KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

A Multivariate Time Series Data Analysis on Real Economic Activity Data

Case Study: Ghana, November 1990 to December 2011

By

ANSONG MACLEAN RICHARD DARKO

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DECLARATION

I hereby declare that this submission is my own original work towards the award of the MSc. degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

Ansong, Maclean R. Darko ……. ……..……..……

(Index No.: PG6317011) *Signature* *Date*

Certified by:

Nana Kena Frempong ……. ……..……..……

(Supervisor) *Signature* *Date*

Certified by:

Mr. F.K. Darkwah ……. ……..……..……

(Head of Department) *Signature* *Date*

Certified by:

Prof. I. K. Dontwi ……. ……..……..……

(Dean of IDL) *Signature* *Date*

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DEDICATION

With great joy, this project work is dedicated to my **dear** and **loving wife, gifted daughter,** and **graced son: Ohenewaa, *Ohemaa Asantewaa and Nana Fosu*** *respectively.*

ABSTRACT

One of the key objectives of every economy whether or not developing or developed is to achieve a high and sustained economic growth rate coupled with low rates of inflation and interest rate. The real sector growth is particularly the concern, considering the effects that inflation and interest rate could have on it. As a result, this study investigates the nexus between interest rate, inflation and real economic activity in Ghana for the period November, 1990 to December, 2011. The study employed the newly developed multivariate cointegration estimation technique via vector autoregression modeling. The results show that there exists a unique long run relationship between real economic activity and its covariates, although these variables were found to be nonstationary at their levels. Further, interest rate and inflation are identified as important determinants of real economic activity growth in Ghana. The obverse showed that real economic activity does not significantly determine inflation and interest rate. Interestingly, the immediate results suggest the need to critically look at the prime rate and therefore interest rate to help streamline the investment patterns of the economy although according to the study period the interest rate does not affect real activity.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Like many countries, industrialized and developing, one of the most fundamental objectives of macroeconomic policies in Ghana is to sustain high economic growth together with low inflation. There exists a considerable debate regarding the existence and nature of inflation and economic growth relationship. A consensus, nonetheless exists, thus suggesting that macroeconomic stability, which is rooted in the spirit of low inflation, is positively related to economic growth. Also, one of the macroeconomic growth factors is nominal interest rate and its fluctuating nature is closely related to inflation rate. Its vacillating trends also impact on economic boom or gross domestic product (GDP) and extending to influence economic growth rate. Thus, inflation has been touted as the main predictor of interest rates and consequently affecting real economic activities.

Ideally, every economy would wish to achieve zero interest rate. Stated alternately, zero interest rate is one of the most important economic specifications in most countries and one of the most complex puzzles among quantities and economic indices. Interest rate provides an opportunity to perform some calculations through which some results are obtained which are quantitatively perfect and logically undeniable and theoretically interesting. Theoretically, the relationship between interest rate and economic growth is negative. Its direct mechanism is that, investment removes limitations of growth resulting from system oldness and its inability to achieve potential ability and new capital accumulation and technical progress allow reaching desirable capital volume. In this

regard, actual interest rate has two roles (Moazzami, 1991). On one hand, it directs resources to accumulation and on the other hand, it decreases capital cost as cost factor. In theoretical models especially life cycle model, both roles are emphasized. In important experimental fields, actual interest rate is regarded as investment factor. It seems that demand for investment is not satisfactory in low interest rate. As said before, negative relationship between economic growth and actual interest rate is expected.

1.2 Problem Statement

One difficult experience that Ghana has gone through since independence is price determination and inflation on goods and services. Shortly after independence (i.e., 1957 – 1962), there was relative stability in the determination of prices as inflation vacillated around a single digit. Contrastingly, the years 1970s and 1980s recorded unprecedented macroeconomic instability and very high inflation episodes. Indeed, inflation overstepped 100 percent on four occasions between July 1977 and March 1983. Consequent upon this hapless achievement, Ghana embarked on a stabilization policy, dubbed the Economic Recovery Programme (ERP). This policy nonetheless appeared to have done a little in resolving the persistently high and vacillating inflation. Until recently, the country had not achieved a single-digit inflation since the period promptly after independence and had always recorded an annual average inflation rates of about 25 percent in more than half of those years. Thus, inflation, as touted by Sowa (1994) has been an albatross of the Economic Recovery Programme (ERP) for which no remedy necessarily worked out.

Theoretically as stated in the background of the study, higher inflationary rates have deleterious effects on an economy. Thus, the fundamental question that arises in

connection with these issues are “How does inflation and interest rate affect economic activity?” and “To what extent should inflation and interest rate be reduced to achieve high economic activity”. Again, the recent single-digit achievement in inflation, though significant, seems to disconnect theoretically with some key macroeconomic variables like interest rates and exchange rates. Thus the economically interpretable long run relationship between inflation and interest rates seems confusing. Moreover, the means of connection between inflation, interest rates and real economic activity will be the primary concern of this study. Moreover, a preliminary inspection of the trends in inflation, interest rates and real economic activities suggest that, as inflation and interest rate are declining, real economic activity improves significantly. However, higher interest rate and inflation do not seem to clearly portray any significant relationship with real economic activity. Furthermore, though there have been some works that relate inflation to economic performance as well as interest rate to economic performance, best to our knowledge, there is no study available in Ghana that links these three variables contemporaneously together. This study thus seeks to add to the existing literature and fill in the theory the nexus between inflation, interest rate and real economic activity using robust econometric time series techniques.

1.3 Objectives of the Study

The major aim of this study is to empirically assess the nexus between inflation, interest rate and real economic activities in Ghana over the period November 1990 to December 2011.

Specifically, the study aims at achieving the following:

i) Analyze the trends in inflation, interest rate and real activity in Ghana over the study period.

ii) Empirically estimate the sensitivity of inflation and interest rate together with key macroeconomic and policy variables on economic activities.

iii) Investigate the direction of causality between inflation and interest rate, interest rate and economic activity as well as between inflation and economic activity.

iv) Investigate how the real economic activity reacts to shocks from inflation and interest rate and other key macroeconomic and policy variables.

1.4 Research Hypotheses

The study seeks to test and validate the following theoretical hypotheses;

i) H_0: Inflation has a positive impact on economic activity in Ghana.

H_1: Inflation does not have positive impact on economic activity in Ghana.

ii) H_0: Interest rate has a positive impact on real economic activity in Ghana.

H_1: Interest rate does not have positive impact on real economic activity in Ghana.

iii) H_0: Higher rate of inflation does not have positive impact on interest rate in Ghana.

H_1: Higher rate of inflation does have a positive impact on interest rate in Ghana.

1.5 Justification of the Study

Ghana has been experiencing a relatively vacillating trend in inflation post independence, albeit there are some periods of extremely high levels. Ghana embarked on economic reforms in 1983 after finding herself on the brink of collapse with inflation fluctuating

around 123 percent and other worse economic conditions. The reforms were necessitated by continuously weak macroeconomic policies from previous administrations which resulted into weak and fragile financial discipline leading to generally high inflation, large exchange rates swings and negative real interest rates for extended periods (Kyereboah and Agyire-Tetteh, 2008). Interest rate reform, a policy under financial sector liberalization was to achieve efficiency in the financial sector and engendering financial deepening. Thus expectation of interest rate reforms is that it would encourage domestic savings and make loanable funds available in banking institutions and consequently lead to improvement in the economic performance of an economy. Thus, delving deep in the relationship between inflation, interest rate and real activities is crucial for understanding how inflation and interest rate work in the country to affect economic activities, thus giving empirical guide for policy formulation. Moreover, since most of the studies either link inflation to economic performance or interest rate to economic performance, there is a relatively scanty empirical literature connecting the three variables. Thus, this study is meant to fill in the lacuna on this subject matter. Furthermore, this study will shed light on other determinants of economic performance, which invariably would inform policy makers on which particular policies to adopt to help accelerate and improve real economic activities in the country. Finally the findings of this study would perhaps provoke further research in relation to this study.

1.6 Method of Study

1.6.1 Data Type and Sources

The study will employ mainly secondary macroeconomic time series data in its analysis. All data used in the analysis will be taken from Bank of Ghana, IMF, International

Financial Statistics, Government Finance Statistics and the World Bank Development Indicators (CD-ROM) and The State of the Ghanaian Economy (various issues). Other augmenting sources will include published articles and journals, working papers, textbooks and relevant internet resources.

1.6.2 Data Analysis

The data collated will be analyzed both descriptively and quantitatively. Charts such as Time plots and tables will be employed to aid in the descriptive analysis. Additionally, stationarity tests will be carried out on all variables to ascertain their order of integration to avoid the spurious regression problem. Further, the study will adopt the multivariate cointegration econometric approach to estimate both the short and long run relationship between real economic activities and its determinants with particular emphasis on inflation and interest rate. All estimations were carried out using the econometric packages Gretl and Stata.

1.7 Scope of Study

The study will utilize time series monthly data spanning from the period November 1990 through to December 2011, thus making use of 254 data points enough for effective regression analysis. The choice of the study period is dependent on data availability. It would have been better if data were available in high frequency units on each of the variables used in the model. Nonetheless, utilising the monthly dataset would provide enough data points necessary for effective time series analysis.

1.8 Limitations of the Study

The major limitation the study encountered, typical of such studies in developing countries, was quality and limited availability of data on some of the key variables used in estimation. An attempt to extend the data length to 2012 was constrained by unavailability of these macro series as the researcher had to fall on mainly foreign sources such as the World Bank, *IMF*.

One should be cautious in interpreting the results of the time-series models because of the shortness of the time period covered. In addition, the results of the time-series models apply only to Ghana. These results might not be applicable to other developing countries.

1.9 Organization of the Study

The study will be organized into five main chapters with each chapter comprising appropriate sections including the general introduction. The rest of the study is organized as follows. Chapter two will seek to undertake a review of relevant literature including theoretical and empirical reviews with respect to the theories of inflation, interest rate and economic performance. Chapter three will present the research methodology adopted for the study, touching on issues such as data description and definition, and model specifications. The fourth chapter also will analyse the estimated relationship. The research will conclude in chapter five, with a summary of major findings, policy implications of results, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

As indicated in the preceding chapter, the relationship between interest rates, inflation, and real activity has long been recognized as central to both macroeconomic and finance theory, and as critical in formulating economic policy and in investment decisions. In this chapter, the review of the theoretical and empirical studies that investigate the relationship between interest rates, inflation and real economic activity is done. Extensive theoretical and empirical work has been devoted to the relationship between real activity, inflation and interest rates. Thus, far, however, there is neither a commonly accepted theoretical framework nor agreement on empirical regularities. Consequently, this chapter also concentrates on the pair-wise relationship amongst the variables under consideration both theoretically and empirically. Moreover, a trend analysis of the financial indicators in Ghana is reviewed to aid a casual interpretation.

2.1 The Inflation

Inflation is a sustained increase in the general price level leading to a fall in the purchasing power of money. Inflationary pressures can come from domestic and external sources and from both the supply and demand side of the economy; however the simplest definition of inflation is little money chasing goods. Inflation is also said to be the average increase in the prices of goods and services (Mankiw, 1998). When there is a rise in the general price level for all goods and services it is known as inflation. An inflationary movement may be

due to the rise in any single price or a group of prices of related goods and services (Miller, 2009).

Most people automatically think of inflation as a bad thing, but that's not necessarily the case. Inflation is the natural byproduct of a robust, growing economy. No inflation, or deflation (the lowering of prices), is actually a much worse economic indicator. Also, in a healthy economy, wages rise at the same rate as prices.

Over the years inflation has become a global problem that most economies are dealing with. Zimbabwe still remains a good example of countries battling with the rate of inflation. It is mind boggling to buy box of chocolate for two cedis only to return some days after and realize that the same box of chocolate bought for two cedis earlier now costs five cedis. An example of this case of Hyper Inflation occurred in 1923 in Germany, where Lenders run at heavy losses because Inflation rendered the money borrowers paid worthless. (McMahon, 2007). This may be the simplest explanation of inflation. Inflation in itself is not the rise and fall of individual prices in an economy, Inflation occurs when most prices are rising by some degree across the whole economy.

2.1.1 Causes of inflation

Inflation takes many forms, but is generally grouped into two main causes; Demand- pull and Cost-push inflation.

Demand- Pull inflation describes inflation that occurs for the most basic of economic reasons, that is when prices of goods increase because demand for the product exceeds supply. When there is excess demand in the economy, producers are able to raise prices and achieve bigger profit margins because they know that demand is running ahead of

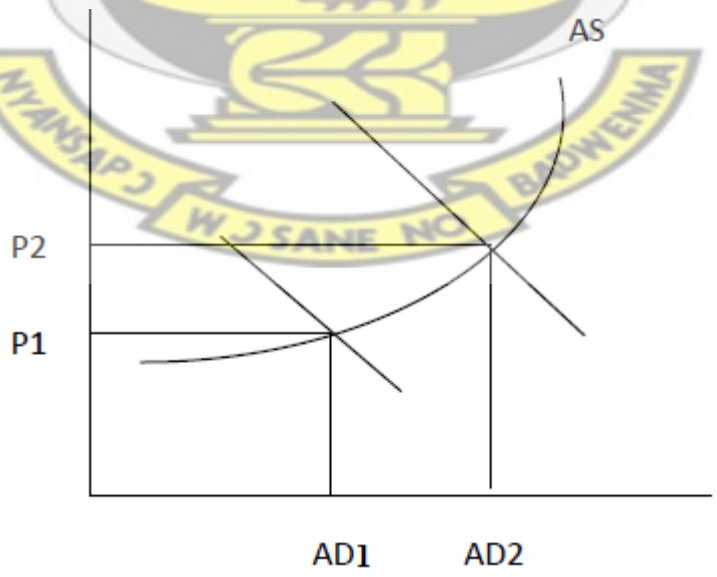
supply. The last time this happened to any great extent in the UK economy was in the late 1980s. This is what is simply termed as “more money chasing few goods”.

Here's how it works:

a) A depreciation of the exchange rate which makes exports more competitive in overseas markets leading to an injection of fresh demand into the circular flow and a rise in national and demand for factor resources – there may also be a positive multiplier effect on the level of demand and output arising from the initial boost to export sales.

b) Higher demand from a government (fiscal) stimulus e.g. via a reduction in direct or indirect taxation or higher government spending and borrowing. If direct taxes are reduced, consumers will have more disposable income causing demand to rise. Higher government spending and increased borrowing feeds through directly into extra demand in the circular flow.

Diagrammatically,



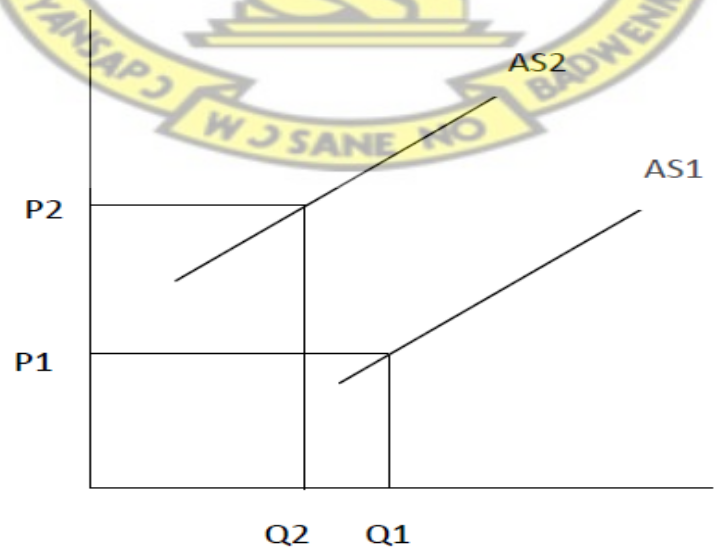
c) Monetary stimulus to the economy: A fall in interest rates may stimulate too much demand – for example in raising demand for loans or in causing rise in house price inflation.

d) Faster economic growth in other countries – providing a boost to UK exports overseas.

e) Improved business confidence which prompts firms to raise prices and achieve better profit margins

From the diagram above, as firms increase production to meet increased demand, additional cost is incurred which is represented by an increase in price, form P1 to P2.

However, Cost-push inflation occurs when businesses respond to rising costs, by increasing their prices to protect profit margins. With higher production costs and productivity maximized, companies cannot maintain profit margins by producing the same amounts of goods and services. As a result, the increased costs are passed on to consumers, causing a rise in the general price level (Wenzel, 2009).



From the graph, increases in production cost will cause AS (aggregate supply) to decrease from AS1 to AS2, thus causing an increase in price level from P1 to P2.

This is due to the fact that firms would want to maintain their profit margins thereby increasing prices (Barro, 1994).

There are many reasons why costs might rise:

a) Component costs: e.g. an increase in the prices of raw materials and components. This might be because of a rise in global commodity prices such as oil, gas copper and agricultural products used in food processing – a good recent example is the surge in the world price of wheat.
b) Rising labour costs - caused by wage increases that exceed improvements in productivity. Wage and salary costs often rise when unemployment is low (creating labour shortages) and when people expect inflation so they bid for higher pay in order to protect their real incomes.
c) Higher indirect taxes imposed by the government – for example a rise in the duty on alcohol, cigarettes and petrol/diesel or a rise in the standard rate of Value Added Tax. Depending on the price elasticity of demand and supply, suppliers may pass on the burden of the tax onto consumers.
d) A fall in the exchange rate – this can cause cost push inflation because it normally leads to an increase in the prices of imported products. For example during 2007 to 2008 the pound fell heavily against the Euro leading to a jump in the prices of imported materials from Euro Zone countries.

Aside causes of Inflation, various types of inflation exist in economies, but the most commonly known are creeping, chronic and hyper inflation. Creeping inflation is when

Inflation moves at a mild rate and may be considered as a natural rate of Inflation which is almost impossible to eliminate (Grilli, 1994). Chronic inflation also occurs when high Inflation rate persists for some time, with little or no reduction. This type of Inflation mostly precedes hyper Inflation. Lastly, hyper inflation, also known as galloping or runaway Inflation usually occurs during or soon after a country's economic failure or disturbance. A typical example was in 1923 when the Inflation rate in Germany averaged 322% per annum. Interestingly, this type of Inflation is normally short-lived.

2.2 Interest Rate

Interest rate may be defined as the rate charged for the use of money, and this is often expressed as an annual percentage of the principal. There exist different types of interest rate. In Ghana, two main types of interest rate are widely known; the prime rate and the base rate.

The prime rate is the rate that the central bank charges on loans to commercial banks, whereas the base rate refers to the rate at which commercial banks give loans to individuals and organisation. Interest rate really affects purchasing and consumption decisions made by consumers, firms and government. This is because individuals may base their consumption decisions on the current interest rate (Begas, 2000). During instances of recession, central banks may reduce nominal interest rate in order to boost investments. Some economists say a zero nominal interest rate may be due to a liquidity trap (Lars, 2003). When expected returns from investments are low, the rate of investment falls plunging into a recession. People may tend to hold cash since they expect spending and investment to be low (Keynes, 1936).

2.3 Exchange Rate

An exchange rate is the price of one currency, given in terms of another. The movement of a currency's value relative to others has a profound effect on economies exposed to this currency. Given the interlinked nature of modern economies, exchange rate movements have the power to profoundly affect businesses, governments, and people around the globe.The spot rate is also referred to as the nominal exchange rate. The nominal exchange rate measures the value of one currency in terms of another and it can be expressed in two ways: the direct and the indirect quotation. The indirect quotation expresses the price of a foreign currency in terms of the domestic currency. Assuming the naira (N) is the home currency and the United States of America dollar (USD) the foreign currency, an indirect quotation of N125 per USD can be written as follows; USD/N125. The direct quotation on the other hand expresses the price of the local currency in terms of a foreign currency. A direct quotation in this case will be the units of the USD per naira and is written as follows: N/USD0.008. The spot rate is particularly useful because it is directly observable thus making it possible to compare the prices of goods. A problem that arises with the spot rate however is that it fails to indicate a change in the strength of a home currency with respect to the home country's trading partners (other than the United States of America). The spot rate also fails to indicate the effect of acquiring foreign goods and services on the exchange rate itself (Appleyard et al, 2006).

Exchange rate control could be very costly, and even become pointless, when speculators attack a currency, in even under government protection. High interest rate will prevent capital outflows, hinder economic growth and, consequently, hurt the economy (Solnik, 2000). Several factors could cause exchange rate changes. These include changes in

foreign exchange supply and demand, balance of payments problems, rising inflation, interest rate, national income, monetary supervision, changing expectations and speculation (Khalwaty, 2000).

2.4 McKinnon-Shaw Financial Liberalization Hypothesis

The first theoretical pillar to the independent works of McKinnon (1973) and Shaw (1973) is on the premise that interest rates have a positive relationship with economic growth via investment and that financial repression, far from being regarded as growth promoting, is deleterious to investment and economic growth. However, the transmission mechanism or the 'channel of influence' of how interest rates affect investment differs according to the view points of these two economists. McKinnon (1973) put forward that potential investors must accumulate money balances prior to investment. He argues that money holding and capital accumulation are complementary in the developing process, which is in contrast to the neoclassical monetary growth theory. He contends that because of the lumpiness of investment expenditure and the reliance on self-finance, agents need to accumulate money balances before investment takes place. Positive (and high) real interest rates are necessary to encourage agents to accumulate money balances, and complementarities with capital accumulation will exist as long as the real interest rate does not exceed the real rate of return on investment. A higher real deposit rate of interest provides an impetus for firms purporting to finance investment projects.

Shaw (1973), on the other hand, emphasizes the importance of financial liberalization for financial deepening, and the effect of high interest rates on the incentive to save and disincentive to invest in low-yielding projects. The increased liabilities of the banking

system, resulting from higher real interest rates, enable the banking system to lend more resources for productive investment in a more efficient way. According to him, measures to raise real rates of return on financial assets, to reduce the variance of returns, and to improve financial technology, along with measures in non-financial areas, extend savers' horizons over both space and time. Shaw, therefore, included debt intermediation in his model of financial repression, reflecting what investors could borrow. He also included opportunity costs (in real terms) of holding money, such as non-monetary financial assets and inflation hedges. However, the point of convergence with McKinnon is that he also places premium on the role of deposits as a source of funds for financial intermediaries. As he explains, the expanded financial intermediation between savers and investors as a result of higher real interest rates increase incentives to save by means of deposits. This then stimulates investment due to an increased supply of credit, and raises the average efficiency of investment. In addition, the important policy conclusion emanating from the M-S hypothesis is that financial liberalization policies that lead to a deregulated interest rate result in an increase in the nominal deposit rate which undoubtedly stimulates savings and investments.

However, several other theoretical studies have criticized this hypothesis, particularly those of the neo-Keynesian economists and structuralists. Contrasting the M-S hypothesis and the transmission mechanism, Bhatia and Khatkhate (1975) contend that savings and investment differ behaviourally since transfer of savings to investment depends on a host of other factors other than the real interest rate. Such factors include availability of investment opportunities at rates exceeding the cost of funds, institutional constraints and cost of administering funds. Another attack on the transmission mechanism by a neo-

Keynesian is Rittenberg (1991) and to some extent, Warman and Thirlwall (1994). They actually reverse the direction of causation by emphasizing the fundamental Keynesian message that "prior savings has no more tendencies to release funds available for investment than prior spending". They argue that it is investment that determines saving and not the other way round, and that high interest rates may stifle investment and growth. According to them, what is important is not prior saving, but the prospect of profit and an ample and elastic supply of credit to the private sector.

2.5 Theoretical and Empirical Relationship between Interest Rates and Economic Growth

The theoretical association between interest rates and economic growth as recognized in the literature on growth can be found in the neoclassical growth framework and the McKinnon-Shaw hypothesis[1]. For instance, McKinnon-Shaw (1973) argued that financial repression – indiscriminate distortions and financial prices including interest rates – reduces real rate of growth. One of the basic arguments of McKinnon-Shaw model is an investment function that responds negatively to the effective real loan rate of interest and positively to the growth rate. McKinnon-Shaw school expects financial liberalization to exert a positive effect on the rate of economic growth in both the short and medium terms. Albu (2006) used two partial models to investigate the impact of investment of GDP growth rate and the relationship between interest rate and investment in the case of the Romanian economy. The models are specified as:

$$r(\alpha) = a\alpha + b$$

$$\alpha(I) = c/(d+i)$$

[1] A much detailed review of the McKinnon-Shaw hypothesis is done in the preceding section.

where r = GDP growth rate; α = investment rate; i = interest rate; a, b, c, and d are parameters to be estimated.

He found that the behaviour of the national economic system and the interest rate - investment – economic growth relationships tend to converge to those demonstrated in a normal market economy. Oosterbaan et al. (2000) estimated the relationship between the annual rate of economic growth (YC) and the real rate of interest (RR) in equations of the basic form:

$$YC = \beta_0 + \beta_1 \left(RR + \beta_2 \right).\left(RR + \beta_2 \right)$$

The study shows the effect of a rising real interest rate on growth and claimed that growth is maximized when the real rate of interest lies within the normal range of say, −5% to +15%. De Gregorio and Guidotti (1995) cited in Oosterbaan et al. (2000) suggest that the relationship between real interest rates and economic growth might resemble an inverted U-curve: Very low (and negative) real interest rates tend to cause financial disintermediation and hence to reduce growth. However, the World Bank reports, cited in Oosterbaan, et al. (2000) show a positive and significant cross-section relationship between average growth and real interest rates over the period 1965 to 1985.

The Fisher (1930) hypothesis suggests that expected inflation is the main determinant of interest rates as the inflation rate increases by one per cent, the rate of interest increases by one percent. This suggests that expected interest rates change in proportion to the changing expected inflation, or expected real interest rates are invariant to the expected inflation.

Mundell (1963) concluded that nominal interest rate with expected inflation rate do not have one for one adjustable relations. It is the Mundell-Tobin effect that nominal interest rates would rise less than one-for-one with inflation because in response to inflation the public would hold less in money balances and more in other assets, which would drive interest rates down.

Estrella and Hardouvelis (1991), examining data over the period 1955 to 1988, they document that the spread between the yield on the ten year Treasury bond and the three-month Treasury bill is a useful predictor of both cumulative economic growth up to four years in the future and marginal economic growth rates up to seven quarters in the future. They also found that the spread contains information for future economic growth not already embodied in the current level of real interest rates, in current economic growth, in the current growth rate of the index of leading economic indicators, or in the inflation rate.

Haubrich and Dombrosky (1996) also find that over the period January 1961 to March 1995, the yield spread is a relatively accurate predictor of four-quarter economic growth but that its predictive content has changed over time. For example, they find that the yield spread was not a very good predictor of economic activity over the period 1985 to 1995.

Estrella and Mishkin (1998), for example, using data over the period January 1959 to January 1995, show that the spread between the yield on the ten-year and three-month Treasury securities is the best out-of-sample predictor of the probability of a recession occurring in the next four quarters. For shorter horizons, they find that adding movements in various stock price indexes improves forecast accuracy.

Berument (1999) indicated inflation rate influenced three month Treasury bill rate by using conditional variance of inflation rate to represent risk index. The results showed inflation rate had positive influence to three month Treasury bill rate.

Engen and Hubbard (2004) determined that an increase in federal government debt equivalent to one percent of GDP, all else equal, would be expected to increase the long-term real rate of interest by about three basis points.

2.6 Some Empirical Evidence on the Inflation-Growth Relationship

The investigations into the existence and nature of the link between inflation and growth have experienced a long history. Although economists now widely accept that inflation has a negative effect on economic growth, researchers did not detect this effect in data from the 1950s and the 1960s. A series of studies in the IMF Staff Papers around 1960 found no evidence of damage from inflation (Wai, 1959; Bhatia, 1960; Dorrance, 1963, 1966). Johanson (1967) found no conclusive empirical evidence for either a positive or a negative association between the two variables. Therefore, a popular view in the 1960s was that the effect of inflation on growth was not particularly important.

This view prevailed until the 1970s, when many countries, mainly in Latin America, experienced hyperinflation or chronic inflation. Numerous empirical studies were devoted to finding the effects of inflation in high-inflation countries. These studies repeatedly confirmed that inflation had a significant negative effect on economic growth, at least at sufficiently high levels of inflation. Therefore, today, the dominant view regarding the effects of inflation has changed dramatically. Fisher (1993) found negative associations between inflation and growth in pooled cross-section, time series regressions for a large set

of countries. He argued that inflation impedes the efficient allocation of resources by obscuring the signaling role of relative price changes, the most important guide to efficient economic decision-making. Later, a famous paper by Barro (1995) more precisely examined the five-year average data of 100 countries over the period of 1960 to 1990 by using the Instrumental Variable (IV) estimation method. Using different instrumental variables, he obtained a robust estimation result showing that an increase in average inflation by 10 percentage points per year would slow the growth rate of the real per capita GDP by 0.2 to 0.3 percentage points per year. He argued that although the adverse influence of inflation on growth appeared small, the long-term effects on standards of living were actually substantial. Nevertheless, some other empirical and theoretical studies argued that the inflation-growth relationship is fragile. Levin and Zervos (1993) showed that the cross-section correlation between inflation and growth depends on extreme inflation observations with high-frequency data. Bruno and Easterly (1998) and Bullard and Keating (1995) found support for the notion that this negative relationship emerges only when rates of inflation exceed some threshold. Levine and Renelt (1992) and Clark (1997) also questioned whether a uniformly negative relationship exists between inflation and real activity independently of the prevailing rate of inflation.

Recently, intensive research has focused on the nonlinear relationship between these two variables. That is, at lower rates of inflation, the relationship is positive or not significant, but at higher rates, inflation has a significantly negative effect on growth. In terms of nonlinearity, explaining why views on the inflation-growth relationship have changed dramatically over the past forty years is not difficult.

The nonlinear view with respect to the inflation-growth relationship not only can convincingly explain the empirical findings but also has a strong policy implication: keep inflation below the structural break. This implication could be the reason why, since the 1990s, numerous economists have been trying to find the exact threshold level. Such a nonlinear relationship was first detected by Fischer (1993). Sarel (1996) used OLS with fixed effects to examine a sample with 87 countries (including both industrial countries and developing countries) over the period 1970-1990. He specifically tested the existence of a structural break point and found evidence of a significant structural break in the relationship between the two variables. Moreover, he estimated the inflection point, or threshold, to be at an 8% annual inflation rate. Ghosh and Phillips (1998) reexamined the issue of the existence of threshold effects, using a larger sample than Sarel (1996). Surprisingly, they found a substantially lower threshold effect at a 2.5% annual inflation rate. Christoffersen and Doyle (1998) estimated the threshold level at 13% for transition economies. Khan and Senhadji (2001) used an unbalance panel with 140 countries for 40 years to estimate the threshold for industrial and developing countries. Using the nonlinear least squares (NNLS) estimation technique, Khan and Senhadji (2001) estimated that the threshold levels for industrial countries and developing countries were at 1-3% and 11-12%, respectively.

2.7 Theoretical Relationship between Interest Rate and Inflation

The channels through which a change in the interest rate is likely to impact the price level in standard macro models can be distinguished into demand and supply channels. The demand side of the economy is determined by equilibrium conditions in the money and goods market. First, consider the impact of a rise in the interest rate on the money market.

A rise in the interest rate increases the opportunity of holding cash balances which has a negative impact on money demand. The reduction in money demand creates excess supply of credit and stimulates a rise in aggregate demand. Consequently, price must increase so that individuals can be satisfied to hold the existing stock of money rather than spending it on commodities of interest-bearing assets (Bose, 2002).

On the other hand, changes in the interest rate are likely to affect the equilibrium condition in the goods market, and, in turn, price. A rise in the interest rate is expected to impact on disposable income and the public's preference to consume out of this income. While net interest gets added to the disposable income of lenders in the economy, it decreases the income available for borrowers to spend. Hence, a rise in the interest rate is expected to increase consumption for the lenders and decrease consumption for the borrowers. If marginal propensity to consume for borrowers is higher than that for lenders, an increase in the interest rate would likely lead to decline in consumption demand. In addition, a change in the interest rate is expected to affect the desire to consume out of income for both borrowers and lenders (i.e., marginal propensity to consume). Higher interest rate makes consumption cheaper tomorrow than today. Hence, economic agents tend to defer consumption, which is consistent with a higher marginal propensity to save. Through this channel, the negative impact of a rise in the interest rate on consumption spending is expected to be further reinforced. In addition to that, a change in the interest rate is expected to impact negatively on investment spending in two directions. First, an increase in the interest rate has a negative impact on the net present value of the expected return on investment. Second, a rise in the interest rate increases the cost of credit, which would also be expected to reduce investment demand. This channel further decreases aggregate

demand and, in turn, price. Thus, the interaction between the interest rate and the demand side of the economy does not provide a clear prediction of the impact of the interest rate on price level (Kandil, 2005).

The interaction between the interest rate and the supply side of the economy is also complicated by the presence of conflicting factors. An increase in the interest rate means a higher cost of the output produced and, therefore, a rise in prices. However, as suggested by Ball (1990), an increase in the interest rate has an intertemporal substitution effect on labour supply. Workers prefer to work more today to increase their saving at the higher interest rate. The increased labour supply increases the output supplied and, in turn, decreases prices. In short, the combined effect of the demand and supply channels suggests an ambiguous impact of the interest rate on price.

2.8 Overview of the Financial System in Ghana

Financial sector reform in Ghana was part of a comprehensive Economic Recovery Program (ERP) and Structural Adjustment Program (SAP), which began in 1983. Prior to that, the country's financial sector was characterized by financial repression policies which, coupled with balance of payments deficit, overvalued exchange rates, and high inflationary pressures culminated in almost the collapse of the country's financial system. This necessitated the introduction of the financial sector reforms between 1988 and 1989, which became known as the Financial Institutions Structural Adjustment Program (FINSAP). Among some of the broad objectives of the program were to restructure banks that were distressed, to improve saving mobilization, to enhance efficiency in credit allocations, to reform banking laws, etc. Consequently, by the mid-1990s, the financial

sector had been progressively liberalized. This had involved interest rates deregulation (i.e., withdrawal of ceilings on deposit and lending rates), removal of credit guidelines, and the introduction of market-based instruments of monetary control. The reform results have, however, been mixed.

One of the initial effects of the reform was that the real interest rates, which had remained largely negative during the regime of the financial repression, turned positive in 1991 and 1992, following the decline in the rate of inflation. Since then, the banking industry has consistently witnessed phenomenal growths, and it is currently one of the fastest growing sectors in the country. The widely deregulated environment and the introduction of the universal banking concept in the early 2000s as well as the relatively stable macroeconomic environment have resulted in the influx of both foreign and domestic banks. The number of banks has consequently increased from nine at the beginning of the reform to 26 currently. This has also resulted in a massive expansion of banks' branch network and a keen competition within the sector.

However, the responsiveness of financial savings and investments to the interest rate deregulation and the apparent improvements in the institutional framework has been worryingly slow. In part, various economists and policy makers have attributed this to the wide interest rate spreads after the reform. While for the most part of the 1990s, the average nominal interest rate hovered around 40%, the average bank deposit rate was below 10%, with its real value remaining negative throughout the period. This obviously not only slowed effective financial savings mobilization, but also crowded out private sector investments as the cost of borrowing was too expensive to bear. The banks however

were not much bothered as they could still make huge profits from the soaring government Treasury bill rates at that time. This situation of a wide interest spread remains, despite the keen competition within the financial sector and the relative stability in the macroeconomic environment. For example, despite the fact that all the major macroeconomic indicators such as the inflation rates, Treasury bill rates and the BOG prime rates show downward trends in recent times, the lending base rates by the banks are much more higher and have failed to fall in tandem with the others (see Figure 2.1). The country reached a single-digit inflation (9.46%) in the third quarter of 2010 for the first time in many years, while the policy rate (also known as the prime rate represents an indicative rate around which all the other rates revolve) had also fallen from a high of 18% in 2009 to 13.5% by mid-2010. Yet, the base rates (i.e., the minimum lending rate quoted by banks) have failed to fall as expected. The base rates are still around 25-28%, albeit the actual rates charged are between 30-34%.

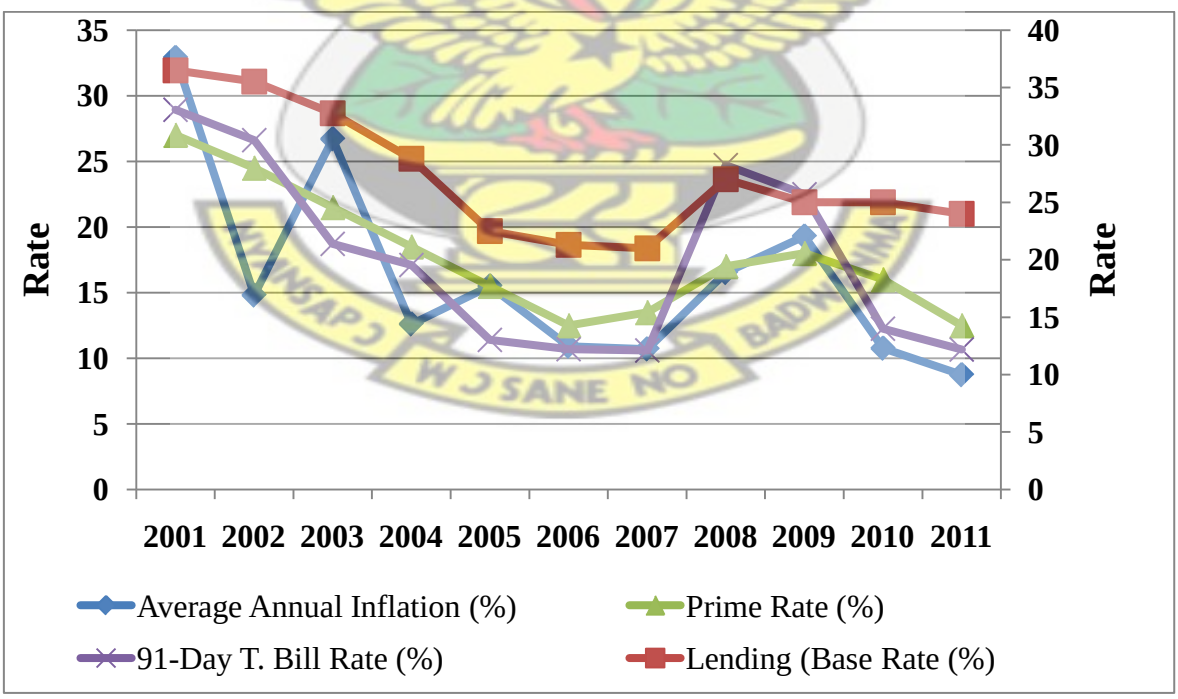


Figure: 2.1: Financial Indicators

Source: BOG Financial Development Reports (2011)

Meanwhile, the deposit rates have been kept so low at about 5%, raising questions about the intermediation efficiency of the banking industry and the ability of the deregulated banking sector to stimulate domestic private investments to bring about the much-needed growth and poverty reduction in the country.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter focuses on the econometric framework of the empirical model of the study. The chapter is organized as follows: Section 3.1 presents the basic concepts and definitions of time series, and Section 3.2 presents the components of time series. Section 3.3 presents the sources of data and the description of variables to be used in the empirical model. Section 3.4 presents the specification of the operational model while section 3.5 introduces the estimation methods of the models/ the empirical strategy. Section 3.6 presents the granger causality analysis.

3.1 Basic Concepts and Definitions of Time Series

3.1.1 Basic definitions

Time series is defined as a collection of observations or measurements on quantitative variables made sequentially or in a uniform set of time period, usually daily, weekly, monthly, quarterly, annually, and so on and so forth. Examples include total monthly crime for a jurisdiction for a period of ten years, daily stock prices of a firm for a period of one year, monthly electricity consumption for a household for a period of five years, etc.

Time series analysis comprises methods or a process that break down a series into components and explainable portions that allows trends to be identified, estimates and forecasts to be made.

Basically time series analysis attempts to understand the underlying context of the data points through the use of a model to forecast future values based on known past values. Such time series models include GARCH, TARCH, EGARCH, FIGARCH, CGARCH, ARIMA, VAR, COINTEGRATION, etc but the main focus of this study is based on VAR and COINTEGRATION.

3.1.2 Time Series Graph

Time series plot is simply a graph which displays observations on the y-axis against equally spaced time intervals on the x-axis. The time series plot specifically consists of:

Time scale (index, calendar, clock, or stamp column) on the x-axis; data scale on the y-axis; and lines displaying each time series as shown in the Figure 3.1 below for a given hypothetical data. The plots are usually used to: detect trends in your data over time; detect seasonality in your data; and compare trends across groups.

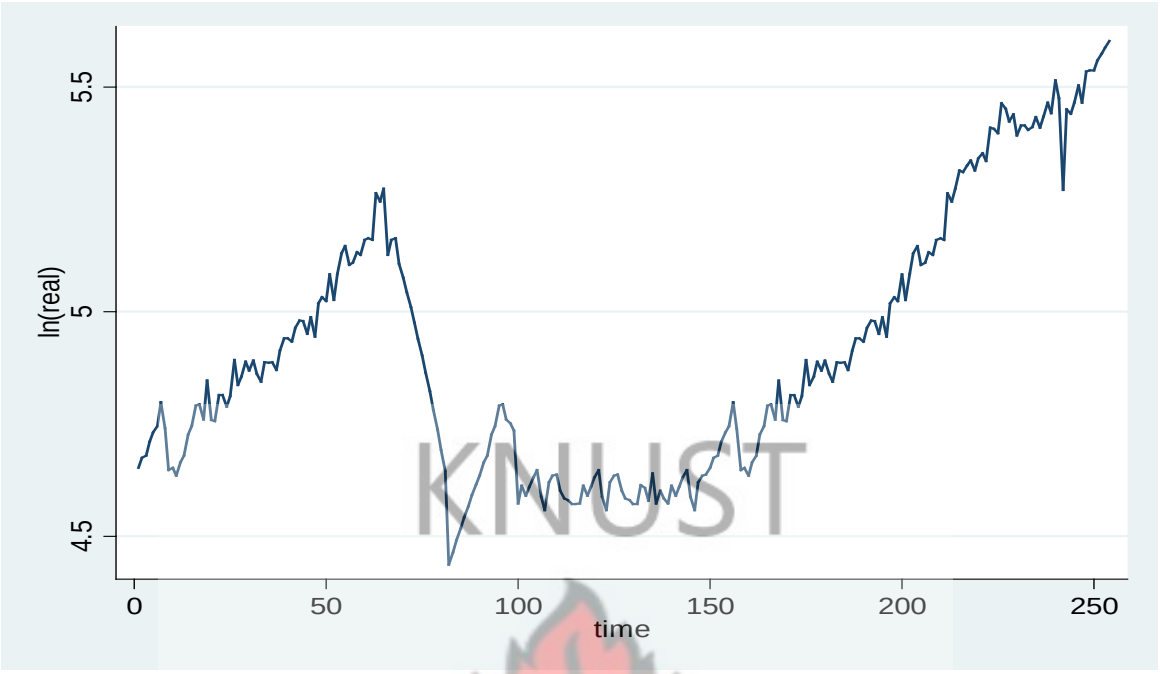


Figure 3.1 Time plot for a hypothetical data of 254 observations

3.2 Components of Time Series

A vital step in choosing appropriate modeling and forecasting procedure is to consider the type of data patterns exhibited from the time series graphs of the time plots. The sources of variation in terms of patterns in time series data are mostly classified into four main components. These components include seasonal variation; trend variation; cyclic changes; and the remaining "irregular" fluctuations.

3.2.1 Trend

The trend is simply the underlying long term behavior or pattern of the data or series. The Australian Bureau of Statistics (ABS, 2008) defined trend as the 'long term' movement in a time series without calendar related and irregular effects, and is a reflection of the

underlying level. It is the result of influences such as population growth, price inflation and general economic changes. The following graph depicts a series in which there is an obvious upward trend over time:

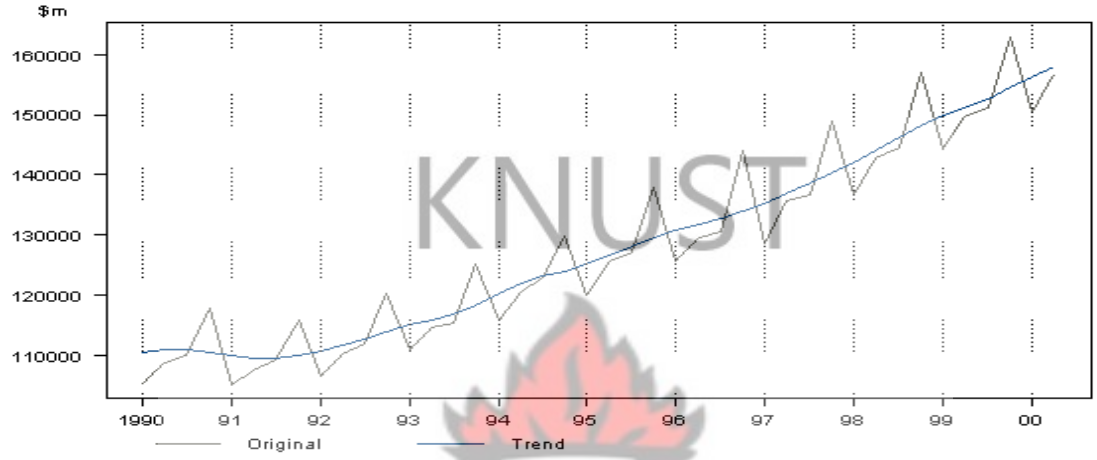


Figure 3.2: Upward trend graph of a hypothetical time series data

3.2.2 Seasonal variation

A seasonal effect is a systematic and calendar related effect. Some examples include the sharp escalation in most Retail series which occurs around December in response to the Christmas period, or an increase in water consumption in summer due to warmer weather. Other seasonal effects include trading day effects (the number of working or trading days in a given month differs from year to year which will impact upon the level of activity in that month) and moving holidays (the timing of holidays such as Easter varies, so the effects of the holiday will be experienced in different periods each year).

Seasonal adjustment is the process of estimating and then removing from a time series influences that are systematic and calendar related. Observed data needs to be seasonally adjusted as seasonal effects can conceal both the true underlying movement in the series, as well as certain non-seasonal characteristics which may be of interest to analysts. Seasonality in a time series can be identified by regularly spaced peaks and troughs which have a consistent direction and approximately the same magnitude every year, relative to the trend as depicted in the figure 3.3 below.

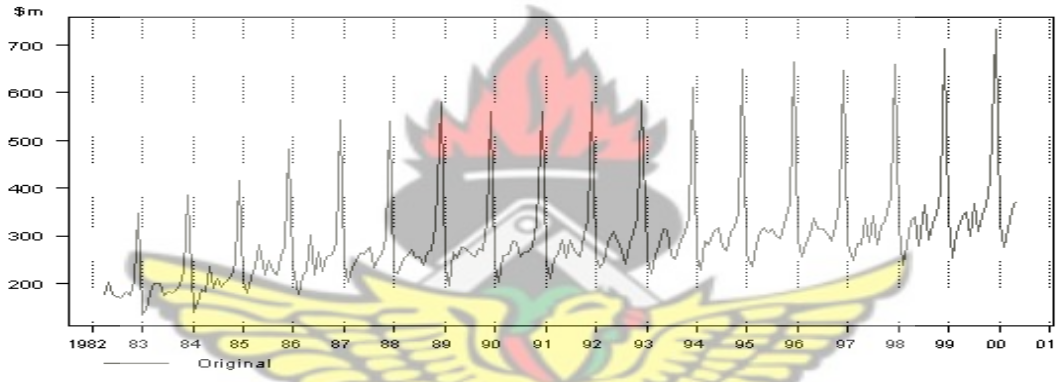


Figure 3.3 Graphical display of seasonal effect of a hypothetical data

Other techniques that can be used in time series analysis to detect seasonality include:

1. A seasonal subseries plot is a specialized technique for showing seasonality.
2. Multiple box plots can be used as an alternative to the seasonal subseries plot to detect seasonality.
3. The autocorrelation plot can help identify seasonality.

3.2.3 Cyclical variations

Cyclical variations are the short term fluctuations (rises and falls) that exist in the data that are not of a fixed period. They are usually due to unexpected or unpredictable events such as those associated with the business cycle sharp rise in inflation or stock price, etc. The main difference between the seasonal and cyclical variation is the fact that the former is of a constant length and recurs at regular intervals, while the latter varies in length. More so, the length of a cycle is averagely longer than that of seasonality with the magnitude of a cycle usually being more variable than that of seasonal variation.

3.2.4 Irregular Variations

The irregular component (sometimes also known as the residual) is what remains after the seasonal and trend components of a time series have been estimated and removed. It results from short term fluctuations in the series which are neither systematic nor predictable. In a highly irregular series, these fluctuations can dominate movements, which will mask the trend and seasonality. The Figure 3.4 below is a graph which is of a highly irregular hypothetical time series.

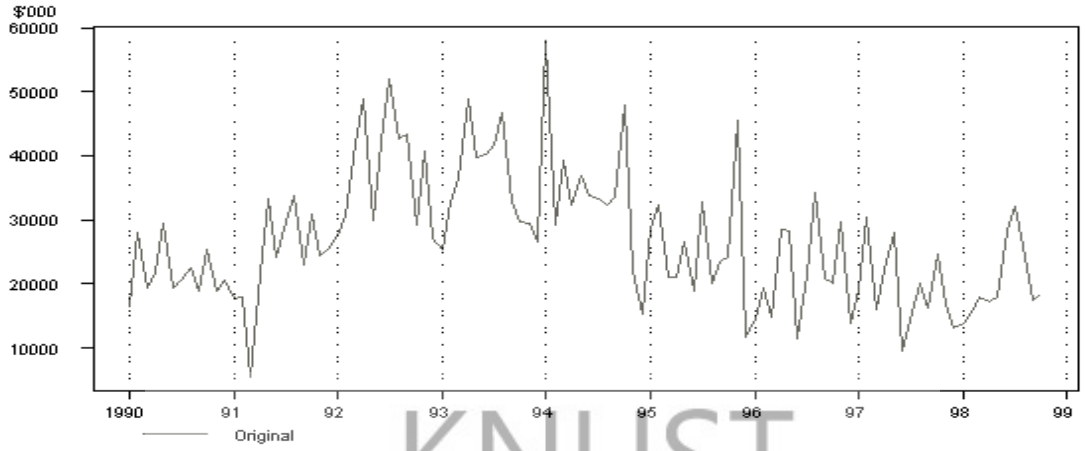


Figure 3.4 Typical irregular effect graph of a hypothetical time series data

3.3 Data Sources and Description

3.3.1 Data Sources

This empirical study relies primarily on time series monthly data spanning from the period 1990: 11 through to 2011: 12, thus making use of 254 data points on the key variables used in the study. Moreover, the choice of the study period is mainly dependent on the availability of data on the variables under consideration. All data used in the analysis are gleaned from Bank of Ghana, IMF, International Financial Statistics, Government Finance Statistics and the World Bank Development Indicators (CD-ROM) and The State of the Ghanaian Economy (various issues). Other augmenting sources include published articles and journals, working papers, textbooks and relevant internet resources.

3.3.2 Variable Description

Since GDP figures are unavailable on a monthly basis, we use a composite index for economic activity (CIEA) from the Bank of Ghana as a proxy variable for the real economy. Nominal exchange rate is the nominal monthly average Ghana Cedi (GH¢)[2] to US dollar (US$) rate. Inflation is proxied by the average monthly inflation while 91-day Treasury bill rate is used as a proxy for interest rates. We use M2+ (broad money supply including foreign currency deposits) as a proxy for money supply while external supply shocks are proxied using monthly crude oil prices.

3.4 Model Specification

To undertake the empirical investigation of the nexus between inflation, interest rates and real economic activities, the present study specifies an augmented model for Ghana based on the theoretical and empirical literature. Specifically, following the neoclassical model, McKinnon-Shaw hypothesis and Albu's (2006) specifications, the present study specifies an augmented model of the form:

$$real_t = \alpha_0 + \alpha_1 inf_t + \alpha_2 int_t + \alpha_3 exrate_t + \alpha_4 m2_t + \alpha_5 oilp_t + \varepsilon_t \qquad (3.1)$$

where *real* is a measure of economic activity; *inf* is the rate of inflation; *exrate* is the exchange rate; *int* is the interest rate; *m2* is a measure of money supply (which captures the effect of financial deepening); *oilp* is oil prices to proxy external supply shocks which is also treated as an exogenous variable since Ghana until recently that it discovered oil in

[2] Cedi (¢) is Ghana's official unit of currency generally denoted as GH¢. On 3rd July 2007, the Ghanaian cedi (GHC) was redenominated. The new Ghana cedi (GHS) is equal to 10,000 old Ghanaian Cedis (1 GHS = 10,000 GHC). The old currency remained in circulation alongside the new until December 2007. One Ghana cedi is divided into one hundred Ghana pesewas (Gp).

commercial quantities was a small oil importing country and hence cannot influence the world market price of oil; and ε is the usual white noise error term.

We log-linearize equation (3.1) in order to be able to interpret the coefficients as partial elasticities.

Thus, the estimable static long-run model is specified as follows:

$$lnreal_t = \alpha_0 + \alpha_1 lninf_t + \alpha_2 lnint_t + \alpha_3 lnexrate_t + \alpha_4 lnm2_t + \alpha_5 lnoilp_t + \varepsilon_t \qquad (3.2)$$

where all variables are as previously defined except ε_t, which represents the white noise error term, *t*, is time and *ln* denotes natural logarithm. Equation (3.2) shows the long–run equilibrium relationship. A few words must be said regarding the intuitive sign for each independent variable.

The inflation rate indicates the overall ability of the government to manage the economy: high inflation rates implying that the government has lost control. Inflation is expected to proxy the general macroeconomic instability. We expect that this variable will be negatively related to real economic activity (i.e. $\alpha_1 < 0$).

Typically, increases in interest rates slow down growth in real economic activities because consumers have less money to spend and less motivation to borrow. Conversely, if interest rates drop, the economy may benefit from increased spending. Consequently, interest rates and real economic activity are negatively related (i.e. $\alpha_2 < 0$).

Depreciation or devaluation of a country's currency triggers an "expenditure switching" mechanism, which leads to domestic demand away from imports to locally produced import-competing goods. It also improves international competitiveness thereby boosting exports. These two effects together exert an expansionary effect on overall economic activity. Thus, we expect the coefficient of nominal exchange rate to be positive ($\alpha_3 > 0$).

Furthermore, *m*2 over *GDP* is used as a proxy for financial deepening. Financial development stimulates economic growth by enlarging the services provided by financial intermediaries such as savings mobilization, project evaluation, and risk management. The size of financial intermediaries, traditionally measured by the ratio of *m*2 to *GDP*, is assumed to be positively associated with the provision of financial services. Financial repression is also expected to be detrimental to growth. Many developing countries over-regulate their financial sectors through controls on interest rates on deposits and restrictions on credit to the private sector, which hamper its ability to intermediate savings efficiently (World Bank, 1989). Although financial liberalization is usually argued to foster growth, it may not be effective if it also creates macroeconomic instability. For example, a reduction in forced lending to government could increase the availability of financing for private investment. However, if the government then resorts to inflationary finance, the move could be counterproductive. Consequently, we expect the coefficient of *m*2 to be ambiguous ($\alpha_2 \gtrless 0$).

Oil price fluctuations have considerable consequences on economic activity. These consequences are expected to be different in oil importing and in oil exporting countries.

Since Ghana is a small oil importing country[3], an oil price increase tends to have a deleterious effect on economic activity. The transmission mechanisms through which oil prices have an impact on real economic activity include both supply and demand channels. The supply side effects are related to the fact that crude oil is a basic input to production, and consequently an increase in oil price leads to a rise in production costs that induces firms to lower output. Oil prices changes also entail demand-side effects on consumption and investment. Consumption is affected indirectly through its positive relation with disposable income. The magnitude of this effect is in turn stronger the more the shock is perceived to be long-lasting. Moreover, oil prices have an adverse impact on investment by increasing firms' costs. Consequently, oil price has a negative relationship with real economic activity in this study (i.e., $\alpha_5 < 0$).

3.5 Empirical Strategy

The specific estimation technique used in this study is cointegration. This statistical concept introduced by Engle and Granger (1987) has received wide attention and is beginning to be applied to test the validity of various theories and models.

Cointegration is a property possessed by some non-stationary time series data. In this concept, two variables are cointegrated when a linear combination of the two is stationary, even though each variable is non-stationary. In particular, if we if consider two time series, *X* and *Y* that are non-stationary, conventionally one would expect that a linear combination of two the variables would also be non-stationary. In order to avoid the problem of non-

[3] Until the last quarter of 2010 when Ghana started exporting crude oil in commercial quantities, it was over the years a small oil importing country. Since a large chunk of the dataset is found within the periods when Ghana had not started drilling oil, we generally assume that in this study, it is an importing country.

stationarity it is necessary to make use of first (or higher) differentiated data. Such differencing, however, may result in a loss of low frequency information or long-run characteristics of the series data. However, Engle and Granger (1987) showed that, if there is an equilibrium relationship between such variables, then for this relationship to have any meaning a linear combination of these variables the disequilibrium error should fluctuate about zero i.e. should be stationary. Testing for cointegration involves two steps.

1. Determine the degree of integration in each of the series, a unit root analysis.

2. Estimate the cointegration regression and test for integration.

3.5.1 Unit Roots

A two variable cointegration test requires that the variables be integrated of order one. In other words the series data should be stationary only in their first differences, and not in levels. A number of alternative tests are available for testing whether a series is stationary or not, the Augmented Dickey-Fuller (*ADF*), Dickey and Fuller (1979), as well as the Phillips Perron (PP) test developed by Phillips (1987) and Phillips and Perron (1988). The *PP* tests are based on the following *ADF* regression, and the critical values are the same as those used for the *ADF* tests:

$$\Delta X_t = \lambda_0 + \lambda_1 X_{t-1} + \lambda_2 T + \sum_{i=1}^{n} \psi_i \Delta X_{t-1} + \varepsilon \qquad (3.3)$$

where Δ is the difference operator, X is the natural logarithm of the series, T is a trend variable, λ and ψ are the parameters to be estimated and ε is the error term. The *PP* unit root test is utilized in this case in preference to *ADF* unit root tests for the following

reasons. First the *PP* tests do not require an assumption of homoscedasticity of the error term (Phillips, 1987). Secondly, since lagged terms for the variable of interest are set to zero there is no loss of effective observations from the series (Perron, 1988), which is especially useful if the number of data points is limited. The *PP* unit root test corrects the serial correlation and autoregressive heteroscedasticity of the error terms. This aims at providing unit root tests results that are robust to serial correlation and time dependent heteroscedasticity of errors.

In both the *PP* and *ADF* unit root tests the null hypothesis is that the series is non-stationary and this is either accepted or rejected by examination of the t-ratio of the lagged term X_{t-1} compared with the tabulated values. If the t-ratio is less than the critical value the null hypothesis of a unit root (i.e. the series is non-stationary) is accepted. If so the first difference of the series is evaluated by equation (3.3) and if the null hypothesis is rejected the series is considered stationary and the assumption is that the series is integrated of order one $I(1)$. Critical values for this t-statistic are given in Mackinnon (1991).

3.5.2 Multivariate Cointegration Model

The vector autoregression (VAR) approach is employed in this study. This approach has become somewhat standard in time series modeling because compared to the structural approach; it avoids the need to provide a dynamic theory specifying the relationships among the jointly determined variables. Moreover, it can handle endogenous variables on both sides of the equation as well as a mix of $I(1)$ and $I(0)$ variables in one system. In a VAR system, each variable is regressed on its own lags plus the lags of the other variables.

The appropriate lag length (p), which should be specified long enough for the residuals not to be serially correlated, can be determined using standard model selection criteria such as the Akaike information criterion (AIC), Schwarz information criterion (SIC), Hannan-Quinn information criterion (HQ) and the Final prediction error (FPE) information criteria. The VAR model can also be used to test for weak exogeneity and parameter restrictions.

Assume **Yt** is a vector of k jointly determined endogenous variables and **Xt** is a vector of m exogenous variables. A pth order VAR model of the inter-related time series, VAR(p), can be written as:

$$Y_t = \sum_{i=1}^{p} \Phi_i Y_{t-i} + \Psi X_t + \varepsilon_t \qquad (3.4)$$

where Φi and Ψ are matrices of coefficients to be estimated, and ε_t is a vector of independent and identically distributed disturbances. If the endogenous variables are each $I(1)$ we can write the VAR(p) model as a vector error correction model (VECM):

$$\Delta Y_t = A_0 + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-1} + \Pi Y_{t-1} + \Psi X_t + \varepsilon_t \qquad (3.5)$$

where A_0 is a $n \times 1$ vector of constants, Y_t is an $n \times 1$ vector of $I(1)$ variable, p is the number of lags

$\Gamma_i = -\sum_{j=i+1}^{p} \Phi_j$ and $\Pi = \sum_{i=1}^{p} \Phi_i - I$, Δ is a difference operator, I is a $n \times n$ vector of identity matrix and ε_t is $n \times 1$ vector of independently and identically distributed error terms.

Granger's Representation Theorem asserts that if the coefficient matrix Π has reduced rank (i.e., rank (Π) = $r < k$) then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' X_t$ is $I(0)$. The rank r is the number of cointegrating relations and each column of β is the cointegrating vector (CV). The Johansen maximum likelihood estimation procedure (Johansen, 1988, 1990, 1991, 1995; Johansen and Juselius, 1990) can be used to estimate the two matrices α and β and test for the number of distinct CVs. Restrictions on the elements of β help to determine which variables are relevant in the long-run relations; economic theory may have to be invoked to decide on the restrictions to impose on each CV (Johansen, 1995). The elements of α are known as the adjustment parameters in the VECM. The hypothesis that Π has a reduced rank $r < n$ is tested using the trace and the maximum eigenvalues test statistics. Restrictions on the adjustment parameters help to determine which variables are weakly exogenous.

The impulse response functions (IRFs) generated from the VAR model trace out the time paths of the effect of a shock in a nominated variable on each of the other variables in the system. From them we can determine the extent to which an exogenous shock causes short-run and long-run changes in the respective variables.

The vector error-correction model (VECM) with a lag order p is specifically modeled as follows:

$$\Delta \ln real_t = \delta_0 + \delta_{1i} \sum_{i=1}^{p} \Delta \ln real_{t-i} + \delta_{2i} \sum_{i=1}^{p} \Delta \ln \inf_{t-i} + \delta_{3i} \sum_{i=1}^{p} \Delta \ln \text{int}_{t-i} + \delta_{4i} \sum_{i=1}^{p} \Delta \ln exrate_{t-i}$$
$$+ \delta_{5i} \sum_{i=1}^{p} \Delta lnm2_{t-i} + \delta_{6i} \sum_{i=1}^{p} \Delta lnoilp_{t-i} + \varphi ecm_{t-1} + \eta_{1t} \qquad (3.6)$$

where all variables are as previously defined, $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5$, and δ_6 represent short-run elasticities, ecm_{t-1} is the error correction term with its coefficient, φ denoting the speed of adjustment to long-run equilibrium after a shock to the system. The econometrics packages used in the estimation are Stata.

3.6 Granger Causality Analysis

The final stage of the estimation involves conducting Granger causality tests to find the direction of causality and possible feedback between real economic activity, inflation, interest rates and the other determinants of real economic activity. By Granger's representation theorem, if variables are cointegrated, there must be causality in at least one direction and the long run relationship is free of spurious correlations. Granger causality tests whether lagged values of one variable predict changes in another, or whether one variable in the system explains the time path of the other variables. Hence, a variable *x* is said to Granger cause another variable *y* ($x \rightarrow y$) if past values of *x* can predict present values of *y*. Granger (1988) posits two cardinal principles namely the cause precedes the effect and; 'the causal series contains special information about the series being caused that is not available in the other available series' (Granger, 1988). Similarly, there is an instantaneous causality from *x* to *y* ($x \vdash y$) if present and past values of *x* predict present value of *y*. If causality is in one direction e.g. from *x* to *y*, we have uni-directional causality while if *x* Granger causes *y* and *y* Granger causes *x*, we have bi-directional or feedback

causality ($y \leftrightarrow x$). There are two commonly used causality tests: one due to Granger (1969) and the other due to Sims (1972). The former is, however, more widely used in applied econometrics, partly because of its simplicity and also because it is less costly in terms of degrees of freedom (Charemza and Deadman, 1997). The Granger-causality test is based on the assumption of stationary variables. Thus, if the variables are non-stationary then, Granger-causality tests are applied on the first differences of the variables that have unit root. The test for Granger causality is performed by estimating equations of the following form:

$$\Delta X_t = a + \sum_{i=1}^{n} b_i \Delta X_{t-i} + \sum_{i=1}^{m} l_j \Delta Y_{t-j} + m_t$$

$$\Delta Y_t = a + \sum_{i=1}^{n} b_i \Delta Y_{t-i} + \sum_{i=1}^{m} l_j \Delta X_{t-j} + n_t$$

(3.7)

The F-test is applied to test the null hypothesis of Granger-non-causality against the alternative of Granger-causality. If the F-statistic is significant at any of the conventional levels, the null hypothesis that 'Y does not Granger-cause X' is rejected, otherwise it is accepted.

CHAPTER FOUR

EMPIRICAL RESULTS, ANALYSIS AND DISCUSSION

4.0 Introduction

This chapter seeks to present and analyze the regression results of the empirical models specified in the preceding chapter. Fundamentally, this study seeks to establish the nexus between real economic activity, interest rate and inflation. As a consequence, the present chapter seeks to provide an in-depth analysis of the long and short run relationship of the variables mentioned as well as testing the sensitivity of such relationship in the presence of some other key macroeconomic indicators. The chapter is decomposed into three major sections of which the first section looks at the descriptive statistics of the data as well as the graphical representation which will aid in doing some trends analyses of the series. The second part of the chapter concentrates on estimating and analyzing the various models under investigation. This is done by first ascertaining their order of integration and consequently establishing a cointegrating relationship between the variables under investigation. By so doing, we apply the Johansen's cointegration test and subsequently establish the causal link between the variables. We also perform a battery of diagnostics on the models estimated. The last section of the chapter basically discusses the results of the empirical model and relates them to the existing literature.

4.1 Descriptive Statistics and Pair-wise Correlation of the Variables

The descriptive statistics and the pair-wise correlation of the variables are presented in Tables 4.1 and 4.2 respectively. The statistics presents basically the first and second

moments of each series as well as the maximum and the minimum values. This is to ascertain the degree of variability in each of the series which is necessary to ensure that they can be used in any regression analysis. The statistics show that (refer to appendix), real economic activity averaged 142.16 with a minimum and maximum indices of 84.55 and 271.21 respectively. The standard deviation of real activity variable indicates that, there have been periods of extremely low records of economic activity and other periods of extremely good economic conditions. The rate of the Ghana cedi to the US dollars averaged GH¢0.63 to $1 within the period with a standard deviation of GH¢0.49. This indicates that within the period under investigation, the Ghana cedi did not experience such greater depreciation. Moreover, the mean inflation was 21.8% whiles the mean interest rate proxied by 91 Day T-Bill rate was 27%. The standard deviations of inflation and interest rates are suggestive of intense volatility of these variables, as there have been periods of very low inflation and interest rates and periods which they recorded high values. Crude oil price averaged $39.62 dollars per barrel while money supply recorded a mean value of GH¢2881.32 billion.

There is variability in the raw data since all of them have different units of measure. Therefore, there is a need for transformation in order to bring stability. The data was then transformed to the natural logarithm (i.e. ln). The table 4.1 below then presents the summary statistics of the transformed data.

Table 4.1 Summary Statistics of the Log Data

Variable	Obs	Mean	Std. Dev.	Min	Max
lnreal	254	4.912	0.293	4.437	5.603
lnint	254	3.180	0.509	2.213	3.870
lninf	254	2.945	0.506	2.127	4.196
lnm2	254	6.649	1.876	3.346	9.818
lnoilp	254	3.449	0.659	2.343	4.887
lnexrate	254	-0.982	1.197	-3.370	0.460

Table 4.2 also presents the pair-wise correlation of the variables used in the study. This is to identify variables that could potentially cause multicollinearity in the model. Also this is done to provide some firsthand knowledge as to the linear relationship between the variables, particularly between real economic activity, inflation and interest rate. The results indicate that real economic activity is negatively correlated with both inflation and interest rates. However, the correlation is somewhat weak. Inflation and interest rate are positively correlated with the magnitude indicating a fairly high correlation. It is, however, important to emphasize that, correlation does not necessarily imply causation. Thus, latter sections will seek to establish a causal linkage amongst these variables of interest.

Table 4.2 Sample Correlation Matrix

Variable	*lnreal*	*lnexrate*	*lnintr*	*lninf*	*lnm2*	*lnoilp*
lnreal	1.0000	0.3354	-0.4469	-0.2716	0.5108	0.6292
lnexrate		1.0000	-0.5241	-0.4182	0.9678	0.7624
lnintr			1.0000	0.7736	-0.6512	-0.7805
lninf				1.0000	-0.5244	-0.6184
lnm2					1.0000	0.8632
lnoilp						1.0000

4.2 Time Plots for Real Economic Activity, Inflation and Interest Rate

This section seeks to explore the relationship between inflation, interest rates and real activity usually by examining trends over the sample period. Figure 4.1 shows the time plot of the three time series data. Apparently, it appears there is a weak negatively relationship (Table 4.2) between the interest rate and real economic activity index series in the sense that, periods of high interest rates were accompanied by periods of relatively low economic activities and vice versa. For instance, the period after November, 2003 saw a generally upward trend in economic activity with low but quite fluctuating interest rates. Figure 4.1 also shows the Time plots for real activity and inflation. Inflation appears to have sustained fluctuating trends, though generally downwards, whiles the real activity fluctuates frequently upwards, thus indicative of a weak negative correlation (Table 4.2) between the two variables. That is, as one variable increases, the other decline on average.

Also, the Time Plots for Exchange Rate, Money Supply and Oil Prices is at the Appendix. It could be seen that all these variables increases over time though oil prices appears to have sustained fluctuating trends generally increases over the time period.

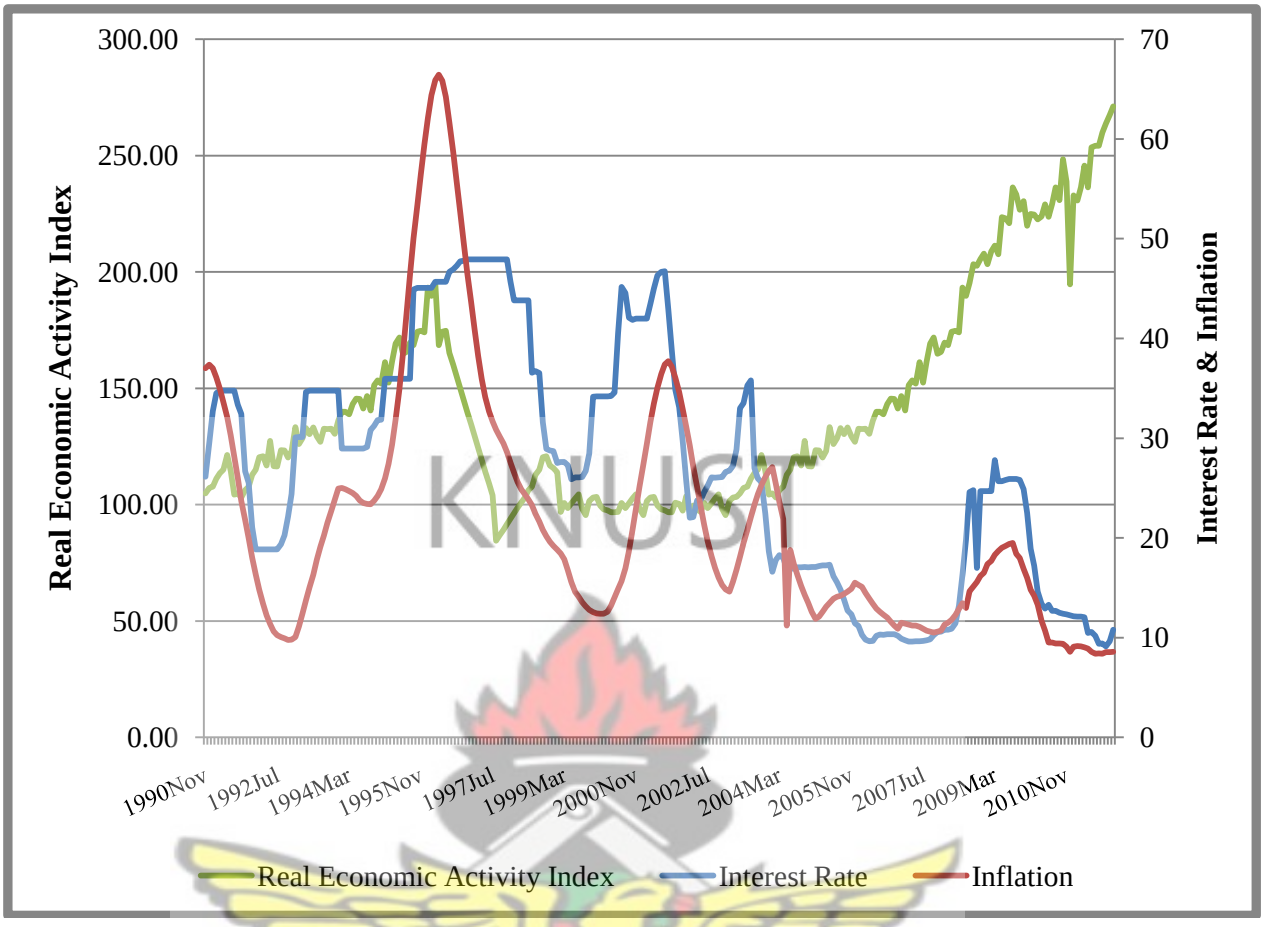


Figure 4.1: Time Plot for Real Economic Activity Index, Interest Rate and Inflation in Ghana for the period November, 1990 to December, 2011.

In sum, the period from October 2003 shows clearly the linkage between real economic activity and the two other series as the periods after this saw a generally upward time plot in real economic activity against the generally downward time plot in interest rate and inflation. Thus, lower inflation and interest rates are likely to be associated with higher real economic activities and vice versa.

Figure 4.1 also relates inflation and interest rate within the same period under consideration. There is an indication that periods of high inflation are accompanied by high interest rates. Contrarily, periods of low inflation are accompanied by periods of low interest rates. This is suggestive of a positive relationship (see Table 4.2) between the two

series. Though, the two series are positively related, inflation seems to exert much inertia than interest rates as its rates follow consistently. Thus, there seems to be some momentum built in inflation which triggers either upward moments or downward movements. The same, however, cannot be said of the interest rate variable which is careens much frequently.

4.3 Proposed Time Series Regression Models

As a precursor to the final estimation, we present five different models including differing variables to give us an idea as to which model will be appropriate. The choice of the correct model will be dependent on the one with the minimum Akaike Information Criterion (AIC). The models thus estimated are specified as follows:

$$Model\ 1:\ \ln real_t = \alpha_0 + \alpha_1 t + \varepsilon_t \tag{4.1}$$

$$Model\ 2:\ \ln real_t = \phi_0 + \phi_1 t + \phi_2 lninf_t + \phi_3 lnexrate_t + \varepsilon_t \tag{4.2}$$

$$Model\ 3:\ lnreal_t = \gamma_0 + \gamma_1 t + \gamma_2 lninf_t + \gamma_3 lnintr_t + \gamma_4 lnexrate_t + \gamma_5 lnm2_t + \gamma_6 lnoilp_t + \varepsilon_t \tag{4.3}$$

$$Model\ 4:\ lnreal_t = \delta_0 + \delta_1 t + \delta_2 lninf_t + \delta_3 lnexrate_t + \delta_4 lnoilp_t + \varepsilon_t \tag{4.4}$$

$$Model\ 5:\ lnreal_t = \theta_0 + \theta_1 t + \theta_2 lninf_t + \theta_3 lnexrate_t + \theta_4 lnm2_t + \varepsilon_t \tag{4.5}$$

The estimated results based on the above proposed models are presented in Table 4.3 with their relevant statistics as well as the Akaike Information Criterion.

Table 4.3: OLS Estimation Results for the Candidate Models

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	4.642***	1.727***	1.157**	1.715***	1.858***
	(0.031)	(0.147)	(0.521)	(0.153)	(0.479)
Time	0.002***	0.014***	0.014***	0.013***	0.014***
	(0.0002)	(0.0005)	(0.003)	(0.0008)	(0.003)
lnexrate		-0.668***	-0.696***	-0.662***	-0.661***
		(0.030)	(0.039)	(0.035)	(0.037)
lnintr			0.141***		
			(0.035)		
lninf		0.272***	0.212***	0.2720***	0.274***
		(0.024)	(0.030)	(0.024)	(0.026)
lnm2			0.007		-0.036
			(0.127)		(0.126)
lnoilp			0.054	0.011	
			(0.038)	(0.036)	
Adj R^2	0.279	0.761	0.773	0.760	0.760

Note: *** and ** denote significance at 1% and 5% levels respectively.

Table 4.4: Summary of the Candidate Models

Regressor	Adj. R^2	AIC
Model 1	0.279	15.813
Model 2	0.761	-262.328
Model 3	0.773	-272.359
Model 4	0.760	-260.416
Model 5	0.760	-260.412

The estimation results presented in Table 4.3 illustrate each model in each column. The dependent variable in all the models is the logarithm of real economic activity. In Model 1, the coefficient of time indicates that, real economic activity approximately grows significantly by 0.002 percent per month on average. The result is consistent across all the models as real economic activity grows positively over time and significantly. Exchange rate also shows consistently significant negative effect on real economic activity across all the candidate models. Additionally, inflation has the surprising sign of positive and is consistent across the candidate models and interest rate also has a surprising positive sign and significant in Model 3.

As stated earlier, the choice of the best model is based on the Akaike Information Criterion (AIC), see Table 4.4. Consequently, model 3 is the chosen model for this study since it has the minimum AIC compared to the others. The choice of this model is also not inconsistent as interest rate appears to be an important explanatory variable in the real sector of the economy. Incidentally, introducing interest rate in Model 3 has rendered it the best model. It must be emphasized, however, that the estimations in Table 4.3 are not to be given

absolute relevance since the variables at their levels are potentially non-stationary. This was done to give primary information as to which variables are appropriate to be included in the model in the final estimation.

The error for this best model (Model 3) based on the minimum AIC was normally distributed (See Figure A2: Error is Normally Distributed in the Appendix).

4.4 Unit Root Test Results

In establish that there exists long run relationship amongst the variables, and to avert false regression, the order of integration of each of the variables is inspected using the Augmented Dickey-Fuller (ADF) unit root tests. Before performing these tests, an informal inspection of the trends in the logarithmic levels and differences is done (see appendix). The plot of each of the series indicates that the variables are non-stationary at their logarithmic levels. However, the first differences indicate that the variables are stationary. Though, the time plot examination provides some insights into the order of integration of the variables, a formal test is appropriate.

Table 4.5: Augmented Dickey-Fuller Unit Root Test

	Level			First Difference	
Variable	Constant No Trend	Constant Trend	**Variable**	Constant No Trend	Constant Trend
lnreal	-0.102	-0.829	Δ*lnreal*	-3.389**	-3.647**
lnexrate	-2.778*	-1.435	Δ*lnexrate*	-3.161**	-3.838**
lnintr	-1.161	-2.861	Δ*lnintr*	-4.464***	-4.590***
lninf	-1.195	-2.402	Δ*lninf*	-4.398***	-4.512***
lnm2	-1.553	-3.284*	Δ*lnm2*	-2.914**	-3.159*
lnoilp	0.072	-2.424	Δ*lnoilp*	-5.114***	-5.232***

The null hypothesis is that the series is non-stationary, or contains a unit root. The rejection of the null hypothesis based on the MacKinnon critical values. *, ** and *** indicate the rejection of the null hypothesis at 10%, 5% and 1% significance level, respectively.

Thus Table 4.5 presents the results of the unit root testing using the ADF tests. The results indicate that, each of the series is integrated of order one (that is, each series is I(1)), and thus contain unit root. The results of the unit root test corroborate the graphical test that all the series are nonstationary at their levels. It is relevant to stress that, achieving stationarity is a precondition for the estimating our VAR model and consequently cointegration analysis.

4.5 Cointegration Test Results

This study accounted for potential influences of important exogenous factors. Consequently, we incorporate in the model oil price to capture the influence of external shocks or supply shocks.[4] Thus, a general-to-specific modeling approach (Charemza and Deadman, 1997) led to the selection of a VAR model of order 2 (that is, VAR(2)).[5] Table 4.6 indicates that, the optimal lag to be used in the VAR is 2 according to the AIC criteria. These criteria are appropriate to use particular because we have large sample data. The results of the VAR model are presented in Table A1 (see appendix). Our main interest is not to interpret the coefficients in the VAR but to use it as a basis to estimate the cointegrating relationship between real economic activity and its covariates. As a consequence, we perform a battery of diagnostics on the estimated VAR model of serial correlation, stability and normality of the residuals.

Table 4.6: VAR Lag Order Selection Criteria

Lag	AIC	SBIC
0	-17.213	-17.073
1	-17.715	17.223*
2	-17.813*	-16.970

* indicates lag order selected by the criterion (each test at 5% level of significance); AIC: Akaike information criterion; SBIC: Schwarz information criterion.

[4] Ghana, prior to drilling and exporting oil in commercial quantities was a net importer of crude oil, it had no influence on the oil price. Thus, using oil price as an exogenous factor is an innocuous assumption.
[5] Table 4.6 indicates the VAR lag order selection criteria and the optimal lag chosen in this study is 2 based on the AIC.

The results of these diagnostics are also presented in the appendix. The results indicate that, the VAR(2) model estimated does not suffer from serial correlation and the residuals are normally distributed. Also since the eigenvalues are found in the unit circle, the VAR is said to be stable. Consequently, we can proceed to test for the cointegrating ranks of using 2 lags in the VAR and subsequently one lag in the vector error correction (VEC) model.

The results of the cointegration test are presented in Table 4.7. At the 5% level of significance, the Trace test statistic of the Johansen cointegration test indicates there is one cointegrating relationship whilst the Maximum Eigenvalue test statistic indicates there is no cointegrating relationship among the variables. We rely on the results of the Trace test and conclude that at least there exist a stable long run relationship between real economic activities and the other determinants. This further repeats the fact that the selected macroeconomic variables have some directional explanation of the long run movements in the real economic activity. The cointegrating vector (CV) reflecting real economic activity was normalized on logarithmic of real sector activity index (*lnreal*).

In the notation of Granger's Representation Theorem, and with reference to the arrangement of the variables in the vector of endogenous variables Y = (*lnreal, lnintr, lninf, lnexrate, lnm2*)[1], the β matrix containing the cointegrating vectors can be written as:

$$\beta' = \left(\beta_{11}\ \beta_{12}\ \beta_{13}\ \beta_{14}\ \beta_{15}\ \beta_{16}\right)'$$

Table 4.7: Johansen Cointegration Results

Eigenvalue	Null Hypothesis	Maximum Eigenvalue ($\lambda_{\max}$)		Trace Test (λ_{trace})	
		Test Statistics	5% CV	Test Statistics	5% CV
	$r = 0$	44.2781	36.41	93.7320	77.74
0.16114	$r \leq 1$	21.3257	30.33	49.4539*	54.64
0.08114	$r \leq 2$	15.8518	23.78	28.1282	34.55
0.06097	$r \leq 3$	11.8730	16.87	12.2764	18.17
0.04602	$r \leq 4$	0.4034	3.74	0.4034	3.74
0.00160	$r \leq 5$				

4.6 Long Run Results

Normalizing on the logs of real activity (*lnreal*), the cointegrating (long-run) relationship was estimated to be:

Table 4.8: Long Run Relationship Results

Variable	Coefficient	Standard Error	Prob. Value
Constant	-4.897		
lnintr	0.368	0.109	0.001***
lninf	-0.582	0.090	<0.001***
lnexrate	0.849	0.111	<0.001***
lnm2	0.635	0.369	0.085*
lnoilp	0.490	0.115	<0.001***
trend	-0.036		

* and *** represent significance levels at the 10% and 1% levels respectively.

Thus the model for the long run will be modeled as follows:

$$lnreal = -4.897 + 0.368lnintr - 0.582lninf + 0.849lnexrate + 0.635lnm2 + 0.490lnoilp - 0.036Trend$$

The results indicate that all the coefficients are statistically significant at 1 percent with the exception of the coefficients on money supply which is significant at 10 percent. The long run equation indicates that, inflation has a deleterious effect on real economic activity as anticipated. Specifically, the results indicate that a percentage point increase in inflation will cause a 0.582 reduction in real growth in economic activity, other things equal. Thus, inflation retards the efficient allocation of resources obscuring the signaling role of relative price changes. Our results agree with the findings of Fisher (1993) who found negative associations between inflation and growth in panel regression for a large set of countries. The results also concurs with Barro (1995) who found a robust evidence that inflation rate has a pernicious effect on the growth rate of real activities for 100 countries over the period 1960 to 1969.

The long run results further indicate that, interest rates are associated positively with real economic activities. Thus, an increase in interest rate is expected to increase growth in real economic activity, ceteris paribus. This is not in accordance with theoretical expectation as higher rates of interest are disincentive to investment, particularly in low-yielding projects (Shaw, 1973). As a matter of fact, we test this within the framework of the vector error correction model for which we treat all these variables as endogenous. Moreover, we find the Granger causality between these variables of interest to confirm or refute this result.

The long run relationship also indicates a positive effect of exchange rate on real economic activity. Thus, the results specifically indicate that a depreciation of the Ghana cedi by 1

percentage point will promote real activities by 0.85 percent approximately. The result is somewhat in accordance with some theoretical arguments, as depreciation of the local currency would mean goods and services produced in Ghana will be cheaper for foreigners and hence increase their propensity to buy more of Ghanaian goods. As a consequence real activity is been promoted due to the depreciation of the currency.

In addition, the long run relationship indicates that money supply has a positive effect on real economic activity, although not statistically significant. The exogenous factor considered in this study, oil price, has a significant positive effect on real activity (see Table 4.8). This is not in conformity with the theoretical expectation as crude oil prices almost affect every sector of the economy. Increases in crude prices, automatically cause prices of most goods and services to increase.

4.7 The Error Correction Models (or Short-Run Relations)

The existence of unique cointegrating vectors implies that an error correction model can be estimated to investigate the short-run dynamic relationship. The vector error correction models (VECMs) are reported in Table 4.9. The negative signs of the coefficients of the error terms $ecm1_{t-1}$, of the real economic activity equations are in accordance with a priori expectations and indicate that the model is dynamically stable, that is, the model's deviation from the long run relationship is corrected by increase in real economic activity. The magnitudes, however, suggest for instance that about 2% of the imbalance in real economic activity is corrected every month. This suggests that the speed of adjustment is very slow. Concerning the interest rate equation, the error correction term indicates that

approximately 0.4% of shocks in interest rate will be corrected every year. However, regarding inflation, approximately 14% of such imbalances will be restored every month.

The short run results also indicate that, none of the variables significantly influence the activities in the real sector. Though, the coefficient of determination is low, the frequent statistical insignificance of the coefficients is suggest of multicollinearity amongst the variables.[6] The only significant variable in the real economic activity equation is the lagged value of real economic activity. This is indicative of the fact that, past economic activities potentially affect current activities positively. This could cast doubt on the fact that, actually inflation and interest rates cause real economic activities.[7]

Considering interest rate as the dependent variable, it appears inflation increases interest rate significantly. The upshot of this result is that, in the short run, an increase in interest rate will be inflationary which consequently leads to a fall in economic activities, particularly in the long run. Furthermore, the results show that consistently, oil price which is the exogenous variable in the model has insignificant negative effect on all the endogenous variables with the exception of exchange rate. An immediate corollary is that, though high crude oil prices are detrimental on most economic variables, the effect is not that significant. Perhaps other factors in combination with the crude oil prices could generate significant effects.

[6] A casual inspection of the correlation matrix of the variables is in order to ascertain mildly the multicollinearity problem. This is presented in Table 4.2 in the preceding sections.
[7] This assertion is tested formally using Granger-Causality test in latter sections.

Table 4.9: The Error Correction Models

Regressor	Dependent Variable				
	$\Delta lnreal$	$\Delta lnintr$	$\Delta lninf$	$\Delta lnexrate$	$\Delta lnm2$
$ect(-1)$	-0.017	0.038	0.154***	0.003	0.008
	(0.014)	(0.024)	(0.023)	(0.006)	(0.010)
$\Delta lnreal_{t-1}$	-0.175***	-0.044	-0.013	-0.011	0.037
	(0.064)	(0.102)	(0.098)	(0.026)	(0.042)
$\Delta lnintr_{t-1}$	0.011	0.185***	0.006	0.018	0.040
	(0.040)	(0.065)	(0.062)	(0.016)	(0.027)
$\Delta lninf_{t-1}$	0.044	0.021	0.041	0.009	-0.042
	(0.039)	(0.063)	(0.061)	(0.017)	(0.026)
$\Delta lnexrate_{t-1}$	0.133	0.474**	0.098	0.551***	0.153*
	(0.136)	(0.218)	(0.208)	(0.056)	(0.089)
$\Delta lnm2_{t-1}$	-0.077	-0.366**	-0.093	0.067*	0.034
	(0.098)	(0.157)	(0.150)	(0.040)	(0.065)
$\Delta lnoilp_{t-1}$	-0.020	-0.017	-0.037	0.002	-0.025
	(0.035)	(0.056)	(0.053)	(0.014)	(0.023)
Constant	-0.003	-0.002	-0.012	0.010***	0.021***
	(0.007)	(0.011)	(0.011)	(0.003)	(0.005)
Trend	0.0001	0.00001	0.00004	-0.00004**	0.00001
	(0.00004)	(0.0001)	(0.0001)	(0.00002)	(0.005)
R^2	0.059	0.125	0.225	0.594	0.468

Notes: Values in parentheses are standard errors. *, **, and *** represent significance levels at the 10%, 5% and 1% levels respectively.

4.8 Granger Causality Analysis

The existence of a cointegrating relationship among real economic activity and the other variables suggests that there must be Granger causality in at least one direction. As a consequence, the bivariate Granger causality tests were conducted to find out the direction of causality and possible feedback amongst the variables which are presented in Table 4.10. The results indicate that interest rate Granger causes real economic activity. Thus past interest rates can be used to predict future real activities. However, past real economic activities cannot be used to predict future interest rates according to the results. Thus, there is a unidirectional causality running from interest rate to real activity. The results further show that, inflation and real economic activity have a unidirectional causality between them. Specifically, inflation Granger causes economic activities but not the reverse. Concerning interest rate and inflation, there is bidirectional causality between them. Thus, the past values of each variable can be used to predict the other. Thus, a clear picture is created regarding the nexus between inflation, interest rate and real economic activity. There is an obvious indication that, inflation and interest rate are key in determining the activities pertaining in the real sector of the Ghanaian economy. These variables are sensitive and hence affect every sector of the economy. The reverse is not the case as real sector growth does not affect both inflation and interest rate. It is therefore not surprising that interest rate and inflation are causing each other significantly and consequently on real economy.

Table 4.10: Summary Results of the Granger Causality Test

Variables	Direction of Causality	χ^2	Prob. Value	Inference
lnreal (Y); *lnintr* (X)	X→Y	9.045**	0.021	Reject
lnintr (Y); *lnreal* (X)	X→Y	6.367	0.832	Do not reject
lnreal (Y); *lninf* (X)	X→Y	7.5733**	0.024	Reject
lninf (Y); *lnreal* (X)	X→Y	0.47923	0.787	Do not reject
lnintr (Y); *lninf* (X)	X→Y	15.445***	0.000	Reject
lninf (Y); *lnintr* (X)	X→Y	14.1624***	0.001	Reject
lnreal (Y); *lnexrate* (X)	X→Y	1.7637	0.414	Do not reject
lnexrate (Y); *lnreal* (X)	X→Y	3.8029	0.149	Do not reject
lnreal (Y); *lnm2* (X)	X→Y	2.3872	0.303	Do not reject
lnm2 (Y); *lnreal* (X)	X→Y	4.3728	0.112	Do not reject
lnexrate (Y); *lnintr* (X)	X→Y	2.1036	0.349	Do not reject
lnintr (Y); *lnexrate* (X)	X→Y	7.628**	0.022	Reject
lnm2 (Y); *lninf* (X)	X→Y	1.6625	0.435	Do not reject
lninf (Y); *lnm2* (X)	X→Y	0.48163	0.786	Do not reject
lnintr (Y); *lnm2* (X)	X→Y	5.9325*	0.051	Reject
lninf (Y); *lnexrate* (X)	X→Y	2.5827	0.275	Do not reject
lnm2 (Y); *lnintr*(X)	X→Y	16.377***	0.000	Reject

Note: Null hypothesis: X↛Y (X does not Granger Cause Y); ***, **, * denotes rejection of null hypothesis at 1%, 5% and 10% significance levels respectively. → implies direction of causality.

4.9 Impulse Response Functions

The impulse response function of VAR is to analyze the dynamic effects of the system when the model received the impulse. We plot the orthogonal impulse responses from real

economic activity following shocks from interest rates, inflation, exchange rate and oil prices. The plots are illustrated in Figure 4.2 and in each of the figure, the first variable is the impulse and the second variable is the response.

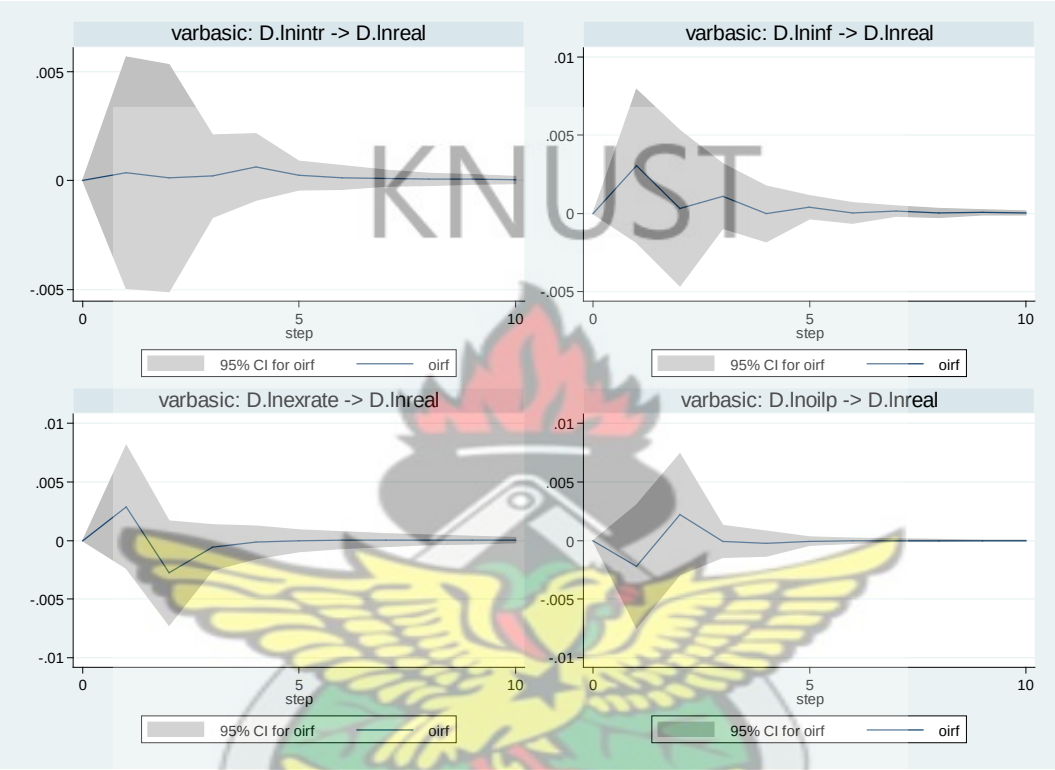


Figure 4.2: Orthogonalised Impulse Response Functions

The figure 4.2 indicates that when the impulse is inflation, then every response of real sector activity is all positive at each responsive time period, but fluctuates. After the first month, following the shock, real activity responds positively and then after falls and remains positively until all the shocks die out. The response to the shocks from inflation is not stable as they wander about for the first month before it finally settles. Unsurprisingly, impulses from oil prices affects real economic activities negatively a month following the shock after which the response turns positive and dies out by the third month. Impulses

from exchange rates also seem to have a similar pattern as shocks die out after few months. Responses from interest rates impulses are mild and hence remain quite low and stable until all the shocks are accommodated. Exchange rate shocks are contemporaneous deleterious to real economic activities after which the reaction becomes positive and subsequently dies away gradually. Real economic activity responds to shocks from exchange rate in the similar manner as that of inflation. Shocks die away by the fourth month as the reactions hover in a dampening manner.

CHAPTER FIVE

SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.0 Introduction

This chapter is divided into three sections. The first section looks at the summary of the primary empirical findings of the study. The second section concentrates on providing some policy implications of the results as well as providing some recommendations to help boost the real sector of the economy. The final section concludes the study.

5.1 Summary of Major Findings

The present study has sought to empirically investigate the relationship between real economic activity, inflation and interest rate in Ghana for the period November 1990 to December 2011. The empirical findings of the study analyzed in the preceding chapter are summarized below:

There are variations in the raw data because all of them have different units of measure. In order to bring stability and uniformity, all the data was transformed to a log data using the natural logarithm (*ln*). It was evident that the transformation brought consistency in the data used for the analysis.

The time plots of the various variables indicates that all the series have trend in them and hence nonstationary. In particular, the plots of the main variables under consideration indicate a mixed relationship between them. Specifically, real activity is somewhat negatively related to inflation and interest rate. Also inflation and interest rate are positively related according to the time series data.

The candidate models indicate that, the model including interest rate is appropriate. In all the models, the trend coefficient is positive and significant which further repeats the nonstationary nature of real economic activity in particular. Model 3 had the lowest Akaike Information Criterion (AIC) and provided the basis for using the variables in that model for the main empirical strategy used in the study.

Furthermore, the unit root results formally confirmed the earlier conclusion that the series are nonstationary at their level using the ADF unit root test. However, all the series are stationary after their first difference.

We can also attest to the fact that, though the series are nonstationary at their levels, a linear combination of them achieved stationarity. Hence, the Trace cointegration test indicates that, there is at least one cointegrating relationship existing among real activity and its covariates. Thus, there exists a long run relationship between the variables.

Having achieved cointegration amongst the variables, we estimated the long and short run relationship existing among the variables. The long run results indicated that, inflation is detrimental to real sector growth as increase in inflation reduces real sector growth by approximately 0.58 percent. Interest rate however, improves real sector growth in the economy with the sample period. This contradicts theoretical expectation as low interest rates boosts investment by encouraging borrowing. Consequently, higher interest rates are harmful to the economy.

The short run results reversed the sign of inflation and its statistical significant but interest rate maintained its sign as the long run. Thus, in the short run, inflation does not significantly affect real sector activity. Nonetheless, inflation significantly decreases interest rates according to the short run results. The short run results further indicates that the error correction terms are in accordance with expectation in terms of signs, magnitude and significance. The coefficients are suggestive of the slow adjustment mechanism following a shock to the system.

The Granger causality test which apparently relates the variables as to which is the main causal variable reveal that, interest rate and inflation are bi-causal. Thus, the two variables can each be used as a predictor of the other. Also, inflation and interest rate individually Granger causes real economic activity but the reverse is not true. Consequently, past values of inflation and interest rates can be used to predict the present values of real activities. Real activity does not Granger cause each of these variables implying that it cannot be a good predictor of the other variables.

Finally, the results obtained empirically indicate that shocks to real economy activities are accommodated within the shortest possible time. Specifically, shocks from inflation and exchange rate hover in a dampening manner before they settle whereas impulses from interest rates are absorbed quite swiftly by real economic activities.

5.2 Conclusion

The results show that there exists a unique long-run relationship between real activity and the other variables. Accordingly, inflation is identified as important determinant of real economic activity growth in Ghana. Conversely, real economic activity was found not to significantly determine inflation and interest rate within the period under investigation. The relationship between inflation and interest rate is, however, significant determined positive in either direction. This implies that the connection between inflation, interest rate and economic activity is not immediately automatic.

5.3 Policy Implication and Recommendations

The policy implication is that the real sector is quite responsive to specifically inflation and interest rate. Consequently, predicting changes in the real sector by the macroeconomic factors generally might be quite dubious. Nonetheless, regarding inflation, the predictive ability is actually in order. Policy direction consequent upon the empirical results is to sensitize the central bank to carefully define the monetary policies which affect the interest rate determination which also affect the inflation rates in the country. The results suggest the need to critically look at the prime rate and consequently interest

rate to help streamline the investment patterns of the economy although according to the study period the interest rate does not affect real activity. Again, inflation needs to be also looked at since it has a significantly relationship with interest rates.

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Appendix

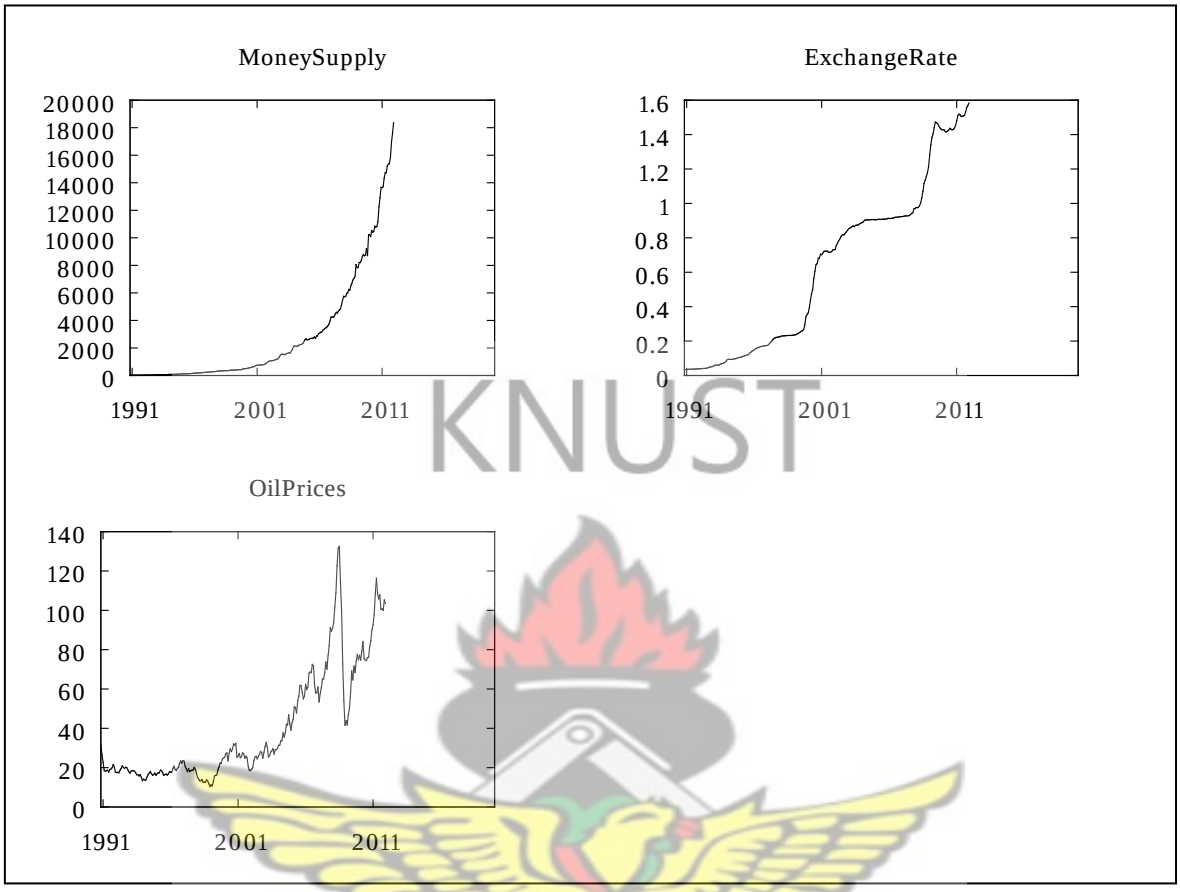

Figure A1: Time Plot for Exchange Rate, Money Supply and Oil Prices in Ghana for the Period November, 1990 to December, 2011

Table A1: VAR(2) Estimation Results

	Dependent Variables				
	$\Delta lnreal$	$\Delta lnintr$	$\Delta lninf$	$\Delta lnexrate$	$\Delta lnm2$
$\Delta lnreal_{t-1}$	-0.186***	-0.036	0.052	-0.024	0.052
	(0.063)	(0.101)	(0.096)	(0.026)	(0.04)
$\Delta lnreal_{t-2}$	-0.044	-0.056	0.051	-0.048	(0.074)
	(0.064)	(0.101)	(0.097)	(0.026)	(.040)
$\Delta lnintr_{t-1}$	-0.007	0.171***	0.065	0.013	(0.07)
	(0.040)	(0.064)	(0.061)	(0.016)	(0.025)
$\Delta lnintr_{t-2}$	0.006	0.10	0.092	0.017	-0.087**
	(0.040)	(0.064)	(0.061)	(0.016)	(0.025)
$\Delta lninf_{t-1}$	0.046	.039	0.066	0.007	-0.028
	(.038)	(0.061)	(0.058)	(0.016)	(0.024)
$\Delta lninf_{t-2}$	0.009	0.006	0.348***	0.007	0.017
	(0.038)	(.061)	(0.058)	(0.016)	(0.024)
$\Delta lnexrate_{t-1}$	0.169	0.554**	0.158	0.54***	0.271***
	(0.154)	(0.246)	(0.235)	(0.063)	(0.097)
$\Delta lnexrate_{t-2}$	-0.191	0.013	0.195	0.09	-0.144
	(0.154)	(0.246)	(0.235)	(0.063)	(0.097)
$\Delta lnm2_{t-1}$	-0.068	-0.345**	0.057	0.062	0.075
	(0.096)	(0.154)	(0.147)	(0.039)	(0.061)
$\Delta lnm2_{t-2}$	-0.131	-0.134	0.083	-0.064	0.073
	(0.097)	(0.154)	(0.148)	(0.039)	(0.061)
$\Delta lnoilp_{t-1}$	0.00005	0.001	-0.098*	-0.016	-0.033
	(0.034)	(0.055)	(0.052)	(0.14)	(0.022)
Constant	0.0102**	0.0009	-0.011	0.006***	0.020***
	(0.005)	(0.007)	(0.007)	(0.002)	(0.003)
RMSE	.043971	.07013	.067062	.017919	.027794
R^2	0.0506	0.1235	0.2285	0.4264	0.1251
χ^2	13.38983	35.35871	74.3608	186.5832	35.90281
	[0.2686]	[0.0002]	[0.0000]	[0.0000]	[0.0002]

** and *** indicate significance at 5% and 10% levels respectively

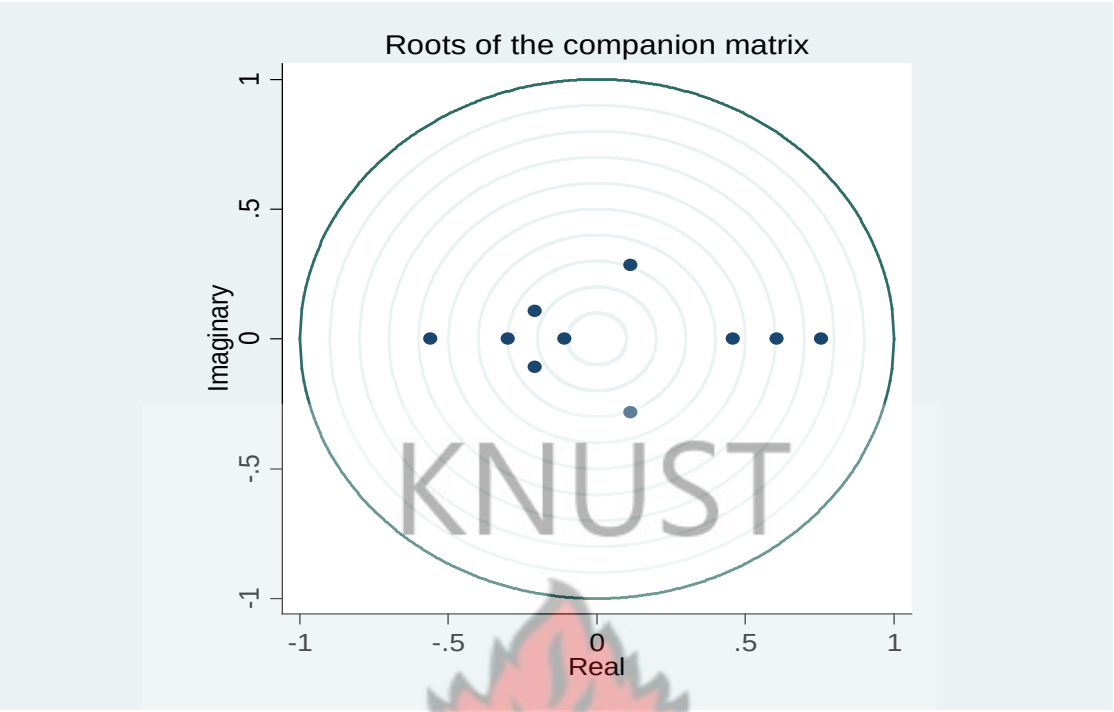

Figure A2: Stability Condition of the Estimated VAR Model

Table A.2 Summary Statistics of the Raw Data

Variable	Obs	Mean	Std. Dev.	Min	Max
real	254	142.161	45.588	84.55	271.21
exrate	254	0.628	0.487	0.0344	1.584
inf	254	21.801	12.691	8.39	66.436
intr	254	27.047	12.108	9.14	47.928
m2	254	2881.322	4153.905	28.392	18366.99
oilp	254	39.618	28.906	10.41	132.55

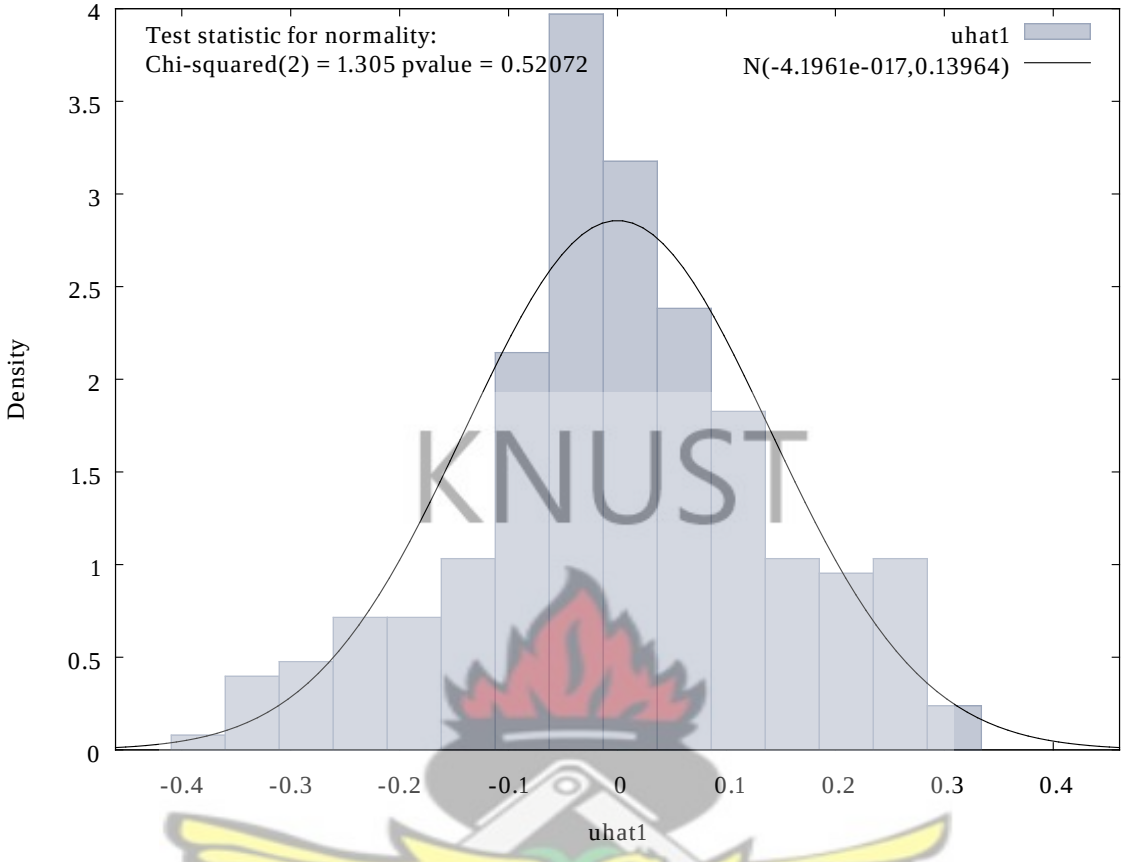

Figure A3: Error is Normally Distributed (Based on the best Model/ Model 3)