number of co-integrating vectors and verify the nature and direction of causality between interest rates and inflation in

Nigeria respectively. The findings of the study suggest that there is a significant causal link from inflation to interest rates in the short-run.

Abiodun and Abdulsamad (2014) examined the prospects and challenges of inflation linked bonds in Nigeria. Their study explored the different motivations for using inflation linked bonds by issuers and the preference by investors relative to other funding options and investment portfolio in Nigeria. The study highlighted the benefits to both issuers and investors especially in the management of pension assets. However the study emphasized the need to develop capacities terms human resource especially in risk management as well good publicity to make the general public to be informed of the new initiative if introduced

Oyedele (2014), examined the relationship between the term structure of interest rates, economic growth and inflation rate in Nigeria. The study employed quarterly time series data, from 1986-2008 and employed the dynamic ordinary lest square (DOLS) techniques in the analysis. The study concluded the term structure of interest rate in Nigeria does contain information about future inflation rate and economic

Basically, the empirical studies reviewed showed that bond market contains information which can help improve forecasts for inflation and the state of the economy. Though these studies are mostly foreign, empirical works on this topic are lacking in Nigeria. This study therefore seeks to fill this gap in the existing literature and form the basis for further research in this area.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Theoretical Framework

The theoretical literature provides detailed explanation on the term structure of interest rates. The expectation theory of the term structure forms the basis on which the study would be anchored. The expectation theory of the term structure regards expected future rates as the major determinant of the present structure of interest 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. These are because bonds of various maturities are believed to be perfect substitutes. The difference between long term and short term bonds is simply 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 (Ramos-francia and Sidaoui, 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 of inflation.

Basically, the literature identifies private sector expectations as one of the channels through which monetary policy impacts the economy. According to the expectation channel, all

variables that have inter-temporal implications and are therefore determined in a forward looking way, are affected by agents belief about future shocks to the economy and how the central bank would react to them (Loayza and Schmidt- Hebbel, 2002). As regards monetary policy, it is important for us to have a quick look on how monetary policy through its various channels affects the economy. Drawing from the BoE (1999), a simple and clear structure of monetary policy transmission mechanism is presented in Fig. 3.1

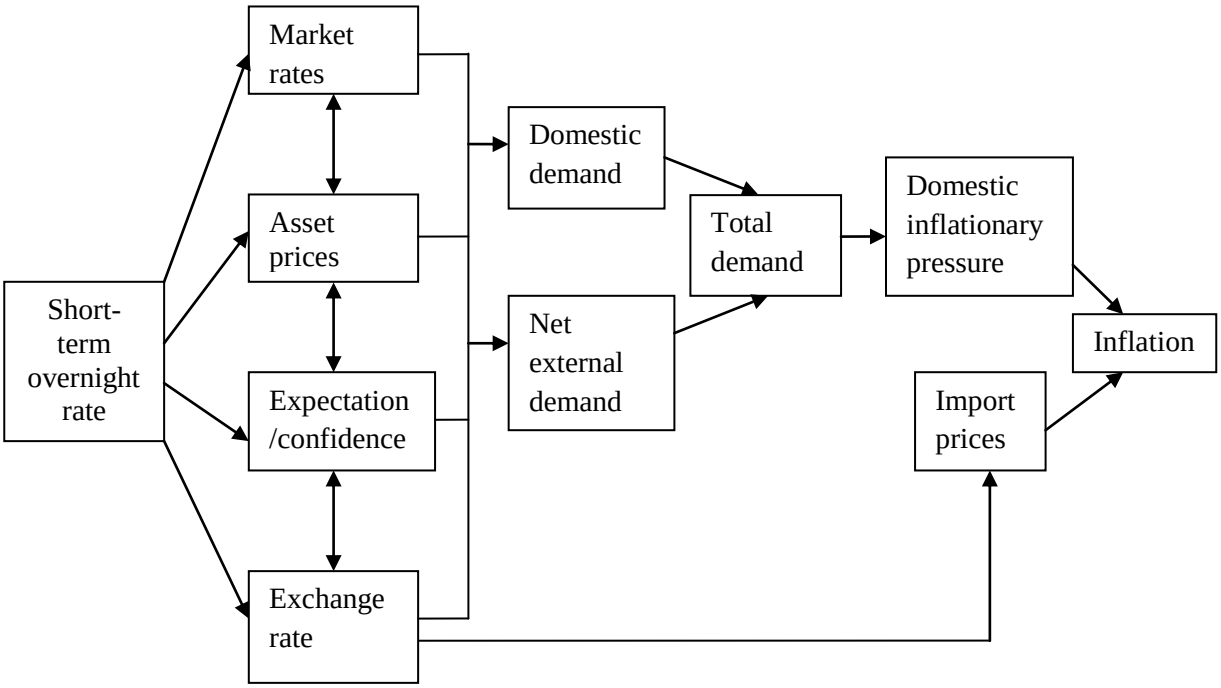


Figure 3.1 Monetary Policy Transmission Mechanism via Interest Rate

Source: Adapted from Bank of England, 1999 Report.

From Figure 3.1, it shows that a change in the overnight rate first affects market rates, assets prices, expectations/confidence and exchange rate. The change in these channels and the interrelationship among these variables will alter spending, saving and investment behavior of individuals and firms in the economy. These then affect domestic demand and net external

demand thereby passing to total demand, domestic inflationary pressure and finally onto inflation. It then follows that if the monetary authority desires to curb inflation for instance, it raises the short term overnight rate. This increase will lead to higher market rates. All things being equal, higher interest rate encourages savings and discourages spending. These have the effect of reducing total demand and consequently the inflation in the economy.

From the above mentioned, it is expected that a change in the short term policy rate lead to an instantaneous one-to-one change in market rates. According to the expectation theory, if the markets agents anticipate the policy rate change in advance, they will incorporate the change into their prices and wages models even before the change in the policy rate is implemented; such that the monetary policy rates will not have the desired effect on the economy. In the light of this, monetary authorities should focus extensively on information about private sector expectations because they are constituents of actual inflation. Moreover, expectation plays a crucial role in the transmission mechanism of monetary policy. To lucidly explain the transmission mechanism of monetary policy via Expectations, a simple but clear figure is presented in Figure 3.2

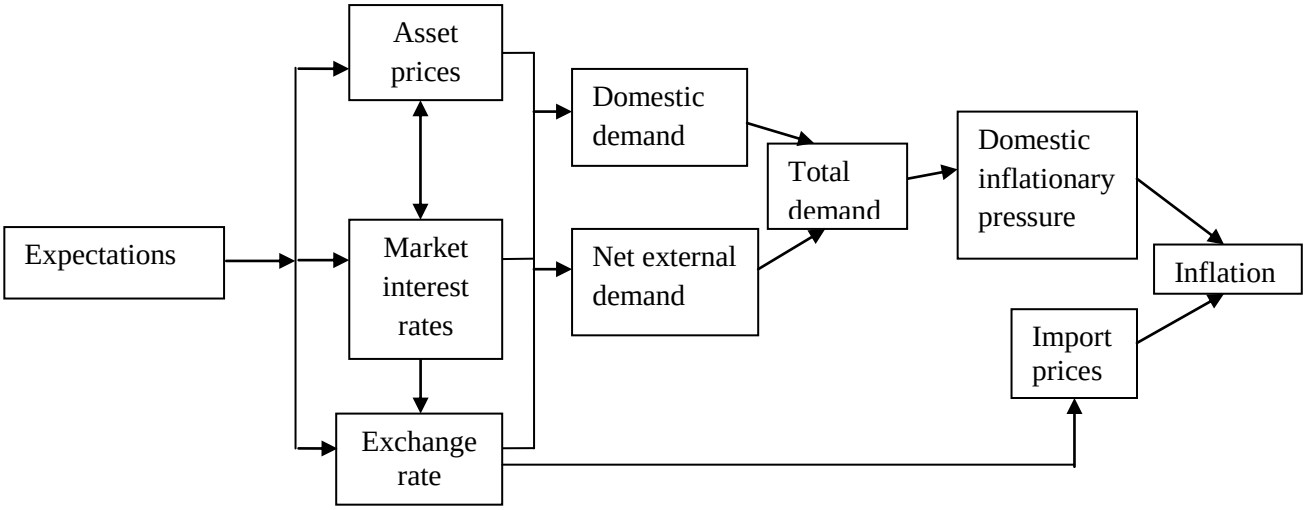


Figure 3.2 Monetary Policy Transmission Mechanism via Expectations

Source: Modified from BoE, 1999 Report by the author.

From Fig.3.2, assuming there is a change in market agents' expectation, such that market participants expect inflation to increase. The money market for instance will react by raising its rates. This increase in the market rates will raise the cost of borrowing which in turn discourages spending and encourages savings in the economy. This has a downward pressure effect on demand, inflationary pressure and finally onto inflation.

3.2 Measuring Inflation Expectations

Inflation expectations play a critical role in the conduct of modern monetary policy, providing timely and useful information with respect to inflation and the central banks' credibility (Cunninghan, Desroches, and Santo 2010). This is because expectations are a major component of actual inflation and can be used as part of the variables to forecast future inflation. According to the Central Bank of Europe (2011), monetary policy must involve anticipating future developments, monitoring and shaping private sector expectations and providing a

nominal anchor for the economy. The CBN must monitor closely the public perceptions' about their commitments to achieving their price stability mandate. Credibility in this regards is essential, if monetary policy is to be used to influence private sector expectations. Accurate and consistent measurement of inflation expectations can serve as vital source of information for calibrating monetary policy and deepening our understanding of economic behaviors' (Bernanke, 2007). Inflation expectations cannot be observed directly, but approximate measures can be observed indirectly from financial markets and surveys (ECB, 2011).

i. **Surveys:** Surveys provide forecast of expectations at various horizons covering the short, medium and long-term. In surveys, three types of respondents are considered; households, businesses and Professionals/experts. Respondents were usually asked questions about future inflation and interest rates in the economy. In other words, they were asked to forecast inflation ranging from 4 to 8 quarters (short horizon) and 5 to 10years (long horizon).

ii. **Financial/Market based measures:** Financial instruments can also provide information about expectation which could be inferred from asset prices/yields such as bonds and stocks. This is because decisions made by market participants are to ensure that inflation does not erode the purchasing power of their assets. Thus asset prices/yields invariably contain investors' expectations of future inflation. Given the term structure of interest rates, the different maturity of various instruments reflects agents' expectations of future inflation.

3.3 Analytical Framework

To achieve our first objective, which is to examine the information content of the bond market, the yield curve would be plotted for various years within the study period. Detailed analysis and explanations would be provided based on the expectation theory of the term structure of interest rate

For the second objective of this study, is to measure the predictive power of the yield curve. Thus this study adapts the forecasting models of; Kozicki (1997), and CBN (2010). Specifically, the study employed the Vector Auto regression technique which was developed by Sims (1980). VAR models are simple multivariate models in which each variable is explained by its own past values and the past values of all other variables in the system (CBN, 2010). The literature on VAR holds the claim that it is reliable in forecasting inflation. Kozicki (1997) model is as follows:

$\pi_t = f(\text{Ys}, \epsilon_t)$ 3.1

Where: π_t is inflation, Ys is yield Spread and ϵ_t is the error term

The yield spread is the difference between a long-term bond and a short term bond and is often used in the literature as a proxy for inflation expectation. However, the information content of the slope of the yield curve will be of more practical value to policymakers only when it is used in combination with information available on other macroeconomic variables in the economy at any point in time (Teriba, 2006). For this reason, the model of CBN(2010) come into play. The model is as follows:

$\pi_t = f(\text{GDP}, \text{EXR}, \text{M2}, \text{MPR}, \varepsilon_t)$ 3.2

Where ; π_t is inflation rate, GDP is Gross Domestic Product, EXR is Exchange Rate, M2 is Money Supply, MPR is Monetary Policy Rate, and ε_t is Error term.

To capture the yield curve (expectations) in the model, we include two variables; the Treasury bill rate for 90days and the yield spread to capture the yield curve both at the levels (short term) and the slope which is the yield spread.

$\pi_t = f($,EXR,MPR, TB90, Ys, ε_t)…….3.3

Where: Ys is Yield spread

TB90 is Treasury bill rates for 90days

Basically to achieve the objectives of this study, the VAR model which captures the inflation expectation would be estimated. The model also takes into account the various channels through which monetary policy impacts on the economy. In ordering the variables it is assumed that monetary policy via expectation would transmit into prices through MPR and exchange rate. However, if there exist one or more co-integrating equations, the Vector Error Correction (VEC) model would be used, because it is designed to incorporate non-stationary series that are co-integrated.

3.4 Estimation Method

3.4.1 Unit Root Tests

Many economic variables are non-stationary because of shocks, changes and fluctuations over time. For this reason, it is important to conduct preliminary diagnostics tests on the properties of the variables to avoid spurious results and unreliable predictions. Thus, the

Augmented Dickey Fuller (ADF) and the Phillips-Perron (PP) tests would be conducted to test for unit root.

$$Y_t = \alpha + Y_t + \beta Y_{t-1} + \sum_{j=1}^{k} \beta_1 \Delta Y_{t-i}^{i} \quad \text{---------- (3.4)}$$

$$Y_t = \alpha + \beta Y_{t-1} + \sum_{j=1}^{k} \beta_1 \Delta Y_{t-i}^{i} \quad \text{---------- (3.5)}$$

Where; Δ = first difference operator, t = the trend variable, Y_t = The variable under consideration, ε_t = a white noise error term. Thus, the null hypothesis for the ADF unit root test is: H_0**:** $\beta = 0$ (presence of unit root) and alternative hypothesis is H_1**:** $\beta \neq 0$ (absence of unit root).

3.4.2 Vector Autoregressive (VAR) Description

Vector autoregressive models are simply multivariate models which are not restricted to any theory and can be used as forecasting instruments. The component part (endogenous and explanatory variables) are believed to interact and hence should be included as part of the economic system which makes the VAR model closer to reality (Euger, 2010). Each variable is expressed as a linear combination of lagged values of itself and lagged values of all variables in the group. In this multivariate setting, the forecast of inflation will be a function of a larger information set that combines not its history alone but also the history of other variables like MPR, Yield spread and exchange rate, thus making the model more parsimonious.

3.4.3 Impulse Response and Variance Decomposition Analysis

Impulse response functions trace out the response of current and future values of each of the variables to a one-unit increase in the current value of one of the VAR errors. It is a one-period shock which reverts to zero immediately. In other words, the impulse response measures how macroeconomic variables respond to different shocks. On the other hand, Variance decomposition function measures the relative importance of the different shocks on the macroeconomic variables by simply decomposing the total variance of a time series into the percentages attributable to each structural shock. In other words, how much variation in a given variable is attributed to each variable over the sample period. In line with these, the impulse response and the variance decomposition will be used to examine the shocks imposed on inflation over the period of study

3.5 Model Specification

The analytical technique outlined above suggests that VAR model would be required to estimate the predictive power of the yield curve alongside other variables in the model.

3.5.1 Inflation Forecasting Model

Building on equations 3.1 to 3.3, the model is specified as

$\pi_t = f(\text{TB90}, \text{YS}, \text{MPR}, \text{EXR}, \varepsilon_t)$ ..... (3.6)

$$\pi_t^i = \beta_o + \sum_{j=1}^{k} \beta_1 \pi_{t-j}^i + \sum_{j=1}^{k} \beta_2 TB90_{t-j}^i + \sum_{j=1}^{k} \beta_2 YS_{t-j}^i + \sum_{j=1}^{k} \beta_3 MPR_{t-j}^i + \sum_{j=1}^{k} \beta_4 EXR_{t-j}^i + \varepsilon_t \quad (3.7)$$

The slope of the nominal yield curve is defined; as the spread between the 5-year Federal Government bond rate and the 3monthsTreasury bill

$Ys_{t=} r_t^l - r_t^s$ ..... (3.8)

Where ; π_t is inflation rate, TB90 is treasury bill rate for 90 days, YS is yields Spread, MPR is Monetary Policy Rate, EXR is Exchange Rate, and ε_t is Error term.

3.6 Source of Data

Purely secondary data (quarterly data) were used for the purpose of analysis in this research work. Data on treasury bills and government bonds of various maturities (90days rate, 180days rate, 365days rate, 3years rates, 5years rates, 7years rates and 10years) were obtained from the Central bank of Nigeria (CBN) auction reports, and the Securities and Exchange Commission (SEC). Other variables that were considered are; the inflation rate, Exchange rate, and monetary policy rate (MPR). Their corresponding data were obtained from the Central Bank of Nigeria (CBN) Statistical Bulletins. The data used covers the period of 2006 to 2013 using quarterly data. These variables taken into consideration are those that instinctively contain information about inflation and accordingly might be good forecasters.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter presents and analyzes the empirical results on the basis of the methodology developed in the preceding. The chapter is organized into: plotting the yield curve for Nigeria followed by the presentation of empirical results its discussion.

4.2 Plotting the Yield Curve for Nigeria

The yield curve shows the relationship between yields on bonds of various maturities, and also provides an insight into market evaluation of future interest rates and the state of the economy. In central banking practice the most important application of the yield curve is to extract expectations of future interest rates. The yield curve provides an insight into market agents' evaluation of future levels of economic activities and thus inflation. Therefore, in fig. 4.1 to 4.8, we would analyze the various shape(s) of the yield curve and provide in details explanations based on the expectation theory of the term structure of interest rates.

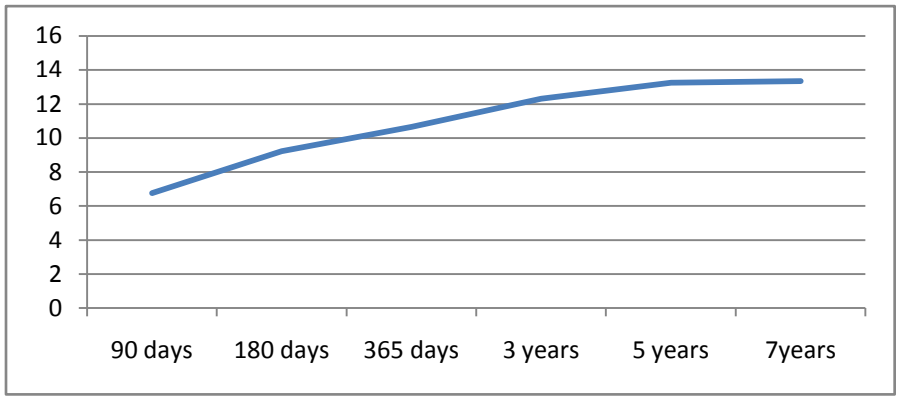


Fig. 4.1: The Yield Curve for Nigeria (2006)

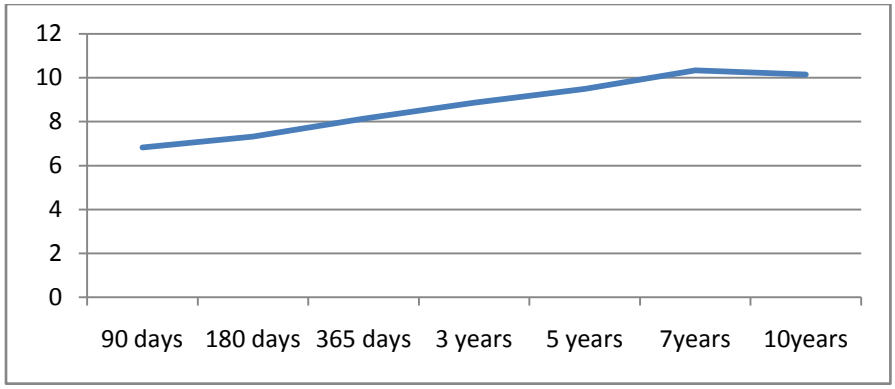


Fig. 4.2: The Yield Curve for Nigeria (2007)

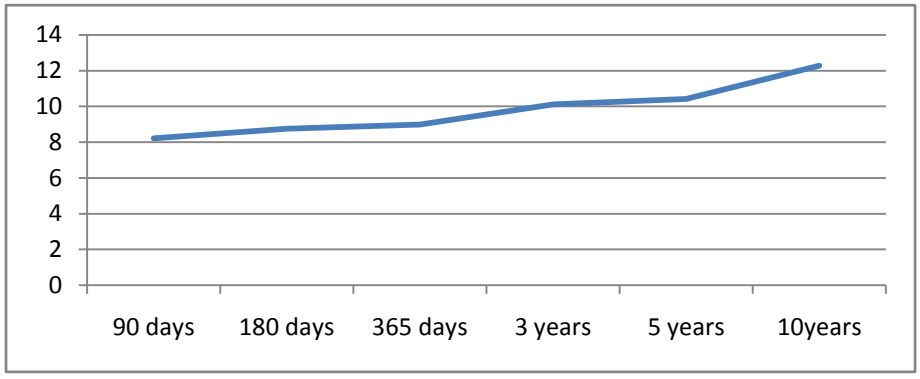


Fig. 4.3: The Yield Curve for Nigeria (2008)

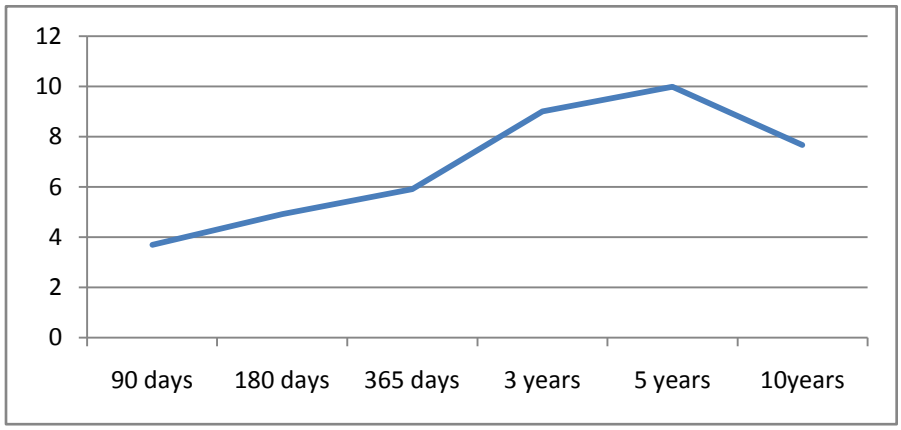


Fig. 4.4: The Yield Curve for Nigeria (2009)

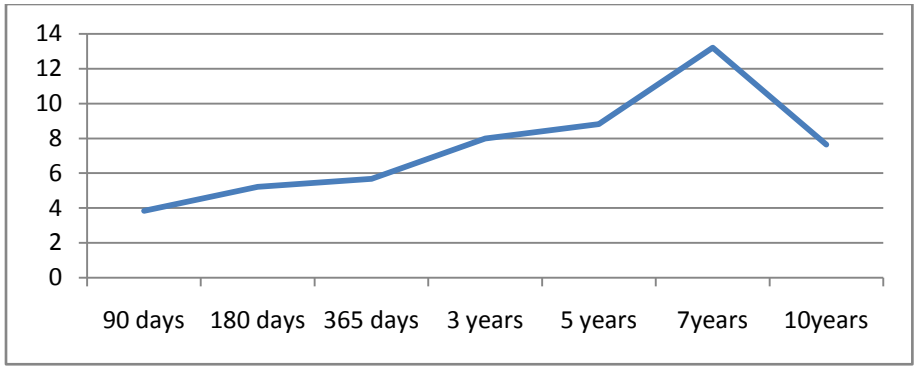


Fig. 4.5: The Yield Curve for Nigeria (2010)

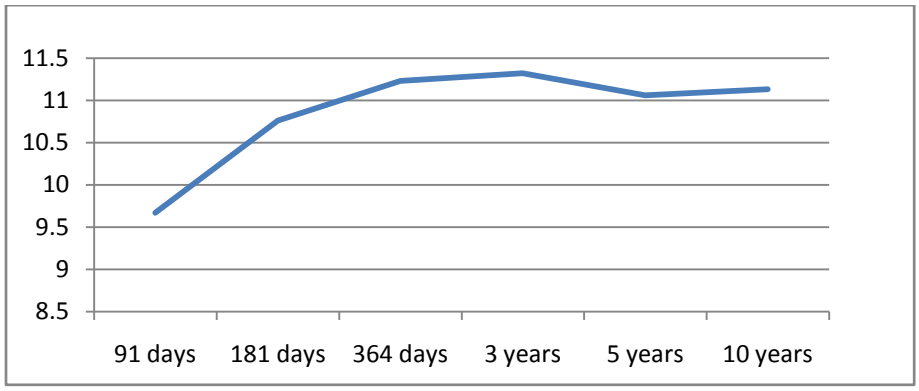


Fig. 4.6: The Yield Curve for Nigeria (2011)

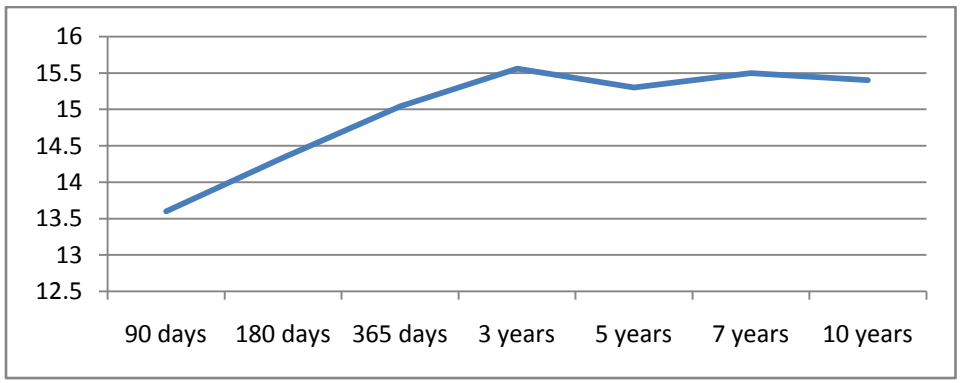


Fig. 4.7: The Yield Curve for Nigeria (2012)

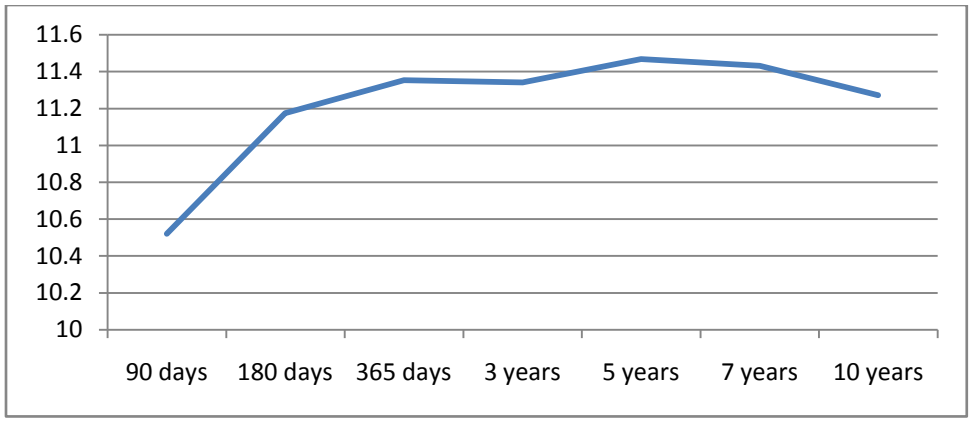


Fig. 4.8: The Yield Curve for Nigeria (2013)

The yield curves sloped upward in general, for both the short and medium end of the periods indicating some anticipation in the economy of an upcoming inflation. Expectation of higher inflation leads to believe that the central bank will tighten monetary policy by raising short term interest rates in the future to slow economic growth and dampen inflationary pressure. However, the yield curve for 2008 was seen to be flats both at the short and medium end of the curve. This could be attributed to the global financial crises which took its toll on the bond market. During this period, market participants were in doubt regarding the future trend of inflation in Nigeria, thus leading to a decline in the activities in the market. The humped shape of the curves for 2009, 2011 and 2013 reflects market agents' indifference to securities of various maturities. Visual inspection of the tail end of the curves signals uncertainty in the economy. The flat end of the curves indicates investors' doubts about the future levels of inflation and economic activities. Basically, the yield curves reveal that the short end of the curves appears to have more information on private sector expectations especially when compared to the long end of the curves.

4.3 Unit Root Test

The Augmented Dickey Fuller (ADF) and Phillip-Perron (PP) tests of stationarity were carried out in this study. This is to determine the order of integration of the variables after which Vector Autoregressive (VAR) models would be estimated. The two tests are required given the objective of the study to provide reliable estimates for policy recommendations. Both tests indicate that all variables are integrated of order one I(1) (See table 4.1). The finding implies that, a test is needed to see whether there is co-integration among the variables. In other words a test for co-integration is needed to see whether the variables in the model will converge in the long-run. This also informs us on whether to use the restricted or unrestricted VAR is appropriate for estimating the model.

Table 4.1 Unit Root Test Results

	Levels		***First Difference***		
Variable	***ADF***	***PP***	***ADF***	***PP***	***Comment***
INF	-1.9001	-1.8161	-4.8785**	-4.8661**	I(1)
TB90	-2.3533	-2.3533	-5.8751	-5.9136**	I(1)
YS	-3.4953	-2.4406	-4.8725**	-5.3300**	I(1)
MPR	-2.0961	-1.3203	-3.4618**	-3.4618**	I(1)
EXR	-1.8881	-2.1443	-4.6492**	-4.6492**	I(1)

Note: For the levels, we included trend and intercept (where applicable) and the 5% critical value is -3.5628. For the first differences, line graphs indicate only intercepts can be included; the 5% critical value is -2.9639. (**) indicate the rejection of unit root at 5% for both Augmented Dickey Fuller (ADF) and Phillips-Perron (PP).

4.4 Co-integration Test Results

The Johansen co-integration test has been conducted having confirmed that the variables in the model are integrated of order one I (1). Using the three traditional model selection information criteria (AIC, SIC and HQIC), it is observed that the optimal lag length that make the residuals free from serial correlation to be one

The test for co-integration using the Johansen maximum likelihood approach suggests that there is evidence of co-integration among the variables in the model. Table 4.2, shows that the Trace test indicates two co-integrating equation at 5% and 1% level of significance. While Maximum Eigen value test indicates also two co-integrating equations at 5% and 1% level between inflation and other variables in the model.

Table 4.2: Summary of Co-integration Test Result

Trace Rank Test					
Hypothesis	r=0*	r≤1	r≤2	r≤3	r≤4
Trace statistics	97.83	55.97	28.15	11.59	4.37
95% Quantiles	69.81	47.85	29.79	15.49	3.84
99% Quantiles	77.81	54.68	35.45	19.93	6.63

Maximum Eigen Values					
Hypothesis	r=0*	r≤1	r≤2	r≤3	r≤4
Trace statistics	41.86	27.81	16.56	7.21	4.37
95% Quantiles	33.87	27.58	21.13	14.26	3.84
99% Quantiles	39.37	32.71	25.86	18.52	6.63

Estimation of the (idendified) Long Run Equation

	INF	TB90	YS	MPR	EXR
CV	1.00	-4.39	-9.93	0.58	-0.24
t-stat		(1.24618)	(1.34495)	(1.12184)	(0.12959)
Adj.α	0.06	-0.03	0.08	0.02	-0.02
t-stat	(0.02466)	(-0.03168)	(0.02073)	(0.01549)	(-0.08749)

Note: trace statistics indicates two co-integrating equation at both 5% level and 1% level. Max-Eigen value indicates that two co-integrating equation at both 5% and one co-integrating equation at 1% level.

It is revealed from section 4.3 that all the series are integrated of order one I(1). This implies that unless they are co-integrated the estimation of the model, with these series at levels will lead to spurious results. The task of this section is to interrogate whether there exist a long run relationship among these variables.

Table 4.2 reports the summary statistics of co-integration test using Johansen maximum likelihood approach. The result shows that for both trace rank and maximum eigenvalue rank tests the null hypothesis of no co-integrating equation and at most 2 co-integrating equations are rejected at 5% level of significance. This outcome, despite the rejection of the latter hypothesis, suggests that only one co-integrating equation exist among the variables. On the contrary from this result, the adjustment coefficients which validate long run relationships as well as identify the co-integrating equations, contradict the earlier finding of two co-integrating equation revealed by the trace and maximum eigen-value rank tests. The signs of these coefficients are positive. This implies that errors occurring in the system cannot be reverted back to equilibrium again. We therefore conclude that there is no co-integration between the variables and thus proceed to estimate the unrestricted VAR in first difference.

4.5 Vector Autoregressive Model Estimates

Having identified the errors occurring in the system cannot be reverted back to equilibrium in the long run; we proceed to estimate the unrestricted VAR in order to capture the short-run relationships. Therefore, the VAR model was estimated with an optimal lag length of one. The full estimates of the VAR are reported in the appendix; however the impulse-response functions and the variance decomposition are reported in tables 4.3 below.

4.5.1 Impulse Responses to Generalized One S.D Innovation

Figure 4.9 show the impulse response to generalized one standard deviation (SD) innovations in the variables within a horizon of 12 quarters. The responses are for a particular variable to a one- time shock in each of the variable in the system.

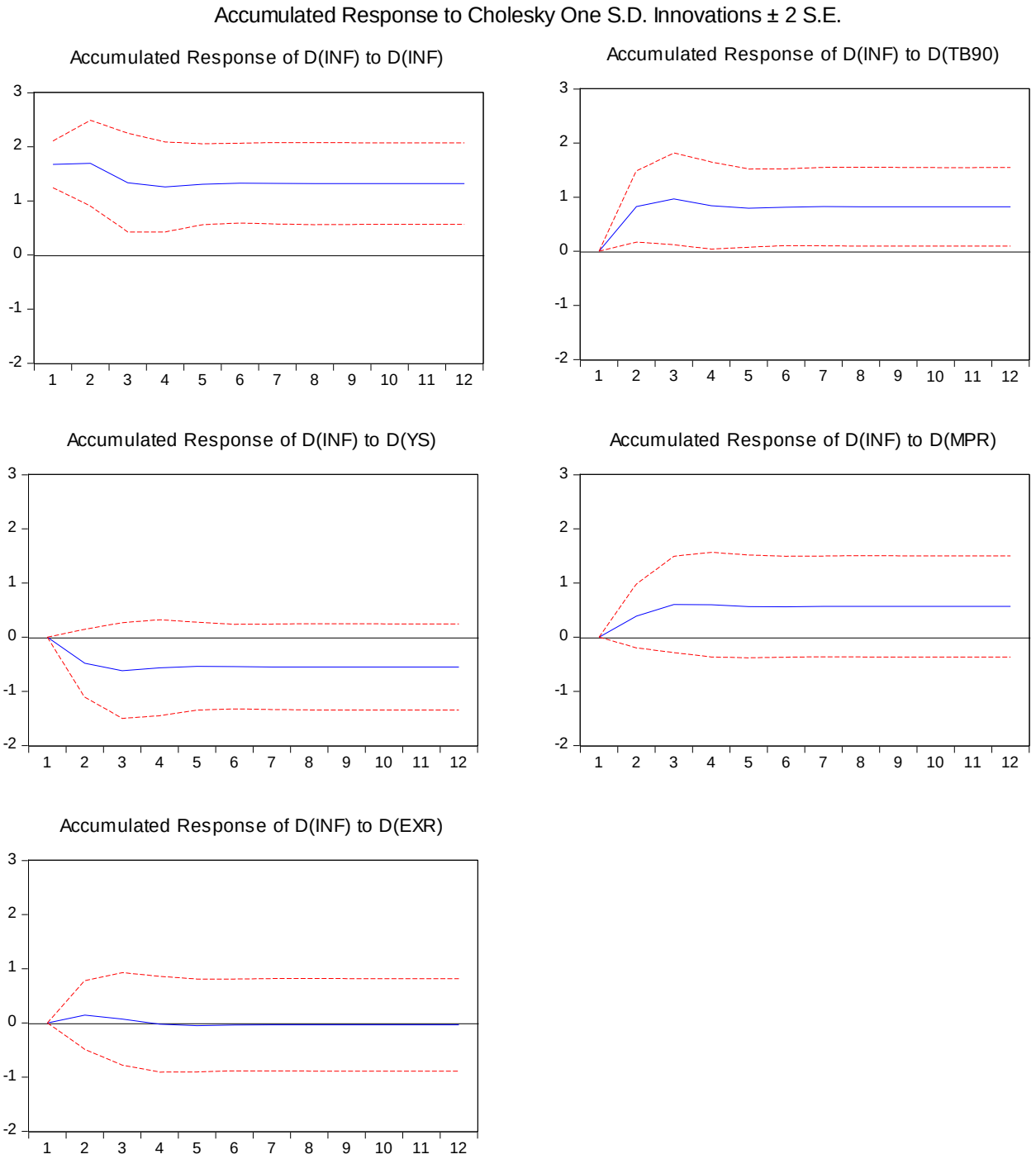
Figure 4.9 represents the dynamic response of INF to generalize one standard deviation (SD) shock of TB90, yield spread and other variables in the model within a horizon of 12 periods. TB90 impacted positively on INF and stood at 0.83% in the second quarter and by the seventh quarter, stood 0.82% and remained consistently the same throughout the remaining quarters. This finding is consistent with the expectation theory which suggests that a positive relationship exist between security prices and inflation. Yield spread impacted negatively on INF and stood at -0.48% in the second quarter. By the third quarter it had increased to -0.61% and decreased to -0.54% in the sixth quarter. It remained -0.54% in the eighth quarter and the following quarters. The negative relationship goes against the expectation theory and can be attributed to inflation volatility and the lack of liquidity in the domestic bond market which distorts the information signals embodied in security prices. This finding is consistent with the study of Mehl (2006) and Kozicki (1997).

INF responded positively to a one standard deviation shock on MPR in the second quarters was as expected and responded by -0.39% and increased to 0.6% in the fourth quarter. From the sixth quarter, the shocks became steadily pegged at 0.56% and remained the same throughout the remaining quarter. The result suggests a positive relationship between MPR and INF which goes against the design of MPR as a tool to curtail inflation.

Furthermore INF responded positively to a one standard deviation shock on EXR. It responded by 0.15% after two quarters. The impact reverted back to negative and stood at 0.03%

in the sixth quarter. The result remained the same throughout the remaining quarters. This implies that an increase in exchange rate depreciates the value of the domestic currency and puts pressure on inflation.

Figure 4.9: Accumulated Response of INF



4.5.2 Variance Decomposition

The forecast variance decomposition provides information on the dynamic behavior of variables in the model. It decomposes historical variations in the variables and attributes some to the effect of all the variables in the system. The full estimate of the findings of the variance decomposition is reported in the appendix. However, the variance decomposition of inflation is reported in table 4.3.

From Table 4.3, TB90 had no contribution to changes in INF in the first quarter. But in the second quarter, it accounted for about 17% of the variation in INF and remained consistently the same throughout the remaining quarters. Like TB90, YS has no contribution to changes in INF in the first quarter. But it accounted for 5.9% in the second quarter and increased to 6.1% in the fourth quarter and remained consistently the same throughout the remaining quarters. In other words the results were the same for the subsequent periods (2-12 quarter). For MPR, its contribution to the variation in INF was about 3.9% in the second quarter and increased to 4.78% in the sixth quarter and remained the same throughout the remaining period. EXR contributed the list to the changes in INF when compared to other variables in the model. Its contribution stood at 0.53% in the second quarter and increased to about 0.87% in the sixth quarter. Like YS and MPR it remained the same throughout the remaining periods. The policy implication of these findings is that there is a strong linkage between the TB90 (Treasury bill rate with 90 days maturity) and inflation in Nigeria

Table 4.3: Variance Decomposition of INF

PERIOD	S.E	D(INF)	D(TB90)	D(YS)	D(MPR)	D(EXR)
T=1	1.6748	100.0000	0.0000	0.0000	0.0000	0.0000
T=2	1.9735	72.0306	17.5548	5.9603	3.9179	0.5361
T=4	2.0363	70.9147	17.3543	6.1050	4.7674	0.8584
T=6	2.0383	70.8501	17.3767	6.1145	4.7862	0.8723
T=8	2.0384	70.8467	17.3786	6.1151	4.7866	0.8729
T=10	2.0384	70.8465	17.3786	6.1151	4.7866	0.8729
T=12	2.0382	70.8465	17.3786	6.1151	4.7866	0.8729

The innovation analysis showed that shocks to the TB90 have a significant effect on prices. The major conclusion from the VAR analysis is that the basic transmission mechanism runs from inflation expectation (TB90) to prices

Figure 4.9.1 Stability Test for Inflation Model

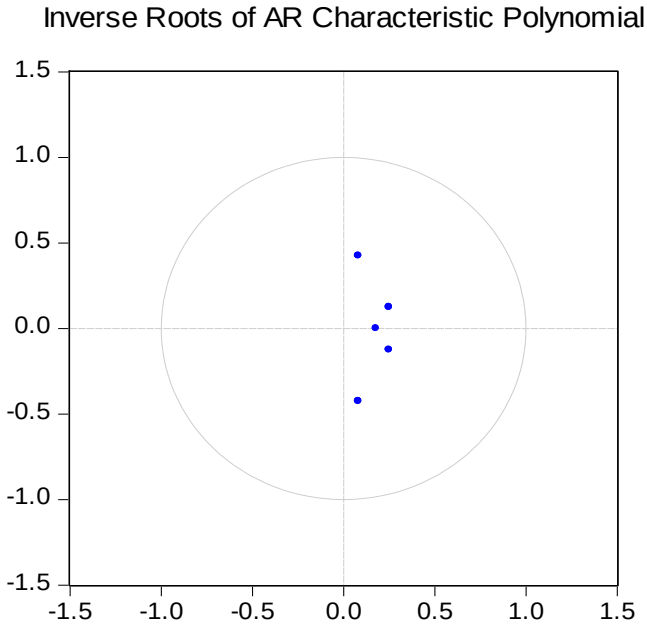


Figure 4.9.1 shows the inverse roots of AR polynomial. Thus, the VAR model of Inflation satisfies the stability condition because all the Eigen values of the residuals lay within the unit circle. Hence the Inflation model is stable and suitable for policy.

Table 4.4 LM Residual Test

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 04/10/15 Time: 07:59
Sample: 2006Q1 2013Q4
Included observations: 30

Lags	LM-Stat	Prob
1	14.81916	0.9455
2	21.18195	0.6824
3	16.12652	0.9110
4	17.18573	0.8749
5	22.30822	0.6179
6	23.35913	0.5566
7	15.29420	0.9342
8	23.97539	0.5208
9	26.38675	0.3872
10	31.11450	0.1853
11	34.72804	0.0932
12	34.77494	0.0924

Probs from chi-square with 25 df.

Table 4.4 presents a test for the presence of serial correlation in the inflation model within the study period. The result shows that there is no autocorrelation in the inflation model. This is because the probability values are greater than 0.05. Therefore, the null hypothesis of no serial correlation has been accepted.

4.7 Summary of Research Findings

From the econometric investigations carried out, the following are the major findings of the study.

i. The yield curves in Figure 4.1 to 4.8, reveals that the yield curves contain information about private sector inflation expectation in Nigeria.

ii. There is no long run relationship between inflation and the other variables in the model as shown by the Johansen co-integration test. This is because the adjustment coefficients which validate long run relationships as well as identify the co-integrating equations, contradict the earlier finding of one co-integrating equation revealed by the trace and maximum eigenvalue rank tests. The signs of these coefficients are positive indicating that the errors occurring in the system cannot be reverted back to equilibrium again. Since long run relationship is doubted among these variables, we estimated the unrestricted VAR in first difference.

iii. The impact of the proxies for inflation expectation had mixed results; TB90 had a positive relationship which validates the expectation theory of the term structure. The second proxy for expectation which is the yield spread had a negative relationship with inflation. This can be attributed to inflation volatility and the lack of liquidity in the domestic bond market which distorts the information signals embodied in security prices. EXR tends to be positive indicating that a rise in exchange rate depreciates the domestic currency and puts pressure on inflation. While the MPR is seen to be positive, this goes against its original design of curbing inflation.

iv. In the VAR model, it is observed that the proxy for expectation (TB90) contributes significantly to inflationary pressure in Nigeria. The major conclusion from the VAR

analysis is that the basic transmission mechanism runs from inflation expectation (TB90) to prices.

v. The VAR model is robust and suitable for policy. The LM autocorrelation stability test and the AR root stability test confirm this finding.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Study

The study aimed at examining signal extraction from the bond market as a strategic instrument for monetary policy in Nigeria spanning from 2006-2013. The objectives of this study has been to plot the yield curve, examine the extent to which the yield spread can improve inflation forecast and deduce policy implications from the estimates. The study used VAR techniques to estimate the Inflation model. The yield curves were used to capture the information content of the bond market while the inflation model was to capture the relationship and forecasting abilities of the variables in the model under study. It was observed that the yield curves plotted indeed, contained information on private sector inflation expectation

Furthermore, the VAR model was used because there was no long run relationship between the variables considered for this study. The empirical estimates of the impulse response function and variance decomposition were used to determine the information content embedded in securities prices in relation to inflation in Nigeria. The result indicates that the shocks to the treasury bill rate with maturity of 90 days (proxy for expectation), has a significant effect on inflation and thus can improve inflation forecast in Nigeria.

5.2 Conclusion

The empirical analysis presented in the previous chapter allows us to draw some conclusions about each of the research questions raised at the beginning of this study. First, on the question of whether there is information in the bond market about private sector inflation

expectation, we can conclude on the basis of evidence provided by the theory, and the yield curves plotted for various years shows that there is indeed information about private sector expectations in yields of various maturities. Second, on the question of if the information content of the bond market can be used to forecast inflation, the VAR model indicates that the shocks to the treasury bills rate with maturity of 90 days (proxy for expectation), have a significant effect on inflation in Nigeria. The results further reveals that the basic transmission mechanism runs from expectations to prices. Basically, these findings are in accord with the existing theories and empirical literatures reviewed in this study.

5.3 Recommendations

Arising from the empirical findings, the following recommendations are proffered.

i. First, Central bank of Nigeria should take into cognizance the role of inflation expectation in the conduct of monetary policy. As shown by the study, the proxy for inflation expectation (the yield spread) has a significant effect on inflation. In other words, the yield curve like other macro variables contains information useful in predicting future changes in inflation. Therefore the CBN should develop a suite of yield curve models to capture inflation expectations which would improve its forecast of inflation, increase the effectiveness and efficiency of monetary policy in Nigeria.

ii. The bond market plays an important role in the growth of the economy and also in enhancing efficiency in monetary policy. The study further recommends that the government in collaboration with the central bank should take effective measures to improve liquidity in the bond market which often disrupt the information signals found in security prices. Therefore concerted effort must be taken to develop a deep and liquid

bond market through monthly or quarterly sensitization programs on bond market investment and easing the conditions for purchase and resale of securities. A well developed bond market would invariably lead to a well established yield curve that allows accurate inferring of inflation expectation.

iii. Moreover, since inflation expectations are advanced indicators of credibility of monetary policy, a good communication policy would help increase the central bank's credibility ratings. It is essential that market agents and the general public know and understand the monetary policy stance of the CBN and its changes as they occur. This could be done through its continual release of communiqués, reports and publications concerning various changes in the economy.

iv. For further research, it is recommended that studies on the inflation expectation using household surveys should be carried out, in other to provide a comprehensive and empirical insight to the importance of expectations in the conduct of monetary policy.

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APPENDIX

Appendix A: Lag order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: D(INF) D(TB90) D(YS) D(MPR) D(EXR)
Exogenous variables:
Date: 04/09/15 Time: 21:09
Sample: 2006Q1 2013Q4
Included observations: 28

Lag	LogL	LR	FPE	AIC	SC	HQ
1	-250.5841	NA	248.2770*	19.68458*	20.87405*	20.04821*
2	-232.7664	22.90844	479.5553	20.19760	22.57654	20.92487
3	-208.5441	22.49219	802.6127	20.25315	23.82155	21.34404

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Appendix B: Co-integration Test of Inflation Model

Date: 04/09/15 Time: 21:20
Sample (adjusted): 2006Q3 2013Q4
Included observations: 30 after adjustments
Trend assumption: Linear deterministic trend
Series: INF TB90 YS MPR EXR
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.752279	97.83491	69.81889	0.0001
At most 1 *	0.604280	55.97134	47.85613	0.0072
At most 2	0.424387	28.15992	29.79707	0.0763
At most 3	0.213697	11.59034	15.49471	0.1777
At most 4 *	0.135783	4.377954	3.841466	0.0364

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.752279	41.86358	33.87687	0.0045
At most 1 *	0.604280	27.81141	27.58434	0.0468
At most 2	0.424387	16.56958	21.13162	0.1933
At most 3	0.213697	7.212385	14.26460	0.4643
At most 4 *	0.135783	4.377954	3.841466	0.0364

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

INF	TB90	YS	MPR	EXR
-0.087726	0.385618	0.871413	-0.050658	0.021046
0.187751	-0.719266	-0.515967	0.823501	0.006561
0.470902	0.272893	0.052681	-0.032484	-0.079201
-0.131542	0.224454	0.242650	-0.323586	-0.067375
0.160520	-0.298206	-0.078457	-0.013581	0.011447

Unrestricted Adjustment Coefficients (alpha):

D(INF)	-0.706653	0.084601	-0.052218	0.584654	-0.068612
D(TB90)	0.352125	-0.190718	-0.742280	0.143317	0.451779
D(YS)	-0.985397	0.161272	0.581144	-0.144490	-0.061060
D(MPR)	-0.183205	-0.603992	-0.001739	0.003528	0.117719
D(EXR)	-0.189702	0.664932	2.840840	0.174625	0.635691

1 Cointegrating Equation(s): Log likelihood -256.1974

Normalized cointegrating coefficients (standard error in parentheses)

INF	TB90	YS	MPR	EXR
1.000000	-4.395714	-9.933368	0.577459	-0.239907
	(1.24618)	(1.34495)	(1.12184)	(0.12957)

Adjustment coefficients (standard error in parentheses)

D(INF)	0.061992
	(0.02466)
D(TB90)	-0.030890
	(0.03168)
D(YS)	0.086445
	(0.02073)
D(MPR)	0.016072
	(0.01549)
D(EXR)	0.016642
	(0.08749)

2 Cointegrating Equation(s): Log likelihood -242.2917

Normalized cointegrating coefficients (standard error in parentheses)

INF	TB90	YS	MPR	EXR

1.000000	0.000000	45.99256	30.22219	1.899389
		(6.78069)	(5.41225)	(0.92493)
0.000000	1.000000	12.72283	6.744008	0.486678
		(1.69080)	(1.34958)	(0.23064)

Adjustment coefficients (standard error in parentheses)

D(INF)	0.077876	-0.333348
	(0.05813)	(0.22893)
D(TB90)	-0.066698	0.272962
	(0.07437)	(0.29288)
D(YS)	0.116724	-0.495985
	(0.04846)	(0.19085)
D(MPR)	-0.097328	0.363784
	(0.02564)	(0.10097)
D(EXR)	0.141483	-0.551416
	(0.20468)	(0.80606)

3 Cointegrating Equation(s): Log likelihood -234.0069

Normalized cointegrating coefficients (standard error in parentheses)

INF	TB90	YS	MPR	EXR
1.000000	0.000000	0.000000	0.685883	-0.129855
			(0.20464)	(0.03514)
0.000000	1.000000	0.000000	-1.426563	-0.074668
			(0.15045)	(0.02584)
0.000000	0.000000	1.000000	0.642197	0.044121
			(0.10739)	(0.01844)

Adjustment coefficients (standard error in parentheses)

D(INF)	0.053286	-0.347598	-0.662189
	(0.14421)	(0.24121)	(0.28425)
D(TB90)	-0.416239	0.070399	0.366146
	(0.16658)	(0.27863)	(0.32834)
D(YS)	0.390386	-0.337394	-0.911285
	(0.10290)	(0.17211)	(0.20282)
D(MPR)	-0.098147	0.363309	0.151901
	(0.06365)	(0.10647)	(0.12547)
D(EXR)	1.479241	0.223830	-0.358735
	(0.40661)	(0.68011)	(0.80146)

4 Cointegrating Equation(s): Log likelihood -230.4007

Normalized cointegrating coefficients (standard error in parentheses)

INF	TB90	YS	MPR	EXR
1.000000	0.000000	0.000000	0.000000	-0.909263
				(0.30064)
0.000000	1.000000	0.000000	0.000000	1.546416
				(0.61508)
0.000000	0.000000	1.000000	0.000000	-0.685645
				(0.27734)
0.000000	0.000000	0.000000	1.000000	1.136357
				(0.42954)

Adjustment coefficients (standard error in parentheses)

D(INF)	-0.023620	-0.216370	-0.520323	-0.082024

	(0.13403)	(0.22446)	(0.26318)	(0.22384)
D(TB90)	-0.435091	0.102567	0.400922	-0.197157
	(0.17121)	(0.28672)	(0.33617)	(0.28592)
D(YS)	0.409392	-0.369826	-0.946345	0.210603
	(0.10500)	(0.17584)	(0.20616)	(0.17534)
D(MPR)	-0.098611	0.364101	0.152757	-0.489192
	(0.06570)	(0.11003)	(0.12900)	(0.10972)
D(EXR)	1.456270	0.263025	-0.316362	0.408393
	(0.41925)	(0.70211)	(0.82321)	(0.70015)

Date: 04/09/15 Time: 21:23
Sample (adjusted): 2006Q3 2013Q4
Included observations: 30 after adjustments
Trend assumption: Linear deterministic trend
Series: INF TB90 YS MPR EXR
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.01 Critical Value	Prob.**
None *	0.752279	97.83491	77.81884	0.0001
At most 1 *	0.604280	55.97134	54.68150	0.0072
At most 2	0.424387	28.15992	35.45817	0.0763
At most 3	0.213697	11.59034	19.93711	0.1777
At most 4	0.135783	4.377954	6.634897	0.0364

Trace test indicates 2 cointegrating eqn(s) at the 0.01 level
* denotes rejection of the hypothesis at the 0.01 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.01 Critical Value	Prob.**
None *	0.752279	41.86358	39.37013	0.0045
At most 1	0.604280	27.81141	32.71527	0.0468
At most 2	0.424387	16.56958	25.86121	0.1933
At most 3	0.213697	7.212385	18.52001	0.4643
At most 4	0.135783	4.377954	6.634897	0.0364

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.01 level
* denotes rejection of the hypothesis at the 0.01 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

INF	TB90	YS	MPR	EXR
-0.087726	0.385618	0.871413	-0.050658	0.021046
0.187751	-0.719266	-0.515967	0.823501	0.006561
0.470902	0.272893	0.052681	-0.032484	-0.079201

-0.131542	0.224454	0.242650	-0.323586	-0.067375
0.160520	-0.298206	-0.078457	-0.013581	0.011447

Unrestricted Adjustment Coefficients (alpha):

D(INF)	-0.706653	0.084601	-0.052218	0.584654	-0.068612
D(TB90)	0.352125	-0.190718	-0.742280	0.143317	0.451779
D(YS)	-0.985397	0.161272	0.581144	-0.144490	-0.061060
D(MPR)	-0.183205	-0.603992	-0.001739	0.003528	0.117719
D(EXR)	-0.189702	0.664932	2.840840	0.174625	0.635691

1 Cointegrating Equation(s): Log likelihood -256.1974

Normalized cointegrating coefficients (standard error in parentheses)

INF	TB90	YS	MPR	EXR
1.000000	-4.395714	-9.933368	0.577459	-0.239907
	(1.24618)	(1.34495)	(1.12184)	(0.12957)

Adjustment coefficients (standard error in parentheses)

D(INF)	0.061992
	(0.02466)
D(TB90)	-0.030890
	(0.03168)
D(YS)	0.086445
	(0.02073)
D(MPR)	0.016072
	(0.01549)
D(EXR)	0.016642
	(0.08749)

2 Cointegrating Equation(s): Log likelihood -242.2917

Normalized cointegrating coefficients (standard error in parentheses)

INF	TB90	YS	MPR	EXR
1.000000	0.000000	45.99256	30.22219	1.899389
		(6.78069)	(5.41225)	(0.92493)
0.000000	1.000000	12.72283	6.744008	0.486678
		(1.69080)	(1.34958)	(0.23064)

Adjustment coefficients (standard error in parentheses)

D(INF)	0.077876	-0.333348
	(0.05813)	(0.22893)
D(TB90)	-0.066698	0.272962
	(0.07437)	(0.29288)
D(YS)	0.116724	-0.495985
	(0.04846)	(0.19085)
D(MPR)	-0.097328	0.363784
	(0.02564)	(0.10097)
D(EXR)	0.141483	-0.551416
	(0.20468)	(0.80606)

3 Cointegrating Equation(s): Log likelihood -234.0069

Normalized cointegrating coefficients (standard error in parentheses)

INF	TB90	YS	MPR	EXR
1.000000	0.000000	0.000000	0.685883	-0.129855
			(0.20464)	(0.03514)
0.000000	1.000000	0.000000	-1.426563	-0.074668
			(0.15045)	(0.02584)
0.000000	0.000000	1.000000	0.642197	0.044121
			(0.10739)	(0.01844)

Adjustment coefficients (standard error in parentheses)

D(INF)	0.053286	-0.347598	-0.662189
	(0.14421)	(0.24121)	(0.28425)
D(TB90)	-0.416239	0.070399	0.366146
	(0.16658)	(0.27863)	(0.32834)
D(YS)	0.390386	-0.337394	-0.911285
	(0.10290)	(0.17211)	(0.20282)
D(MPR)	-0.098147	0.363309	0.151901
	(0.06365)	(0.10647)	(0.12547)
D(EXR)	1.479241	0.223830	-0.358735
	(0.40661)	(0.68011)	(0.80146)

4 Cointegrating Equation(s): Log likelihood -230.4007

Normalized cointegrating coefficients (standard error in parentheses)

INF	TB90	YS	MPR	EXR
1.000000	0.000000	0.000000	0.000000	-0.909263
				(0.30064)
0.000000	1.000000	0.000000	0.000000	1.546416
				(0.61508)
0.000000	0.000000	1.000000	0.000000	-0.685645
				(0.27734)
0.000000	0.000000	0.000000	1.000000	1.136357
				(0.42954)

Adjustment coefficients (standard error in parentheses)

D(INF)	-0.023620	-0.216370	-0.520323	-0.082024
	(0.13403)	(0.22446)	(0.26318)	(0.22384)
D(TB90)	-0.435091	0.102567	0.400922	-0.197157
	(0.17121)	(0.28672)	(0.33617)	(0.28592)
D(YS)	0.409392	-0.369826	-0.946345	0.210603
	(0.10500)	(0.17584)	(0.20616)	(0.17534)
D(MPR)	-0.098611	0.364101	0.152757	-0.489192
	(0.06570)	(0.11003)	(0.12900)	(0.10972)
D(EXR)	1.456270	0.263025	-0.316362	0.408393
	(0.41925)	(0.70211)	(0.82321)	(0.70015)

Appendix C: VAR Estimates of Inflation Model

Vector Autoregression Estimates
Date: 04/09/15 Time: 21:06
Sample (adjusted): 2006Q3 2013Q4
Included observations: 30 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(INF)	D(TB90)	D(YS)	D(MPR)	D(EXR)
D(INF(-1))	0.148841	-0.342334	0.315158	-0.044313	0.409210
	(0.16299)	(0.18989)	(0.16107)	(0.09251)	(0.52042)
	[0.91317]	[-1.80277]	[1.95670]	[-0.47901]	[0.78631]
D(TB90(-1))	0.019306	-0.020206	0.050136	-0.088891	-0.080150
	(0.26156)	(0.30472)	(0.25846)	(0.14845)	(0.83512)
	[0.07381]	[-0.06631]	[0.19398]	[-0.59879]	[-0.09597]
D(YS(-1))	-0.614169	0.071014	0.152648	0.034520	0.307613
	(0.31541)	(0.36747)	(0.31168)	(0.17902)	(1.00707)
	[-1.94718]	[0.19325]	[0.48975]	[0.19283]	[0.30545]
D(MPR(-1))	0.475173	0.264837	0.065543	0.443172	0.100297
	(0.34807)	(0.40552)	(0.34396)	(0.19755)	(1.11135)
	[1.36515]	[0.65308]	[0.19056]	[2.24331]	[0.09025]
D(EXR(-1))	0.031875	-0.031372	-0.024964	-0.081376	0.114895
	(0.06965)	(0.08115)	(0.06883)	(0.03953)	(0.22239)
	[0.45764]	[-0.38661]	[-0.36270]	[-2.05852]	[0.51664]
R-squared	0.369003	0.120790	0.156551	0.305711	0.037972
Adj. R-squared	0.268043	-0.019884	0.021599	0.194625	-0.115953
Sum sq. resids	70.13112	95.18882	68.48152	22.59074	714.9401
S.E. equation	1.674886	1.951295	1.655071	0.950594	5.347673
F-statistic	3.654956	0.858652	1.160047	2.752017	0.246689
Log likelihood	-55.30569	-59.88813	-54.94865	-38.31330	-90.13318
Akaike AIC	4.020380	4.325875	3.996577	2.887553	6.342212
Schwarz SC	4.253912	4.559408	4.230110	3.121086	6.575745
Mean dependent	-0.087778	0.205531	-0.228531	-0.044444	0.962667
S.D. dependent	1.957684	1.932180	1.673240	1.059244	5.062230

Determinant resid covariance (dof adj.)	201.8674
Determinant resid covariance	81.12597
Log likelihood	-278.7808
Akaike information criterion	20.25206
Schwarz criterion	21.41972

Appendix D: Impulse Response and Variance Decomposition of Inflation Model

Period	D(INF)	D(TB90)	D(YS)	D(MPR)	D(EXR)
1	1.674886	0.000000	0.000000	0.000000	0.000000
2	1.695103	0.826908	-0.481830	0.390652	0.144517
3	1.336142	0.968613	-0.617715	0.602980	0.074085
4	1.257266	0.842915	-0.567299	0.600275	-0.024661
5	1.307114	0.797718	-0.538150	0.566513	-0.048369
6	1.329100	0.814228	-0.543747	0.561943	-0.039081
7	1.323253	0.825415	-0.550236	0.567242	-0.034097
8	1.318196	0.824140	-0.550240	0.568795	-0.035079
9	1.318478	0.821828	-0.549012	0.567995	-0.036124
10	1.319477	0.821683	-0.548804	0.567556	-0.036083
11	1.319590	0.822091	-0.548998	0.567629	-0.035870
12	1.319422	0.822184	-0.549068	0.567723	-0.035839

Variance Decomposition

Period	S.E.	D(INF)	D(TB90)	D(YS)	D(MPR)	D(EXR)
1	1.674886	100.0000	0.000000	0.000000	0.000000	0.000000
2	1.973597	72.03062	17.55487	5.960329	3.917982	0.536194
3	2.027936	71.35532	17.11496	6.094178	4.807070	0.628469
4	2.036381	70.91478	17.35432	6.105035	4.767461	0.858401
5	2.038118	70.85374	17.37392	6.115085	4.786777	0.870470
6	2.038338	70.85013	17.37674	6.114522	4.786250	0.872359
7	2.038400	70.84661	17.37869	6.115161	4.786632	0.872903
8	2.038408	70.84671	17.37860	6.115116	4.786655	0.872920
9	2.038410	70.84656	17.37870	6.115140	4.786660	0.872944
10	2.038410	70.84656	17.37869	6.115139	4.786664	0.872944
11	2.038410	70.84656	17.37869	6.115139	4.786664	0.872945
12	2.038410	70.84656	17.37869	6.115139	4.786664	0.872945