UNIVERSITY OF KWAZULU-NATAL

MONETARY POLICY SHOCKS AND INDUSTRIAL PRODUCTION IN BRICS COUNTRIES

By

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DECLARATION

I, Adebayo Augustine Kutu, declare that

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DEDICATION

To my lovely mother, Mary Kutu

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ABSTRACT

This study investigates monetary policy shocks and industrial production in BRICS countries. The study is presented in four separate but related essays. The first (chapter three) employs a Panel Structural Vector Autoregressive model ($P{-}SVAR$) to investigate how monetary policy shocks affect industrial output in BRICS countries using monthly data for the period 1994:1 to 2013:12. A nine variable $P{-}SVAR$ with short-run restrictions among the variables is constructed for the analysis. The study finds that variations in the exchange rate have the largest impact on industrial output in the BRICS countries. It is also observed that inflation rates significantly increase industrial output, peaking after about 11 months. This suggests that monetary authorities should be cautious when formulating policies aimed at reducing the inflation rate because of the spill over effect on industrial output. Further analysis reveals that interest rates have a marginal effect on exchange rates, while money supply makes a relatively large contribution to exchange rate fluctuations. Again, it is observed that changes in money supply exert a very large impact on variations in the rate of inflation. Thus, money supply plays an important role in curbing inflation. The study also analyses variations in interest rates, money supply and inflation and recommends that monetary authorities in the BRICS countries adjust interest rates, and not money supply, in response to inflation expectations.

The second essay (chapter four) models exchange rate behaviour in the BRICS countries. This study examines global shocks and variations in the BRICS countries local currency/United States dollar exchange rate using the symmetric Generalized Autoregressive Conditional Heteroscedasticity (GARCH), Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) and Asymmetric Power Autoregressive Conditional Heteroscedasticity (APARCH) models to determine the relationship between the two. The GARCH, EGARCH and APARCH are employed under normal (Normal Gaussian) and non-normal (Student's t and Generalized Error) distributions. Using monthly exchange rate data covering the period $1994{:}\,01 - 2013{:}\,12$, the study finds that exchange rates in Brazil, Russia and India can well be modelled by the symmetric GARCH (1,1) model while in China, the three models perform well. In South Africa, the results of the three models also perform well but the EGARCH (1,1) model is found to be the best. Further analyses of the models reveal that the Student's t distribution produces better fit for estimating exchange rate variations and global

shocks in BRICS countries compared to the Normal Gaussian and GED values under the non-normal distributions. Overall, the study recommends that the BRICS countries should consider the impact of oil prices and global interest rates when formulating and implementing policies that impact on exchange rates.

The third essay (chapter five) examines whether the five BRICS countries share similar business cycles and determines the probability of any of the countries moving from a contractionary regime to an expansionary regime. The study further examines the extent to which changes in monetary policy affect industrial output in expansions relative to contractions. Employing the Peersman and Smets (2001) Markov-Switching Model (MSM) and monthly data from 1994:01 – 2013:12, the study reveals that the five BRICS countries have similar business cycles. The results further demonstrate that the BRICS countries' business cycles are characterized by two distinct growth rate phases: a contractionary regime and an expansionary regime. It is observed that area-wide monetary policy has significantly large effects on industrial output in recessions as well as in booms. It is also established that there is a high probability of moving from state 1 (recession) to state 2 (expansion) and that on average, the probabilities of staying in state 2 (expansion) are high for each of the five countries. It is, therefore, recommended that the BRICS countries should sustain uniform policy consistency (monetary policy), especially as they formulate and implement economic policies to stimulate industrial output.

The fourth essay (chapter six) investigates the long run and short run dynamics between industrial production and the factors affecting production in the emerging market economies of BRICS countries. Using the Chudik and Pesaran (2013) P-ARDL model and monthly data from 1994:01 – 2013:12, the study finds evidence of a cointegrating relationship between industrial production and selected variables. It is further observed that capital, labour, per capita income and exports have a positive long run impact on industrial production in the BRICS countries. However, a currency appreciation (an increase in the exchange rate) has a negative impact on industrial production. In the short run, it is found that imports, exports, exchange rates, labour, capital and per capita income significantly affect industrial production. The policy implication stemming from the analysis is that a sound economic policy is important for output production and industrialization in BRICS countries while poor policy will result in a nexus of constraints from which escape may be difficult (or impossible). The industrial sector, therefore, should also be listed as a sector that can actualize the diversification process and boost economic performance in the EMEs. There should also be policy consistence in curtailing the declining trend of industrial production.

ABBREVIATIONS

ANC	African National Congress
ADF	Augmented Dickey Fuller
AIC	Akaike Information Criteria
APARCH	Asymmetric Power Autoregressive Conditional Heteroscedasticity
APF	Aggregate Production Function
BIC	Bayesian Information Criterion
BRICS	Brazil, Russia, India, China and South Africa
BSC	Brazilian Securities Commission
CBI	Central Bank of India
COSATU	Congress of South African Trade Unions
CPI	Consumer Price Index
CRR	Capital Requirement Ratio
CRR	Cash Requirement Ratio
DF	Dickey Fuller
DSGE	Dynamic Stochastic General Equilibrium
DTI	Department of Trade and Industry
ECB	European Central Bank
ECM	Error Correction Model
EGARCH	Exponential Generalized Autoregressive Conditional Heteroscedasticity
EMEs	Emerging Market Economies
EMU	European Monetary Union
ESKOM	Electricity Supply Commission
EX	Exchange Rate
EXP	Exports
FAVAR	Factor Augmented Vector Autoregressive
FDI	Foreign Direct Investment
FEVD	Forecast Error Variance Decomposition
FFR	Federal Funds Rate
FMI	Financial Market Infrastructure
FPE	Final Prediction Error

FSSS	Federal State Statistics Service
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GED	Generalized Error Distribution
GNI	Gross National Income
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
HQ	Hannan-Quinn Criteria
IBGE	Brazilian Institute of Geography and Statistics
IIP	Index of Industrial Production
ILO	International Labour Organization
IMF	International Monetary Fund
IMP	Imports
IN	Interest Rates
IP	Industrial Production
IPAP	Industrial Policy Action Plan
K	Capital
KY	Per-capita Income
L	Labour
LERMS	Liberalized Exchange Rate Market System
LR	Lag Residual
MDGs	Millennium Development Goals
MOSPI	Ministry of Statistics and Programmes Implementation
MPC	Monetary Policy Committee
MSM	Markov-Switching Model
NBSC	National Bureau of Statistics of China
NDP	National Development Plan
NFS	National Financial System
NGP	New Growth Path

NIPF	National Industrial Policy Framework
NMC	National Monetary Council
NMCC	National Manufacturing Competitiveness Council
NPP	National Privatization Program
NSSO	National Sample Survey Organization
EXP	Exports
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
OP	Oil Prices
OPI	Oil Price Index
P-ARDL	Panel Autoregressive Distributed Lag
PBC	People's Bank of China
PRC	People's Republic of China
P-SVAR	Panel Structural Vector Autoregressive
RSFSR	Russian Soviet Federative Socialist Republic
SARB	South African Reserve Bank
SC	Schwartz Information Criteria
SLR	Statutory Liquidity Ratio
SMEs	Small and Medium-sized Enterprises
SUMOC	Superintendent of Money and Credit
SVAR	Structural Vector Autoregressive
SVEC	Structural Vector Error Correction
TFP	Total Factor Production
UNDP	United Nations Development Programme
US	United States
USSR	Union of Soviet Socialist Republics
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
WDI	World Development Indicators

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER ONE

BACKGROUND AND INTRODUCTION

1.1 Introduction

The BRICS (an acronym for Brazil, Russia, India, China and South Africa) economies have experienced a steady course towards trade restructuring. This is due to recent global developments where more countries are coming together for regional integration initiatives. Many countries like the United States of America, United Kingdom and Germany have encouraged private capital and portfolio injections to stimulate production and economic growth, a strategy that clearly requires holistic action on the part of policymakers.

In view of the required holistic action, there is no consensus in the literature on whether monetary policy is a more important tool than fiscal policy in stimulating industrial output and achieving economic growth. Some schools of thought believe that the monetary authorities should simply focus on achieving price stability, as they do not have a mandate to help reduce unemployment and stimulate output growth (Brash, 1995). Other schools of thought argue that through policies and programs, the monetary authorities could also stimulate industrial output growth and promote employment (Olivei and Tenreyro, 2007; Mellet, 2011). Against this background, the research question that this study seeks to address is: "Does monetary policy plays an important role in explaining variations in industrial output, prices and real Gross Domestic Product (GDP)? If so, what is the process through which this occurs?" It is upon this basis that we decided to carry out the present study.

1.2 A Brief Overview of the BRICS Countries

The BRICS countries are a group of five large developing economies that are distinguished by their demographic and economic potential that is deemed capable of surpassing the economies of the group of the seven richest countries (G7-Countries, namely Canada, France, Germany, Great Britain, Italy, Japan, and the United States of America) by 2050. The group was created in 2010 with an initial four members (Brazil, Russia, India and China, known as BRIC) as conceived in 2001 by American multinational investment-banking firm, Goldman Sachs. In a meeting in New York on 14 April 2011, the BRIC Foreign Ministers agreed that their scope must expand to Africa and that either Nigeria or South Africa should be invited to join. South Africa was invited to attend the third BRIC Summit in Sanya (Vieira and Alden, 2011) and subsequently joined the group, consequently changing the acronym to BRICS. The aim of these emerging market economies (EMEs) is development, integration and industrialization (Chun, 2014). The group also aims to identify alternative sources of development funds that will increase their trade with one another and diversify their economies towards developing domestic and international markets. According to Indien (2012), the BRICS countries account for around 25% of global GDP, making them a potentially powerful future market grouping.

The resources each country possesses also position them for greater market performance. Brazil has one of the fastest growing agricultural sectors; Russia is the leading producer of oil and gas and it is also one of the biggest producers of military hardware; India is the second leading telecommunications producer; China is the largest producer of manufactured goods; and South Africa is one of the mineral rich countries in the world (gold, diamonds, iron ore, platinum, manganese, chromium, copper, uranium, silver, beryllium, and titanium among others). Taken together, such resources can sustain the infrastructural development required to increase consumer spending, accelerate development and achieve economic growth. The International Monetary Fund (IMF) (2012) estimated that, the BRICS countries would contribute around 56% of global GDP growth in 2012. Table 1.1 shows some of the major economic indicators of the BRICS countries.

The macroeconomic performance described in Table 1.1 translates into different categories of influence that determine the BRICS countries' position in various sectors of the global economy. These indicators have sustained the strong standing and support for global business that has projected the BRICS countries as a successful emerging economic bloc (Kornegay and Bohler-Muller, 2013).

Collectively, the BRICS countries have a large population and domestic markets with growth programs that are higher up on their list of reforms as compared to the Western countries. The current BRICS population is estimated at over three billion (Global Economic Watch, 2013; UNDP, 2014). According to Garth de Klerk (2011), South Africa's inclusion as Africa's representative in BRICS increased the group's global presence; it now represents 46% of the global population and 31.9% of Global Land Mass. The BRICS countries have also opened up their economies without following the full market liberalization policy of John Williamson (the Washington consensus) and have provided something unique in global economic activities.

Table 1.1: BRICS development indicators

Indicators	**Brazil**	**Russia**	**India**	**China**	**South A.**
Population (2013)	200.4mil.	143.5mil	1.252bil.	1.357bil.	52.98mil.
GDP (US $, 2013)	2.246tri.	2.097tri.	1.877tri.	9.24tri.	350.6bil.
GDP per capita (PPP, Current intl. $, 2013)	$11,208.08	$14,611.7	$1,498.87	$6,807.43	$6,617.91
GDP Avg. Annual Growth Rate (1990-2013)	2.5%	1.3%	5%	7.7%	1.9%
Real GDP Projected Avg. Growth Rate (2016-2020)	4%	2%	6.5%	7%	3.8%
Resources Own	Advanced Agriculture Sector	Oil & Gas and military hardware	2nd largest Telecom Producer	Largest Manufacturer	Rich in Mineral Resources
Projected Inflation Rate (2016-2020)	4.8%	5%	6%	3.4%	4.8%
Merchandise Trade (% of GDP, 2010-2014)	*21.2*	*42.9*	*42.1*	47	54.9
Average Annual HDI Growth (%), 2000-2013	0.67	0.64	1.49	0.74	0.36
Labour Force Participation Rate, Female & Male (% Age 15 & Above)	59.5 & 80.9	57 & 71.4	28.8 & 80.9	51.6 & 68	44.2 & 60
Seats in Parliament (% held by Woman), 2013	9.6	12.1	10.9	N.A	41.1

Source: Author's compilation using data from Global Economy Watch, the World Bank, IMF & the UNDP Human Development Report.

Wilson and Purushothaman (2006) predicted that by 2025, the BRICS countries would account for more than half the size of the G6-Countries (France, Germany, Italy, Japan, the United Kingdom and the United States); and in less than 40 years, they would be bigger than the G6-Countries in US dollars. Taken together, BRICS' trade has become relatively dearer over the years as compared to G7 countries. The BRICS countries' GDPs expressed in US dollars is now higher than anyone expected and the bloc has become a global force in international trade (Global Economic Watch, 2013). China is growing faster than envisaged, with the other four countries are moving at the pace that Goldman Sachs predicted in their first long-term projections of the BRIC's economic fate over the next half century. Average projected inflation rates are relatively lower rates for the period 2016 to 2020 as follows: Brazil 4.8%, Russia 5%, India 6%, China 3.4% and South Africa 4.8% (Global Economic Watch).

In terms of trade, BRICS is a natural potential candidate for more extensive market exploration given these countries' dynamism that could contribute to reduced trade disequilibrium based on quantitative and comparative analyses of their resources utilization. The BRICS countries' share of world trade was estimated at 6% in 1997. The trading bloc has sustained relatively stable growth in international trade in the range of 20% to 30% since 2004. This high growth trend has been consistent, with China and India growing faster than the other countries, followed by Russia, South Africa and Brazil (Popa and Carp, 2013).

According to the United Nations Development Programme (UNDP), the Human Development Index (HDI) is a "composite index measuring average achievement in three basic dimensions of human development – a long healthy life, knowledge and a decent standard of living". The 2014 ranking comprises of 187 countries based on estimates for 2013. It shows countries' capabilities in term of economic performance and global business competiveness. Table 1.2 shows the BRICS countries' ranking in terms of the health index, which is life expectancy at birth (that cuts across mortality rate, HIV prevalence, and health expenditure, among others); education, which encompasses the mean years of schooling, adult literacy, and the proportion of the population with at least secondary education, gross tertiary enrolment ratio and expenditure on education; and income, that is, Gross National Income (GNI) per capita and GDP per capita. Gender is the gender inequality index based on participation in the labour force and education. The poverty rate is based on the multidimensional poverty index share of the working poor, below two dollars a day while 'trade' is the trade financial flow (% of GDP) in international trade, foreign direct investment, private capital flow and remittance inflow (% of GDP), among others. The employment ratio is based on indexes for calculating the employment to population ratio (as a percentage of the labour force).

Table 1.2: Human Development Indicators for BRICS countries

HDI (1980-2014)	BRAZIL	RUSSIA	INDIA	CHINA	SOUTH AFRICA
Rank	79	57	135	91	118
Index	0.744	0.778	0.586	0.719	0.658
Health (life expectancy at birth)	73.94	67.98	66.41	75.33	56.92
Education (mean years of schooling)	7.18	11.73	4.43	7.54	9.94
Income (GNI)	14,272.77	22,616.56	5,149.81	11,477.15	11,787.91
Gender inequality	0.441	0.314	0.563	0.202	0.461
Poverty (% of pop.)	3.06	N.A	55.28	5.98	10.31
Trade financial flow (% of GDP)	26.54	51.58	55.36	58.71	59.56
Employment (pop. ratio)	68.4	65	60.8	72.2	48.6

Source: Author's computation using data from the UNDP Human Development Report 24 July 2014.

Finally, in term of politics (one of the development indicators in Table 1.1), the essence is to bring about economic development and poverty alleviation. It further aims to reduce inequality by encouraging women's participation in government. In BRICS countries, women are encouraged to be actively involved in governance irrespective of their color, race, religion or national origins in order to increase the opportunities provided to an underrepresented section of society. Seats in the legislature are also allocated to women. In South Africa, for instance, women occupy 41.1% of the seats in parliament (UNDP report, 2014). It is believed that women are more collaborative and that their style of leadership can be both effective and popular in fast-tracking development.

1.3 Aim and Objectives of the Study

The aim and objective of this study are threefold. They are:

(i) to investigate how monetary policy shocks affect the growth of industrial output in the BRICS countries;

(ii) to investigate the effects of changes in monetary policy on industrial output in the BRICS countries during expansions and contractions; and,

(iii) to investigate the short run and long run dynamics of industrial output in BRICS countries.

These are further grouped under three sub-objectives as highlighted under each of the methodologies.

1.4 Motivation for the Study and Problem Statement

Monetary authorities in the BRICS countries aim at achieving full-employment equilibrium, rapid industrial growth, price stability and external balance. The changes in monetary policy targeted at influencing policy goals are propagated through a transmission process commonly called the monetary policy transmission mechanism (this transmission process is elaborately discussed in chapter three). However, there has been a persistent decline in industrial output and high unemployment rates in BRICS countries. According to Dietzenbacher *et al.* (2013), the total industrial share of BRICS countries' GDP has declined. Aradhna (2014) notes that, while the industrial (manufacturing) share of GDP in India increased slightly from 15% in 2000 to 17% in 2014, in all other members of the group, there is evidence of dis-industrialization. Except for India, industrial activity in these countries measured by industrial/manufacturing value added as a share of GDP declined in 2000 to 2014, from 15.1% to 11% in Brazil, 17% to 14% in Russia, 32% to 30% in China and 19% to 13% in South Africa.

Furthermore, Naudé *et al.* (2013) reveal that the industrial sector's share of employment in the BRICS countries declined from 14.3% in 1980 to 14% in 2008. From 1980 to 2008, it decreased from 12.8% to 12% in Brazil, 17.3% to 13.7% in Russia and 15% to 14.3% in South Africa (Naudé *et al.,* 2013:10) respectively.

In view of the decline trend in industrial production and employment in the BRICS countries, a question that has often been raised in the literature is: "does monetary policy play a significant role in explaining variations in industrial output, prices and real gross domestic product (GDP)?" (Romer and Romer, 1989; Sun, 2013; Cloyne and Hürtgen, 2014, among others). While this has been extensively studied in different groups of countries such as the European Union (Peersman and Smets, 2001; Peersman, 2004; Angeloni *et al*., 2003; Fountas and Papagapitos, 2001), the Organisation of Economic Cooperation and Development (OECD) (Dedola and Lippi, 2000; Britton and Whitley, 1995) and the G-7 (Corsetti *et al*., 2008; Kim and Roubini, 2000) and Europe (Favero *et al*., 1999 and Giuliodori, 2005), the author is not aware of any similar study on BRICS, a group of EMEs with similar interests.

In furtherance to the above, there are also divergent views on the process (transmission mechanism) through which monetary policy is propagated before affecting policy goals. Some empirical studies argue in favour of the traditional Keynesian framework, which holds that the transmission process occurs through interest rates (Smets and Wouters, 2002; Angolani *et al*., 2003; Loayza and Schmidt-Hebbel, 2002; Boivin *et al*., 2010). Ncube and Ndou (2011), Zhensheng (2002), Hall (2001) and Bayangos (2010) support the credit channel of monetary transmission while Adolfson (2001) and Acosta-Ormaechea and Coble (2011) highlighted the exchange rate channel. Kabundi and Ngwenya (2011) show that both the direct and exchange rate channels are important in the monetary policy transmission process, while Mishkin (2001), Elbourne (2008), Disyatat and Vongsinsirikul (2003), Alfaro *et al*. (2003) and Borio and Zhu (2012) reveal that the monetary policy pass-through effects on the real economy occur through asset prices and lending rates. Given these divergent views, it is clear that the nature of the monetary transmission mechanism in the BRICS countries can only be determined empirically. This study, therefore, contributes to the literature by shedding more light on this empirical puzzle/concern. It investigates how industrial output, GDP and prices in BRICS countries respond to monetary policy shocks, and the transmission process using a Panel Structural Vector Autoregressive model ($P{-}SVAR$). This analysis is conducted in Chapter Three.

Empirical evidence shows that variations in exchange rates can cause distortions in the economy and affect industrial output growth. For example, exchange rate volatility (variation) creates uncertainty in macroeconomic policy formulation, investment decisions and trade flows (see for example Arize, Malindretos & Kasibhatla, 2003; Hodge, 2005; Musonda, 2008; Hausmann, 2008; Demir 2010). Consequently, there is a need to model exchange rates for the BRICS countries given that they are exposed to unexpected occurrences on the international market (also known as global shocks). Studies by Belke and Setzer (2003) and Belke and Kaas (2004) indicate that employment decisions have the same characteristics as the behaviour of investment expenditure in the presence of rigidities, indicating that they are branded by some degree of irreversibility (Mpofu, 2013, 2015). As a result, an increase in exchange rate variations is expected to reduce employment growth and industrial production. In the case of the BRICS countries, to what extent are exchange rate variations amidst global shocks responsible for developments in the labour market (the impact on employment and industrial production)? An extensive review of the literature revealed that, to the best of the author's knowledge, no empirical study has modelled exchange rate variations in these countries amidst global shocks. This study, therefore, seeks to fill this knowledge gap. It contributes to the literature on exchange rate variations in EMEs by modelling exchange rate behaviour in the BRICS countries using the symmetric GARCH (1,1), asymmetric EGARCH (1,1) and APARCH (1,1) models. This is carried out in Chapter Four.

Furthermore, this study investigates the relationship between business cycle phases (whether the five BRICS countries share the same business cycles or not) and monetary policy. It also examines the extent to which changes in monetary policy affect industrial output in expansions relative to contractions (booms versus recessions) using the Peersman and Smets (2001) Markov Switching Model (MSM). GDP is used as a business cycle indicator because the cycles are related to aggregate economic activities. Therefore, government and policymakers have an important role to play in business cycles especially in terms of their economic costs (loss of output and high rates of unemployment). While this has been studied in the Euro Area (Peersman and Smets, 2001; Abberger, 2006), OECD (Chauvet and Yu, 2006), and G-7 (Chauvet, 2009; Chauvet and Yu, 2006), no study that we are aware of that has been conducted among BRICS countries to analyse this issue. This study fills this gap and employs the MSM approach to study the relationship between business cycle phases and monetary policy in the BRICS countries. This is the focus of Chapter Five.

Finally, Chapter Six focuses on industrialization (proxied by manufacturing sector contribution to GDP) in the BRICS countries. The rationale for industrializing these countries is rooted in growth theory, evolutionary economics and institutional economics that maintain that manufacturing (industrialization) is important for trade and job creation, and to eliminate poverty and promote economic development (Winters *et al*., 2004; Szirmai, 2012; Naudé and Szirmai, 2012). However, growth in the BRICS countries has been constrained by industrial production (Kedia *et al*., 2006; Schrooten, 2011), thwarting the realization of many goals. This study thus investigates the determinants of industrial production in the BRICS countries; the long run and short run relationship between industrial production and factors affecting production in these countries; and whether the impact of long run factors of production can foster industrial output in the BRICS countries.

A few studies have empirically analysed the nature of industrialization in the BRICS countries (see for, example, Naudé *et al*., 2013; Aradhna, 2014; Aldrighi and Colistete, 2015). Chapter Six complements these studies by providing a more detailed analysis of the determinants of industrial production using a panel ARDL. To the best of my knowledge, no study has been carried out to analyse industrial production in BRICS countries employing the Chudik and Pesaran (2013) Panel ARDL technique. This serves as the study's contribution to knowledge and the literature on the BRICS countries.

1.5 Structure of the Study

This study is organized in seven chapters. Chapter One introduces the study. It sets out the problem statement (motivation for the study), and the study's aims and objectives. Chapter Two reviews the theoretical and empirical literature pertaining to monetary policy shocks and monetary policy regimes in each of the BRICS countries and concludes with an outline of the monetary policy transmission mechanism for the BRICS economies. Chapter Three analyses the effects of monetary policy shocks on industrial production using the P-SVAR methodology. It also constructs a monetary policy transmission mechanism. Chapter Four models exchange rates using the GARCH, EGARCH and APARCH models after the results derived from the P-SVAR analysis find that variations in exchange rates have a large impact through which shocks transmit to other macroeconomic variables and influence industrial output in the BRICS countries. Chapter Five investigates whether the five BRICS countries share the same business cycles. It also determines the effects of changes in monetary policy, in expansions versus contractions, on industrial output, and computes the probability of moving from one regime to another (recession to expansion), as well as investigating how long, on average, a regime lasts. Chapter Six assesses the short run and long run dynamics of industrial production in the BRICS countries using a P-ARDL model; and chapter seven summarizes the findings, makes conclusions and recommendations and identifies areas for further research.

CHAPTER TWO

AN OVERVIEW OF THE BRICS ECONOMIES AND THE MONETARY POLICY REGIME SHIFT

2.1 Introduction

This chapter presents a brief review of the BRICS summits and analyses individual members' Central Banks and how they conduct monetary policy. Each country's policy regime and its specific roles set out in the respective constitutions or central bank charters is analysed to enhance our understanding of the monetary policy transmission mechanism. The dynamics of monetary policy shocks as well as output growth in the countries under study are also examined. This appraisal of concepts and ideas is based on their relevance to the peculiarities of the BRICS economies. The chapter also provides the necessary intellectual platform to link monetary policy and its stimulation of output and prices in the BRICS countries. The focus is on the instruments and policy frameworks of monetary policy and their link with policy targets. The review sheds light on the misconceptions that surround the concept of monetary policy actions and their implications for policy formulation and implementation for economic development and growth.

2.2 The BRICS Summits

As noted earlier, BRIC (Brazil, Russia, India and China) was conceptualised in 2001 by an American multinational investment-banking firm (Goldman Sachs) as part of a plan to reform the bloc in the long term in order to enhance development. Jim O'Neill conceived the concept, which was set out by Goldman Sachs, in their Global Economics Paper No. 66 titled "The World Needs Better Economic BRICs" (O'Neill, 2001). The foreign ministers of BRIC countries held a summit in New York in 2006 to deliberate on the growth trends in each member country. It noted that growth was sluggish in Brazil while Russia seemed not to deserve inclusion in the group and China enjoyed higher economic growth than other members. The meeting was followed by the first BRIC leaders' summit in Yekaterinburg, Russia on 16 June 2009.

Following the 2008 global financial crisis that hit the G7 countries (Canada, France, Germany, Great Britain, Italy, Japan, and the United States of America) hard, the finance ministers and other representatives of BRIC countries held a meeting in Horsham in the United Kingdom on 14 March 2009 to exchange views on the reform of their financial institutions. They strategized on fiscal and monetary policy responses and agreed on stabilization measures to tackle the economic and financial challenges of their emerging economies. At the second BRIC summit held in Brazil in 2010, it was mooted that an African country should be invited to join the bloc in order to expand its scope and lend credence to the claim of speaking for an emerging world. Nigeria and South Africa were considered, and South Africa was subsequently invited to attend the third BRIC Summit in Sanya (Vieira and Alden, 2011). With the country accepted as a member, BRIC expanded to BRICS.

Over the years, there has been extensive debate on whether this grouping of countries is effective. The debate revolves around the striking differences in members' economies and politics and the challenge of curtailing China's drive to control institutions intended to give each partner an equal voice. Other fears and uncertainties include the fear that Africa will be invaded, debate on how to arrive at a compromise during negotiations in the spirit of give and take, how to achieve smooth operations, and the challenges of keeping development on track (Kimenyi and Lewis, 2011). Some analysts have raised doubts that BRICS will make a difference in the wider global scenario.

Nonetheless, the BRICS countries have been able to organize themselves into an economic alliance, thereby converting their growing economic power into increased geopolitical influence and attracting scholarly attention. Their strategic geographical locations have provided a global advantage. Brazil is located in South America, while Russia is one of the largest countries in the world, spreading from northeast Europe across the entire northern width of the Asian continent and sharing borders with 14 other countries. India is located in the south of the Asian continent, China is the world's third largest country after Russia and Canada and is located in Southeast Asia along the coastline of the Pacific Ocean and South Africa is located on the African continent and is one of the most diverse countries in the world.

Nine BRICS summits have been held (see Table 2.1) in order to ensure on-going consultation in the wake of the global economic and financial crisis and, in the process, bringing about elements of an industrial revolution. There have also been meetings of finance/economic ministers, national security advisers, agricultural, trade and industry, foreign, and health ministers, and senior officials representing science and technology as well as BRICS competition conferences and business fora to promote the bloc's aim of "Partnering for integration and industrialization" and achieving sustainable economic growth (Chun, 2014).

Table 2.1: BRICS Summits

Overarching Theme: BRICS Partnership for Economic Stability and Industrialization			
Summit	***Participants***	***Date***	***Location***
1st	BRIC	16 June 2009	Yekaterinburg, Russia
2nd	BRIC	15 April 2010	Brasília, Brazil
3rd	BRICS	14 April 2011	Sanya, China
4th	BRICS	29 March 2012	New Delhi, India
5th	BRICS	26-27 March 2013	Ethekwini-Durban, South Africa
6th	BRICS	14-16 July 2014	Fortaleza, Brazil
7th	BRICS	9-10 July 2015	Ufa in Bashkortostan, Russia
8th	BRICS	15-16 October 2016	Goa, India
9th	BRICS	31 August to September 4, 2017	Xiamen, China

Author's compilation from South African BRICS Think Tank (SABTT)

2.3 The Central Bank of Brazil and Brazil's Monetary Policy Regime Shifts

2.3.1 The Central Bank of Brazil

The roots of a financial institution to organize the Brazilian monetary system can be traced back to 1964, when the Brazilian currency was established. Portugal's Prince-Regent *Dom João* VI arrived in the colony of Brazil in 1808 and mooted the creation of a bank that would perform the duties of central and a commercial bank. The Bank of Brazil was established and tasked with various responsibilities such as taking deposits and issuing bank notes. It was also responsible for selling the products of the State administration and Royal contracts (see the Central Bank of Brazil website). Given these uncoordinated dual roles, it was to be some time before a true

Central Bank was established as the Bank of Brazil carried out all the duties of a monetary authority.

The then President of Brazil, Getúlio Vargas, issued Decree 7,293 in 1945 establishing the Superintendent of Money and Credit (SUMOC). It was tasked with controlling the disorganized financial market, fighting inflation and formulating policies for the creation of the Central Bank of Brazil. SUMOC's duties included specifying the discount rate and the rate for financial assistance in cases of insufficient liquidity, setting reserve requirements for commercial banks, determining interest rates for bank deposits, supervising the activities of commercial banks, steering foreign exchange policy, and representing the country in international institutions.

At this time, the Bank of Brazil operated as a government bank that directed foreign trade; accepted mandatory and voluntary deposits from commercial banks, carried out foreign exchange trade, and acted on behalf of public enterprises and the national treasury.

In the interim, the national treasury issued notes (paper currency) - a complex process covering a number of government entities. The Ministry of Finance, the Central Bank of Brazil and the Bank of Brazil were in charge of the federal budget and other fiscal responsibilities. However, Law 4,595, which was passed in December 1964, established the Central Bank of Brazil as a federal agency as part of the national financial system. It commenced operations in March 1965.

Based on the recommendations of the National Monetary Council (NMC) and in line with Law 10,214/2001, the Banco Central do Brazil (Central Bank of Brazil) performs among others, the following roles stipulated in the constitution. Firstly, it ensures that the purchasing power of the Brazilian currency is stable and maintains the soundness of the financial system. It also performs a regulatory role and promotes the strength of Financial Market Infrastructure (FMI) that plays an important role in the financial system and the economy as a whole. For financial markets to have confidence in the quality and continuity of the services provided by FMI their financial stability must be maintained; hence, the Central Bank must ensure the smooth operation of FMI. In addition, the Central Bank of Brazil acts as a supervisor and general overseer of commercial banks in line with the public interest. This involves promoting financial stability and reduced systemic risk. Finally, the Central Bank of Brazil can, at its own discretion, suspend or exclude applicants and participants that pose a dangerous risk to the smooth functioning of the national financial system or do not operate in compliance with Reserve Transfer System (RTS) rules or the regulations pertaining to the national financial system.

2.3.2 The Monetary Policy Regimes in Brazil

According to Diamond (2003:49-90), monetary policy developed from the pioneering work of Irving Fisher (1911) who laid the foundation for the quantity theory of money through the equation of exchange. He posited that money has no effect on economic aggregates, except prices. Keynes (1930) also highlighted the role of money in an economy that money has indirect effects on economic variables that influence interest rates, thereby affecting the investment and cash holding capacity of economic agents. He argued that unemployment is the result of inadequate aggregate demand and can be corrected by increasing money supply or government expenditure in order to increase spending, employment and economic growth (Keynes, 2006).

In Brazil, the institutional mission of the Central Bank is to ensure the stability of the currency's purchasing power and formulate a solid and efficient financial system (see management report, 2012). The Central Bank of Brazil's monetary policy committee is tasked with achieving this mission. It is responsible for monetary policy and setting short-term interest rates. Various strategic goals were targeted in order to achieve the inflation targets set by the National Monetary Council (NMC) and to ensure the efficient functioning of the National Financial System (NFS). The Brazil's monetary policy regimes can be broken down into three distinct periods, namely 1985-1993, 1994-1999 and 1999 to date.

2.3.2.1 The Monetary Policy Regime from 1985 - 1993

With the establishment of the Central Bank of Brazil, legal frameworks were defined to enable the institution to act as a "banker's bank (bank of banks)". From 1985-1986, government finances were restructured with redefined accounts and accountabilities among the Central Bank of Brazil, Bank of Brazil and a restructured national treasury in order to take firm control of the federal budget and fiscal financing (see Central Bank website and reports). However, in 1986, the redefined account was abolished and money supply from the Central Bank to the Bank of Brazil became part of the budgetary allocation of both institutions, consequently eliminating automatic transfers.

The restructuring of government finances continued until 1988 as monetary responsibilities were formally transferred from the Bank of Brazil to the Central Bank. The 1988 constitution established the rules in relation to the Central Bank's activities. These include:

- The Central Bank may not grant direct or indirect loans to the national treasury as it is only permitted to issue money on behalf of the union.
- Article 192 of the 1988 constitution established the need for a complementary law relating to the National Financial System (NFS).
- It also proposed that Law 4,595 be amended in order to redefine the duties and organizations of the Central Bank.

Backed by a constitutional mandate, these rules enabled the Central Bank's monetary policy plan to become fully operational. However, the need to formulate its main policy instruments, the SELIC (interest) rate and the desire to overcome financial uncertainty in the new democratic era led to a new policy regime.

2.3.2.2 The Monetary Policy Regime from 1994 - 1999

Although the economy improved under the previous monetary policy regime, economic stagnation, high rates of inflation and continued income concentration persisted. It is likely that fear of the consequences of these conditions led to a new monetary policy regime. A new exchange rate targeting system was adopted in which "the Central Bank used high domestic interest rates and privatization to attract foreign capital and sustain the exchange rate peg" (Barbosa-Filho, 2008). This period witnessed high inflation rates and the main monetary policy objective was to reduce inflation and maintain stable exchange rates. According to Lima *et al.* (2007), monetary policy was concerned with protecting the exchange rate peg and interest rate changes were primarily related to movements in international reserves. The macroeconomic stabilization policy was totally reliant on foreign capital inflows, resulting in exposure to shocks from the global market that could negatively affect the Brazilian economy, particularly the spill over effects of international financial crises, such as the currency crisis in East Asia in 1997 and the Russian currency crisis of 1998, among others.

However, due to the currency crisis, the Brazilian real exchange rate to the US dollar rose by 57%, from 1.21 Brazilian real per US dollar in December 1998 to 1.90 Brazilian real in February

1999 (Barbosa-Filho, 2008). Indeed, the current account deficit fell to 4.5% of GDP by the end of 1998 and the drain on the Brazilian Central Bank's foreign reserves meant that the Brazilian real could not be defended in the event of another crisis. Policy makers worked round the clock to save the country from this currency crisis and a new policy known as inflation targeting was put in place in 1999, causing the exchange rate to increase slightly.

2.3.2.3 The Monetary Policy Regime from 1999 - Date

The inflation-targeting regime was adopted on 1 July 1999, representing a shift from the exchange rate targeting (fixed exchange rate) regime that landed the country in a major economic crisis (Barbosa-Filho, 2008). According to De Mello and Moccero (2011), the floating exchange rate regime has played an important role in shaping inflation dynamics in Brazil as inflation has decreased more rapidly.

Empirical evidence has shown that inflation targeting is working well in Brazil (Schmidt-Hebbel *et al.*, 2002; Minella *et al*., 2003; De Mello and Moccero, 2011). In 1981, the inflation rate stood at 101.7% and it continued increasing until 1994. However, it fell to 66% in 1995 (see World Bank data file). After the adoption of inflation targeting, inflation gradually decreased, reaching 14.71% in 2003 and 3.63% in 2007. The policy's success led to the target rate being reviewed downward from 6 - 10% in 1999 to 4 - 8% in 2000 and 2 - 6% in 2001. Lima *et al*. (2007), note that the period of inflation targeting fell under regimes 3 and 4, with the Central Bank focusing on inflation rate stability and marginally on the exchange rate when setting the SELIC rate. The Central Bank was more flexible when pursuing the inflation target, and included macroeconomic parameters in the SELIC reaction function. Table 2.2 shows the full details of the adoption of forward-looking attitudes, regulations and the target limit of the Central Bank in pursuit of policy decisions and their effects on economic stability from 1999 - 2016.

Table 2.2: Inflation Targeting in Brazil

Year	Regulation	Date	Target (%)	Tolerance Intervals (population parameter)	Upper &Lower Limits (%)	Actual Inflation (IPCA, % per annum)
1999			8	2	6-10	8.94
2000	Resolution 2,615	6/30/1999	6	2	4-8	5.97
2001			4	2	2-6	7.67
2002	Resolution 2,744	6/28/2000	3.5	2	1.5-5.5	12.53
2003	Resolution 2,842	6/28/2001	3.25	2	1.25-5.25	
	Resolution 2,972	6/27/2002	4	2.5	1.5-6.5	9.30
2004	Resolution 2,615	6/27/2002	3.75	2.5	1.25-6.25	
	Resolution 3,108	6/25/2003	5.5	2.5	3-8	7.60
2005	Resolution 3,108	6/25/2003	4.5	2.5	2-7	5.69
2006	Resolution 3,210	6/30/2004	4.5	2	2.5-6.5	3.14
2007	Resolution 3,291	6/23/2005	4.5	2	2.5-6.5	4.46
2008	Resolution 3,378	6/29/2006	4.5	2	2.5-6.5	5.90
2009	Resolution 3,463	6/26/2007	4.5	2	2.5-6.5	4.31
2010	Resolution 3,584	7/1/2008	4.5	2	2.5-6.5	5.91
2011	Resolution 3,748	6/30/2009	4.5	2	2.5-6.5	6.50
2012	Resolution 3,880	6/22/2010	4.5	2	2.5-6.5	5.84
2013	Resolution 3,991	6/22/2011	4.5	2	2.5-6.5	5.91
2014	Resolution 4,095	6/28/2012	4.5	2	2.5-6.5	
2015	Resolution 4,237	6/28/2013	4.5	2	2.5-6.5	
2016	Resolution 4,345	6/25/2014	4.5	2	2.5-6.5	

Source: The Central Bank of Brazil website

2.4 The Central Bank of Russia and Russia's Monetary Policy Regime Shifts

2.4.1 The Central Bank of the Russian Federation

The Central Bank of the Russian Federation (also known as Bank of Russia) was established on 13 July 1990 based on the Russian Republic Bank of the Union of Soviet Socialist Republics (USSR), which was accountable to the Supreme Russian Soviet Federative Socialist Republic (RSFSR). The RSFSR passed the Law of the Central Bank of Russia on 2 December 1990, which acknowledged the Bank of Russia as a legal entity. It stated that the bank's functions include managing money circulation, monetary regulation, and foreign economic activity and regulation of the activities of joint stock and Co-operative Banks (see Bank of Russia website).

The Act mandating the Central Bank of the RSFSR to be accountable to the Supreme Soviet of the RSFSR was approved in June 1991. In November 1991, the Supreme Soviet of the RSFSR affirmed that the Central Bank of Russia was the sole body responsible for monetary and foreign exchange regulation in the RSFSR (Trofimov, 2010). The Central Bank of the RSFSR was instructed to assume duties before 1 January 1992, and to take full control of the assets, technical facilities and other resources of the State Bank of the USSR and all its institutions, enterprises and organisations including its function of issuing money and setting the Ruble exchange rate.

The State Bank of the USSR was disbanded on 20 December 1991 and all its assets and liabilities in the RSFSR were reassigned to the Bank of Russia (Central Bank of the Russian Federation). Commercial banks were established in the Russian Federation from 1991-1992 under the supervision of the Bank of Russia through commercialisation of banks' branches. The subsequent disbandment of the State Bank of the USSR was followed by modifications to the register of accounts and the Central Bank's cash settlement centres were linked via computer technology. Thereafter, the Central Bank started to buy and sell foreign exchange in its established currency market. It also fixed and announced the official exchange rate of the Ruble against other currencies.

However, with the establishment of a single unified federal treasury system, the Bank of Russia was no longer charged with the responsibility of providing cash services for the federal budget that became operational in December 1992. The Bank of Russia performs its functions in line with the constitution of the Russian Federation (Article 75) and the Law "On the Central Bank of the Russian Federation (Bank of Russia)" (Article 22), independent of federal, regional and local government structures (see Bank of Russia website). Its functions include maintaining a stable banking system; setting the rules for banking operations and supervising the activities of credit institutions and banking groups. It also regulates, controls and supervises the activities of non-bank financial institutions in compliance with federal laws. Finally, it is responsible for foreign exchange regulation and foreign exchange control pursuant to federal legislation.

2.4.2 The Monetary Policy Regime in the Russian Federation

According to Fjærtoft (2008), monetary policy in Russia is geared towards curtailing inflation and stabilizing the Ruble exchange rate. The aim is to encourage domestic competitiveness and reduce the large foreign currency earnings from the international market that have eroded the domestic market through rising pressure on the exchange rate. As a result, the Central Bank of Russia aims to gradually decrease its control of exchange rate dynamics and shift to a floating exchange rate regime. This is a prerequisite for various independent monetary policies and ensuring price stability through interest rate policy measures.

2.4.2.1 The Monetary Policy Regime from 1990 - 1995

The Central Bank of Russia's control of the supply of money and consequently its transmission became operational from 1995 to date after the dissolution of the Soviet Union. The policy introduced prior to 1995 was termed "managing based money supply" with inflation, output and real exchange rate as the primary targets of the Central Bank (Vdovichenko and Voronina, 2006). Controlling inflation dominated the former agenda of the previous two regimes, but there was no real independent and effective monetary policy instrument, especially from 1991 to 1993. According to Vymyatnina (2006), inflation stood at 24.5% in January 1992 after price liberalization, and reached 10% to 30% per month from 1992 to 1993, less than 10% per month in the first half of 1994, and 15% per month after the first currency crisis ("Black Tuesday", 11 October 1994). A huge budget deficit was recorded during this period. However, from late 1993 to 1995, the monetary authority gradually took an independent and effective stance and formulated a plan to finance the budget deficit through a policy shift towards a contractionary (tightening) monetary policy with the exchange rate pegged to the US dollar.

2.4.2.2 The Monetary Policy Regime from 1995 - 2000

During this period, the monetary authority exhibited some degree of legal independence and a new law on the Bank of Russia was passed in April 1995. Policy reform included the crawling band exchange rate regime against the US dollar (a pegged exchange rate regime) and tightened monetary policy (Mallick and Sousa, 2013; Vymyatnina, 2006). This led to a steadily decreasing inflation rate from 21.3% in 1995 to 11% in 1997 (Fjærtoft, 2008:5). However, high and volatile interest rates caused serious problems in fiscal policy, with the budget deficit funded by certain state security institutions such as the pyramid. As a result, between August 1998 and February

1999, there was a shift from the high fixed exchange rate regime to a floating exchange rate regime. This was in line with monetary expansion in response to the fiscal problem and the need to stabilize the economy. It was estimated that the Central Bank expended approximately $27billion of its US dollar reserves to defend the Ruble and maintain the floating peg in an attempt to avoid another round of public turmoil and a chronic fiscal deficit from 1 October 1997 to 17 August 1998 (Kharas *et al*., 2001). However, inflation increased to 84% in 1998. Welfare costs grew considerably as a result of this policy shift and the Central Bank intervened to ensure a relative stable interest rate and exchange rate that transformed into a new policy regime.

2.4.2.3 The Monetary Policy Regime from 2000 - 2004

Pressure on monetary policy led the Bank of Russia to intervene in the form of monetary expansion to counter an increase in net foreign assets (following favourable oil prices). Tight fiscal policy was adopted to complement the monetary policy in order to ensure that inflation was brought down to target. This was more successful than the crawling band exchange rate regime, as inflation was reduced to 18% with an annual growth rate of 1.5% (Mallick and Sousa, 2013). Furthermore, more emphasis was placed on exchange rate stability (a slightly depreciating Ruble) (Vymyatnina, 2006). More credit was also extended to the private sector. However, for monetary policy to achieve its objectives of price stability and economic development, structural reforms were adopted to support Russia's growth strategy, including expanded infrastructure.

2.4.2.4 The Monetary Policy Regime from 2005 - Date

The Central Bank's monetary policy of targeting the exchange rate continues while inflation control is the main goal. However, the annual inflation rate has not fallen below 9% in past years. In view of this development, the Central Bank of Russia's policy documents of 2007 and 2008 highlight its main goal as bringing inflation within the range of 6% to 7%, with plans to move towards inflation targeting with flexible exchange rates. These strategies have been long in the making, with Alexey Ulukaev, the first deputy chairman of the Central Bank, having stated in 2009 that they might commence in 2010 (Goryunov, 2009). In line with the objective of increased flexibility, the guidelines for monetary policy for 2011, 2012 and 2013 aimed to achieve an annual inflation rate of 5% to 7%, with the guidelines for subsequent years setting the target at 5% in 2014, 4.5% in 2015 and 4% in 2016 (see Central Bank website for details). Furthermore, according to Agabekian (2014), "the Central Bank of Russia's policy announcement in early 2014 restated its commitment to move to a free float beginning 2015, so that money supply will be regulated by conventional monetary policy instruments to combat inflation, which remained above the target of 5-6% in 2013". All these structural reforms aim to support Russia's growth strategy to achieving the G20's collective target of a 2% increase in GDP over the next five years.

2.5 The Central Bank of India and India's Monetary Policy Regime Shift

2.5.1 The Central Bank of India

The Central Bank of India, also known as the Reserve Bank of India (RBI), controls the country's monetary policy. The bank was established in 1911 but only commenced operations on 1 April 1935 after the adoption of the Reserve Bank of India Act, 1934 by the legislative assembly on 22 December 1933, and the council of state on 16 February 1934 (Shirras, 1934; Reserve Bank Bulletin 1993). The main committee of the Central Bank is the Central Board of Directors that is appointed by the government for a four-year term of office. The board comprises the governor and four deputies with extensive knowledge of the economy. Other directors include four from regional boards, two from the Ministry of Finance and ten from various fields (see Reserve Bank of India's organisational structure). The bank has four regional bodies from the north, west, east and south of the country, composed of five members appointed by the central government. The main functions of the Central Bank are:

- Regulating and supervising players in the financial system: The Central Bank regulates and supervises the operations of commercial banks in the country. Its focus is to maintain public confidence in the system and protect depositors' interests.
- Managing exchange rates and exchange control: The Central Bank aims to sustain the Rupee exchange rates with other currencies. It is charged with developing the foreign exchange market in India to facilitate external trade and payments.
- Issuer of currency: The Central Bank issues currency notes and coins and exchanges or destroys currencies that are not fit for circulation.
- Detection of fake currency: The Central Bank launched a website (*www.paisaboltahai.rbi.org.in)* to raise awareness and encourage citizens to report fake currency to the government.

- Developmental role: The Central Bank performs many developmental functions by indirectly providing funds to investors at a lower interest rate in order to support national objectives and industries. It also addresses inflation related problems.
- Banker to the government: The Central Bank acts as a merchant banker to the central and state governments by being the lender of last resort, especially during times of financial stress.

2.5.2 Monetary Policy Regimes in India

A number of studies have traced the evolution of India's monetary policy framework (Mohanty and Mitra, 1999; Kannan, 1999; McKibbin and Singh, 2000; Jadhav, 2003 among others). Reddy (1999) detailed financial sector reform and policy changes in the country.

The main objective of Indian monetary policy is to avoid over-stocking idle money in the economy. The bank aims to maintain price and financial stability and adequate availability of credit (see the Central Bank of India website; Rangarajan, 1998) in order to promote economic growth using interest rates and money supply as policy instruments. The Central Bank is also responsible for promoting employment and responding to market turbulence through incentives to promote savings and raise the savings: income ratio. Hammond *et al.* (2009) maintain that monetary policy is the first line of resistance against internal and external shocks that the economy might be exposed to by devising an appropriate strategy. This can be achieved by regulating interest rates to promote investment and check inflation in order to integrate with the global economy.

2.5.2.1 The Monetary Policy Regime from 1960 - 1979

The RBI adopted the first structural reforms to the monetary policy framework in the 1960s. This was followed by a series of monetary policy mechanisms including direct (quantity) and indirect (price) instruments (Joshi and Little, 1994). Indirect (market based) instruments involve the reserve bank exerting its influence on the money market by setting the interest rate (repo rate) and open market operations (OMO). The direct instruments involve the Central Bank's regulatory power, which includes the Cash Requirement Ratio (CRR), Statutory Liquidity Ratio (SLR), credit control and quantitative controls over reserve bank lending to commercial banks (McKibbin and Singh, 2000). The reserve bank also employs measures to absorb excess liquidity from the financial system from time to time but has a policy preference for indirect instruments. High economic growth averaging 5.6% was achieved under this policy regime compared to 2.9% in the previous one (Mohan, 2008). Nonetheless, the financial system was characterised by extensive regulation, which led to a weak banking structure, lack of proper accounting and risk management systems and a lack of transparency in the operations of major financial market participants (Mohan, 2005; Mohan *et al.*, 2005). Accordingly, there was need to liberate the financial sector as well as a need for openness, which led to a regime of economic liberalization and financial sector reforms.

2.5.2.2 The Monetary Policy Regime from 1980 - 1990

India had no choice but to implement reforms in order to reduce government regulation and restrictions that weakened the financial sector. The early 1980s witnessed economic liberalization of the financial market towards a deeper financial sector and away from dangerous financial suppression (Shah, 2008) in exchange for greater participation by the private sector. The Chakravarty Committee Report (RBI, 1985) recommended a monetary targeting approach as the main basis of monetary policy in India (McKibbin and Singh, 2000). While the Report presumed a target of 4%, as Rangarajan (1998:63) notes, the annual inflation was 9% in the 1970s, 8% during the 1980s and 10% in the years 1990-1995. Furthermore, in line with the Committee's recommendations, the monetary authorities chose broad money as against interest rates as the intermediate target. Bank credit was the intermediate target of monetary policy in the years 1967-1968 (Basu, 2015) as the monetary target framework was based on the stable relationship between money, output and prices.

The reserve bank recognises that the demand function of money could lack accuracy, hence calling for a multiple indicator approach in which broad money remains an important information variable in the conduct of monetary policy (McKibbin and Singh, 2000; Rangarajan, 1998). However, minor regime shifts gained momentum especially given the fact that real money demand increases with real GDP, and that time deposits are regarded as a predominant component of broad money. This led to the deregulation of the base lending rate of commercial banks and financial assets being shifted to bank deposits.

2.5.2.3 The Monetary Policy Regime from 1991 - 2004

The 1990s were marked by deregulation and liberalization of the base lending rate, accompanied by several measures to strengthen the reserve bank's balance sheet and financial position. The inability to achieve the targeted monetary growth recommended by Chakravarty Committee between 1980 and 1998 led the monetary authority to shift away from monetary targeting and formally adopt a discretionary multiple indicator approach (Hutchison *et al.*, 2013). This new operating framework led to short-term interest rates becoming a strong signal of the monetary policy stance. In order to stabilize commercial banks' lending rate and short-term interest rates, the reserve bank controlled market liquidity. From 1998-2000, it increased interest rates and withdrew liquidity by raising commercial banks' Capital Requirement Ratio (CRR) to combat excesses liquidity and speculation in the foreign exchange market. This market also witnessed far-reaching changes and reforms after the balance of payment crisis of 1991. The Liberalized Exchange Rate Market System (LERMS) was introduced in 1992 (Prakash, 2014) but was abolished in 1993. A floating exchange rate system was re-adopted in line with the reserve bank's objective of "maintaining orderly conditions in the foreign exchange market, to prevent the emergence of destabilising and self-fulfilling speculative activities, and to allow the exchange rate to reflect macroeconomic fundamentals" (see Reserve Bank of India website). This policy was successful as volatility in exchange rates and speculative attacks were addressed using appropriate policy measures. However, the rules were later modified due to external considerations such as the fluctuation in nominal exchange rates, the global financial crisis and changes in domestic macroeconomic conditions (e.g, inflation, output and the exchange rate).

2.5.2.4 The Monetary Policy Regime from 2005 - Date

According to Bhattacharya (2006), the RBI retained the multiple indicator approach (an implicit nominal anchor approach), which is the current monetary policy framework. The Federal Reserve (Fed) and the European Central Bank (ECB) have both adopted this approach. In the new monetary policy framework, there is overriding focus on inflation as a forward-looking strategy. Indeed, the RBI has publicly acknowledged price stability as the major overriding concern which Reddy (2005) described as an "informal mandate". The Central Bank normally publishes its own projections with respect to a mandated task in any given year, including inflation. Although these projections are self-imposed and are not official targets, given the power of the RBI, the Central Bank governor announces a proposed new regime of inflation targeting after consultation with the elected representatives. The RBI has set a target range of 4% (+/-2%) to maintain low inflation (Jha, 2008). In 2014, the Central Bank announced that it aimed to see consumer price inflation fall to 8% by the end of 2014 and 6% by January 2016 after it had climbed to nearly 10% in 2013 (Dow Jones Business news, 2014).

However, the RBI's new policy attracted much criticism. Mahajan *et al.* (2014) and Subbarao (2011) observe that, given prevalent conditions in India, alleviating poverty should be the monetary policy authorities' main priority. In contrast, supporters of inflation targeting (Batini and Laxton, 2007; Gupta and Sengupta, 2014) argue that price stability is required to create a stable and non-inflationary environment for resource allocation in India and reduce the inflationary impact of shocks to the economy. It is clear that the policy has been successful as significant improvements have been recorded in anchoring both inflation and inflation expectations with no adverse effects on output growth. In addition, the exchange rate and international reserves are less volatile. An RBI report shows that the risk of a currency crisis relative to money or exchange rate targets has been reduced, restoring investors' confidence which is evidence that India's economy will achieve accelerated growth in 2015/2016. Real GDP growth slumped to 4.74% in 2012 from 6.64% in 2011. However, in 2013 and 2014, it grew to 5.02% and 5.63%, respectively. Furthermore, the country's GDP growth forecast signalled a positive trend of 6.35% for 2015, 6.46% for 2016, 6.63% for 2017 and 6.72% for 2018 (see the Central Statistics Organisation of India website).

2.6 The Central Bank of China and China's Monetary Policy Regime Shift

2.6.1 The Central Bank of China

Sun Yat-sen conceived the idea of a Central Bank of China in 1923 with the primary goal of financing national development. The bank was established in Canton in 1924. The Bank of China, which is one of the big four banks in China along with the Bank of Communications, Farmers' Bank of China and China Construction Bank, was charged with the responsibility of performing the roles of a central bank. However, after the loss of mainland China during the Chinese civil war, the Central Bank of China (known as the People's Bank of China (PBC)) was established and, along with the government, moved to Taipei on 1 December 1948. It commenced full operations in 1961 (see Central Bank of China website).

The amended Central Bank Act of 8 November 1979 placed the bank under an executive, and reiterated its independent role of formulating and implementing monetary policy. Economic reforms during the 1980s resulted in the PBC being divided into four independent state-owned banks based on its commercial banking functions. In 1983, the council of state decreed that the PBC would function as the Central Bank of China. The bank was modernized in the 1990s and its status as the Central Bank was legally confirmed on 18 March 1995. Another round of major reforms was embarked on in 1998, with all provincial and local branches abolished and new nine regional branches opened. In 2003, the law was amended to strengthen the roles of the PBC in formulating and implementing monetary policy. The Act provides that the bank's objectives include promoting financial stability, ensuring sound banking operations, maintaining a stable internal and external value of the local currency and fostering economic development. The functions of the PBC are as follows (see Central Bank of China website):

- Formulating and implementing monetary policy;
- Issuing Renminbi and managing its circulation;
- Determining and regulating the inter-bank lending market and inter-bank bond market;
- Controlling foreign exchange and the fixed inter-bank foreign exchange market;
- Regulating the gold market; holding and managing official foreign exchange and gold reserves;
- Managing the State treasury;
- Maintaining the normal operations of the payments and settlement system;
- Guiding and organizing the anti-money laundering work of the financial sector and monitoring relevant fund flows;
- Compiling financial statistics;
- Participating in international financial activities in the capacity of the Central Bank;
- Performing other functions specified by the State Council.

2.6.2 The Monetary Policy Regime in China

China's monetary policy aims to maintain the value of the Renminbi and contribute to economic growth (Zhou, 2015). It is further designed to strike a balance between inflation and growth

(Mallick and Sousa, 2012). Challenges in relation to monetary policy and macroeconomic management include accelerated urbanization, industrialization and a fast growing economy. It is difficult to reform the interest rate and exchange rate regime in order to build a market-based mechanism that can successfully handle the greater openness of China's economy. "Policymakers were then tasked to give more concerted efforts to external coordination and guide against global imbalance that may trigger instability in the domestic economy with a view to maximise employment and achieve balance of payment equilibrium" (Caijing magazine, 25 December 2006). Various economic reforms and transitions were undertaken to enhance the effectiveness of the monetary policy framework in maintaining the stability of both economic growth and prices.

2.6.2.1 The Monetary Policy Regime from 1978 - 1990

The PBC commenced full operations in 1961 but secured its independent role in formulating monetary policy on 8 November 1979. The first monetary policy instruments were quantity and price measures aimed at ensuring price stability and promoting economic growth, increasing employment, and achieving a balance of payments equilibrium and stability of the financial system (Mallick and Sousa, 2012). The quantity and price rule is the quantitative McCallum rule of monetary policy that specifies a target for the monetary base (M_0) which could be used by the Central Bank. It serves as an alternative to the Taylor's rule and normally performs better during crisis periods. The rule sets a target for the monetary base in each quarter or year where nominal GDP is targeted (both real growth and inflation).

According to Gallmeyer *et al*. (2005), the "McCallum rule shows the need by the monetary authority to adjust short term rates in response to exogenous shocks to the term premiums imbedded in long rates (i.e. 'yield-curve smoothing'), along with a desire for smoothing interest rates across time". This policy was largely successful in ensuring price stability and a stable economic outlook. This led to its extension beyond 1990 and it was adopted by the succeeding regime from 1991 to 2004.

2.6.2.2 The Monetary Policy Regime from 1991 – 2004

In this period, the quantity and price rule (McCallum rule) was adopted due to its prior success in stabilizing economic performance in the period 1978 to 1990. Burdekin and Siklos (2008) note that China appears to have followed the McCallum rule during this period. However, from 1991 to 2004, it was difficult for the McCallum rule to properly capture China's money supply, especially prior to 1997. The difference between the money supply imitation with the McCallum rule and the actual one was extremely large during 1991 and 1997 (Liu and Zhang, 2007; Zhang, 2009). The failure of this monetary policy rule lies in its inability to consider inflation pressure explicitly and it does not take into account forward-looking activity in the economy. This led to a new regime shift known as the exchange rate regime.

2.6.2.3 The Monetary Policy Regime from 2005 - 2010

China adopted an exchange rate targeting regime during this period. The monetary authorities announced a shift to a new managed floating exchange rate regime in July 2005. This aimed to align the value of *Yuan* Renminbi to other currencies (Frankel and Wei, 2007). The managed floating exchange rate allowed movement up to +/- 0.3% bands on each daily trading with other currencies. The currency rate was fixed to the US dollar in order to determine trade flows into and out of China. The PBC also aimed to maintain the value of the currency low in competition with its trading partners in order to reduce the cost of China's exports and consequently attract foreign investors. China thus considers its new exchange rate policy regime as vital for the country to sustain a high growth rate. Further justifying the new policy, China's monetary authority reasoned that the new exchange rate would eliminate some exchange rate uncertainty for Chinese exporters and importers and their trading partners.

As a result of the managed floating exchange rate that kept the Renminbi relatively cheap, China's growth remained remarkable and the value of the Renminbi strengthened by as much as 21% against the US dollar (Xiao, 2010). The country's GDP growth averaged nearly 10% (Prasad, 2007). However, given the fast growth of the country's economy, its export sector came under enormous pressure after the US subprime financial crisis that eventually led to a decline in world trade. This led to another change in China's exchange rate policy in August 2008 where the exchange rate was "re-pegged" for a second time against the US dollar. The main reason was to protect Chinese exporters from further competitive pressures and insulate the economy against the global recession that started in the US. While the policy was successful, China was confronted with imported inflationary pressure, with upward pressure on the prices of land, labor, agricultural products and services which eventually led to another monetary policy regime shift with a plan to target inflation (Sadeghian *et al*., 2013).

2.6.2.4 The Monetary Policy Regime from 2011 - Date

China's economy has grown at a rapid pace in past decades due to a range of economic reforms. In an attempt to manage aggregate demand and control the build-up of imported inflationary pressures and financial risks, in June 2010, the Chinese authorities adopted a minor change to the exchange rate reform. The PBC proclaimed that the exchange rate would be made more flexible; hence, there was a shift from a pegged exchange rate to a floating exchange rate with a 3% inflation target. However, a 4% target rate was set in 2011 and an 8% GDP growth rate. Furthermore, the monetary authorities released a target of a consumer price index of 4% for 2012 and 3.5% for 2013. In 2014, the PBC set its inflation target at 3.5%, aimed at keeping prices in check with a growth target of 7.5% (BBC news 5th, March 2014). This new policy of ensuring price stability was extremely successful, with inflation falling to a five-year low in 2015 (Denise and Reuters, 2015). This creates space for interest rate cuts and other policies to stimulate the economy should there be job losses. The monetary authorities have thus been able to reduce uncertainty among investors, factor in likely interest rate changes and achieve a greater degree of transparency in monetary policy, hence, necessitating its extension and implementation.

2.7 The South African Reserve Bank's Monetary Policy and Regime Shift

2.7.1 The South African Reserve Bank

Section 224 of the Constitution of the Republic of South Africa grants the South African Reserve Bank (SARB) the power to pursue its main objectives and functions. The autonomy and independence of the SARB is entrenched in the constitution (details in Casteleijn, n.d). However, it must hold regular consultations with the cabinet members responsible for national financial matters. This means that, as policymakers, the government is also part of the monetary authority.

However, the conduct of monetary policy and hence the setting of the repo rate has been the sole responsibility of the SARB. Although consultations may be held with the Minister of Finance on policy guidelines, policy changes can be effected without his approval (Aron and Muellbauer, 2000). The governor and the three deputies (appointed by the president) and the adviser to the governor as well as the head of the research department are members of the Monetary Policy

Committee (MPC). MPC members have voting rights to set interest rates at a level they believe is consistent with achieving price stability or increasing economic growth. The MPC receives general briefings on the state of the economy from SARB staff and makes decisions that help achieve the SARB's objectives.

The governor of the SARB meets regularly with the finance minister and Members of the Parliamentary Portfolio and Finance Committee in accordance with section 32 of the SARB Act, 1989.

The SARB is further entrusted with achieving price stability. This means that the bank can independently use any of its policy instruments in pursuit of this goal. Other functions of the SARB include:

- Ensuring that the currency, banks and financial system meet local and international standards for economic development.
- Assisting the South African government and other members or stakeholders involved in decision making by supplying relevant data for policy formulation.
- Maintaining an open door policy on monetary policy and information on the economic situation in the country.

2.7.2 South African Monetary Policy

The SARB oversees monetary policy in conjunction with the finance minister. It uses various instruments to influence the amount of money in the economy and to guide financial institutions by providing incentives to private investors and policy direction. The SARB carries out both national and international transactions on behalf of the public, and acts for the government in dealings with the International Monetary Fund (IMF) and the World Bank (see the SARB website). The MPC sets monetary policy and works within a flexible framework to achieve economic growth. Examples of the policy instruments used by SARB include: (i) the repo rate (the rate at which the reserve bank grants loans to commercial banks) (ii) Open Market Operations (sale and purchase of securities, mainly treasury bills) (iii) Reserve requirement and (iv) Moral suasion (the persuasive power to influence commercial banks in what the SARB considers to be public interest) among others.

In line with the above, Victor (2002:131) identifies three main monetary policy instruments typically used by the SARB to achieve price stability and economic growth. These are open market operations, the discount window policy (repo rate) and reserve requirement. The repo rate is most often used by reserve banks to regulate both interest rates and the quantity of money that can be borrowed, thus imposing both price and credit controls on discount borrowing. However, the use of the repo rate has been criticized; commentators have observed that the substantial lag in monetary policy changes to influence inflation does not effectively impact inflation levels (Mishkin, 2001; Mishkin and Schmidt-Hebbel, 2001).

Five major monetary policy regimes can be observed in South Africa since 1960 (Aron and Muellbauer, 2000). These are: (i) the liquid asset ratio-based system with quantitative controls over interest rates and credit (ii) the mixed system during transition (iii) the cost of cash reserves-based system with pre-announced monetary targets (iv) operating daily tenders of liquidity through re-purchase transactions (repo system) plus pre-announced (M3) targets and informal targets on inflation and (v) the repo rate system with an inflation targeting regime.

2.7.2.1 The monetary policy regime from 1960 - 1981

Between 1960 and the early 1980s, South Africa adopted a restrictive monetary policy regime that employed the liquid asset ratio-based system with quantitative controls over interest rates and credit. Among other instruments, the reserve bank employed credit ceilings, exchange rate controls, deposit rate controls, and import deposit controls. Interest rate adjustments were a minor corrective instrument as monetary policy control was mainly achieved through liquid asset requirements. Commercial banks were mandated by law to hold a minimum proportion of deposits in reserve in order to curtail bank lending and money growth. This limited their lending power to the public and controlled the amount of money in circulation. However, this policy did not yield the expected results, and inflation remained volatile due to neglect of the corrective effect of interest rates by the monetary authorities. The inflation rate rose from 6% in 1970 to 18.52% in 1985, the highest since 1958. This led to the establishment of the de Kock Commission of Inquiry into the country’s monetary system and monetary policy. According to Moolman and Du Toit (2004), there was need to shift focus towards a market-oriented approach due to increasing dissatisfaction with the liquid asset ratio system, leading to a mixed system during the transition to a new regime.

2.7.2.2 The monetary policy regime from 1981 - 1985

The de Kock Commission of Inquiry paved the way for the adoption of a mixed system during the transition from the liquid asset ratio-based system with quantitative controls over interest rates and credit to a cash reserves-based system (Aron and Muellbauer, 2000). The commission found that the velocity of money had fluctuated substantially since 1976 due to fluctuations in the instruments of monetary policy (direct controls on interest rates and bank credit). The liquid asset ratio system prioritized quantitative control of money as the main monetary mechanism rather than interest rates and credit controls. This regime was also characterized by financial liberalization that led to another regime.

2.7.2.3 The monetary policy regime from 1986 - 1998

This regime represents an extension of the recommendations made by the de Kock Commission of Inquiry. Its report showed how poorly the reserve bank predicted the value of the Rand between 1972 and 1978. It further established that the reserve bank was better equipped to predict the future value of the Rand than the exchange rates market. A cash reserve-based system with a pre-announced monetary target (M3) was introduced and used for the first time. The key policy emphasis was the central bank's discount rate in regulating the cost of overnight collateralized lending and market interest rates (Aron and Muellbauer, 2000). This policy was more successful than the liquidity asset ratio based system, as the interest rate of commercial banks was increased to reduce demand for bank credit by tightening the collateral against government bills. Nevertheless, this method also became ineffective in the late 1990s with the opening up of the South African economy (Ludi and Ground, 2006), leading to a fourth monetary policy regime shift.

2.7.2.4 The monetary policy regime from 1998 - 1999

During this period, the SARB operated daily tenders of liquidity through repurchase transactions (the repo system), as well as pre-announced (M3) targets and informal inflation targets. It focused on short-term interest rates that were to be achieved through the amount offered at the daily tender for repurchase transactions and interest rates that were determined by market forces (SARB Quarterly Bulletin, June 1999). Money growth guidelines were announced for three years rather than on an annual basis due to the unstable and volatile correlation between money and prices. A target range for inflation became necessary and the inflation-targeting regime was announced as the new policy regime shift.

2.7.2.5 The monetary policy regime from 2000 - 2008

In February 2000, the South African government through the SARB announced a repo rate system with inflation targeting as an important element. A target rate of 3%-6% based on an annual measure was selected for the Consumer Price Index (CPIX), to be achieved by the end of 2002. According to Mishkin and Schmidt-Hebbel (2007), level, persistence and volatility are lower in inflation targeting countries than in those that do not set targets. Based on other countries' experiences, proponents of inflation targeting in South Africa (Casteleijn, 1999; Jonsson 1999; Mboweni 2002) advanced various reasons for this recommendation. They argued that it would:

- Help to reduce inflation and inflationary expectations by re-orientating people about the future;
- Ensure stability in the value of money to increase growth prospects;
- Keep the public informed about future inflation trends;
- Lead to growing stability in nominal interest rates;
- Further improve the accountability of the monetary authorities;
- Decrease the degree of money illusion in the economy;
- Provide an anchor for inflation expectations;
- Increase the transparency of monetary policy.

In addition, the global inflationary pressure that continued to pose a risk to the domestic and international economies called for change in South Africa's monetary policy. The increase in food prices due to declining agricultural output, decreased manufacturing output, volatility in the Rand's exchange rate against the US Dollar, and low domestic growth, among other factors, posed serious challenges to monetary policy. In view of the above, proponents of inflation targeting won the day and the MPC adopted inflation targeting as a monetary policy framework to further tighten monetary policy.

According to Mishkin (2007), inflation targeting encompasses five basic components: (i) an institutional commitment to price stability, (ii) medium-term numerical targets for inflation, (iii) decisions by the monetary authorities to increase accountability, (iv) increased transparency of monetary policy strategy through timely response to shocks, and (v) effective communication with the public and the markets about monetary policy plans and an inclusive strategy to debate and set policy instruments that are not limited to monetary aggregates or the exchange rate. The achievements recorded during this regime and the on-going need to stabilize prices resulted in its retention and extension.

2.7.2.6 The Monetary Policy Regime from 2008 - Date

The reserve bank continues to target inflation within a range of 3-6% as the outlook remains bleak due to increases in international oil and food prices. Recurrent electricity price increases by the Electricity Supply Commission (ESKOM) have added to inflation uncertainty in the country (Troskie, 2012).

Furthermore, 2008 and 2009 were characterized by the global economic recession that contributed to the failure of key businesses, a decline in consumer wealth and a significant decline in economic activities, leading to a severe global economic collapse. The housing price slump in the United States of America caused the value of securities tied to US real estate pricing to fall, damaging financial institutions globally and leading to bank insolvencies and a decline in credit availability and damaged investor confidence in global stock markets. Securities suffered large losses between 2008 and 2009 and economies worldwide slowed down during this period as credit tightened and international trade declined. The South African economy was not immune to these developments; domestic production contracted sharply due to weak local demand and a significant decline in exports. Real GDP contracted at an annual rate of 1.8% in the fourth quarter of 2008 (SARB Monetary Policy Review, May 2009).

In view of these developments, the MPC agreed to meet every month, with the exception of the month of July in 2009, to assess the rapid changes in the economy and respond appropriately. It cut the repo rate by 50 basis points to 11.5% per annum with effect from 12 December 2008. The MPC further reduced the repo rate by 100 basis points to 10.5% per annum with effect from 6 February 2009, 9.5% per annum with effect from 25 March 2009 and 8.5% per annum with effect from 4 May 2009 in order to tackle the risk of inflation. The year 2010 saw some recovery from the external shocks of persistent low growth in the United States of America due to the global recession and on-going concern about the solvency of the Euro zone that was threatening the South African banking sector's transformation efforts.

The CPI inflation rate fell from 6.3% in December 2009 to 6.2% in January 2010, and 5.7% and 5.1% in February and March 2010, respectively (SARB Monetary Policy Review, May 2010). The repo rate was further reduced by 50 basis points to 5.5% per annum with effect from 19 November 2010.

Real GDP grew by 2.8% in 2010 and 3.6% in 2011, providing a more convincing sign of sustainable recovery from the global recession. In view of this development, the MPC decided to keep the repurchase rate unchanged at 5.5% per annum. In 2012, the MPC's main concern was excessive wage increases against a background of employment growth. For example, employment in the non-agricultural sector increased by 1.0% in 2012 against annual employment growth of 1.6% in 2011. The economic growth outlook remained unchanged but the depreciation of the exchange rate provided an opportunity for the manufacturing sector to become more competitive. The MPC decided to keep the repo rate at 5.0% per annum in 2012 and continued to apply a flexible inflation-targeting framework consistent with its mandate of price stability.

Changes have occurred in the South African economy in line with these phases of regime shifts. According to Chicheke (2009:3), from 1980 until the early 1990s, inflation averaged about 14%. Since the early 1990s, however, it has exhibited a downward trend and averaged 7% between 1994 and 2002. Unemployment rose significantly from 9.8% in 1980 to 25.5% in 2007 and averaged 21% over the same period. However, it decreased to 24.70% in the third quarter of 2013 from 25.60% in the second quarter of the same year (2013). The unemployment rate rose by 0.3% from 25.6% in the first quarter of 2014 and increased to 26.4% in the first three months of 2015 from 24.3% in the preceding quarter (Stats SA, 2015) while employment grew at a slow rate of 0.9% in 2016.

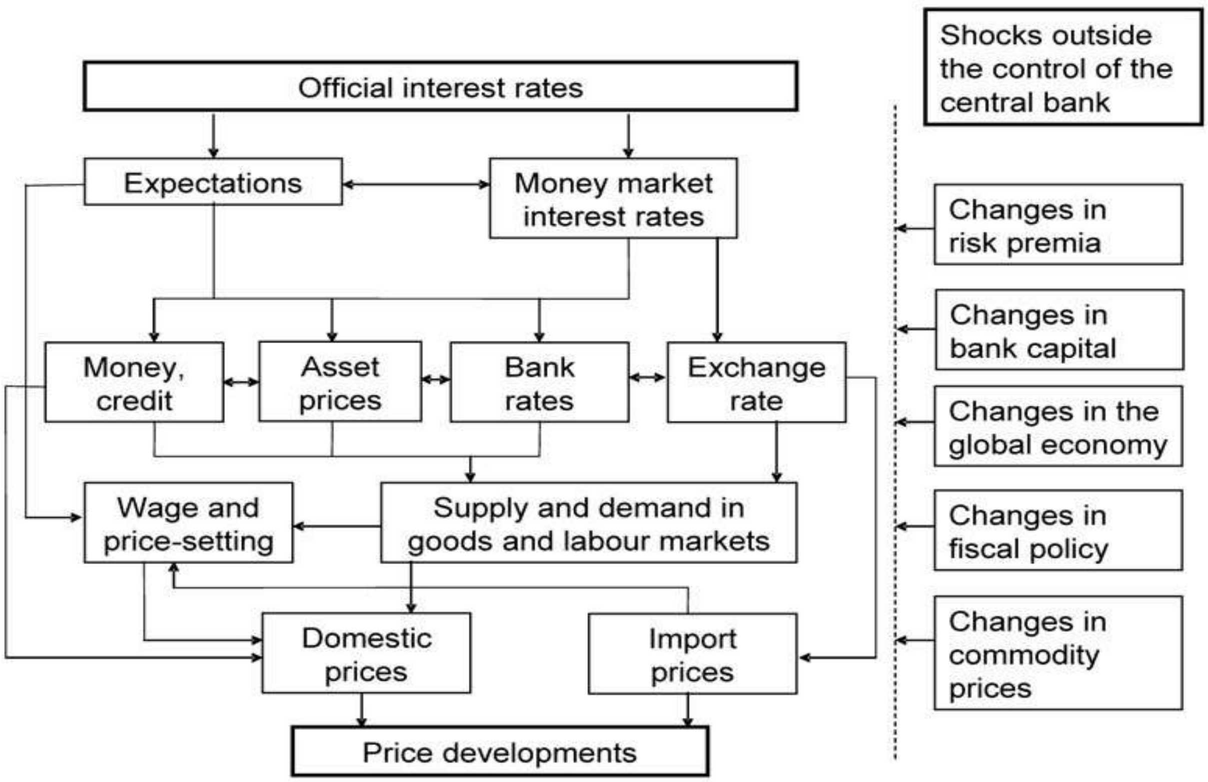
2.7.3 Model Showing the Monetary Transmission Mechanism

According to Ireland (2005), the channels of monetary transmission operate through the effects that monetary policy has on interest rates, exchange rates, equity and real estate prices, bank lending, and firms' balance sheets. Changes in the repo rate directly affect money market interest rates and indirectly affect the lending and deposit rates that commercial banks charge their customers.

Bhattacharya *et al.* (2011) notes that, some EMEs have relatively ineffective monetary policy transmission owing to weaknesses in the domestic financial system and the presence of a large and segmented informal sector. They add that, the exchange rate is the most effective pass-through channel in India. In contrast, Aleem (2010) advocates for lending rates, and Khundrakpam and Jain (2012) describe the exchange rate channel in India as weak I comparison with the interest rate, credit and asset prices channels. Aron and Muellbauer (2000) found empirical evidence in support of both the interest rate and exchange rate channels in South Africa. Poon and Wong's (2011) study revealed that, the interest-rate channel was the major monetary transmission mechanism in China before the financial crisis, but changed thereafter to an asset-price channel. This was confirmed by Fernald *et al*. (2014), who argued that interest rates have a substantial impact on economic activities in that country. In Brazil, Luporini (2008) presented evidence on the interest rate channel of monetary policy transmission, while Tahir (2012) found that the exchange rate and price channels were the major monetary transmission mechanism. Finally, in Russia, Vymyatnina (2005) found evidence that interest rate and exchange rate channels were effective in monetary policy transmission and Ono's (2015) study revealed that, the bank lending channel was the most effective mechanism.

Faure (2005a) identifies six steps in the transmission process: Step 1: transmission of the central bank's lending rate to the private interbank market; Step 2: transmission of interbank rates to other market interest rates; Step 3: transmission of interest rate changes to asset prices, expectations and the exchange rate; Step 4: transmission of changes in asset prices, expectations and the exchange rate to aggregate demand; Step 5: transmission of changes in aggregate demand to money; and Step 6: transmission of changes in aggregate demand and money to prices. Figure 2.1 shows the main transmission channels of monetary policy decisions.

Figure 2.1: A Schematic Illustration of the Monetary Policy Transmission Mechanism for the BRICS countries



Source: *Faure (2005a) and author's drawing*

2.7.4 The Need for Debate on the Monetary Policy Framework

The constitutions of the BRICS countries provide an enabling framework for the central banks to carry out their functions with little disturbance. They enjoy substantial autonomy in achieving and maintaining price stability in the interests of sustainable and balanced economic growth and development. Price stability reduces uncertainty in the economy and offers a favourable environment for growth and employment generation. However, there has been widespread debate on the "dual mandates" of central banks. This involves the monetary authorities' pursuit of both price stability and full employment.

Part of the debate has revolved around whether monetary policy is a more powerful weapon than fiscal policy in achieving economic growth. Some schools of thought believe that the monetary authorities should focus on achieving price stability, as they do not have a clear mandate to help reduce unemployment (Brash, 1995). Other schools of thought argue that through certain policies and programs, the monetary authorities could also promote employment (Mellet, 2011; South African policy suggestions in New Growth Path, 2010). It is important to note that some central banks do have the dual mandate of price stability and maximum employment. Examples include the Reserve Bank of New Zealand and the Federal Reserve Bank (Evan's rule of 2012), among others.

In South Africa, the SARB's mandate of upholding economic growth has been interpreted by some analysts as an "indirect dual mandate" of price stability and employment promotion. According to them, the reserve bank cannot maintain economic growth without promoting employment (Fontana, 2006; Thorbecke, 2000). The central banks of China and India are mandated to ensure price stability and economic growth while those in Brazil and Russia are expected to ensure a stable currency and an efficient financial system to support growth. Economists have thus not reached consensus on the efficacy of a dual mandate for the reserve bank in sustaining economic growth and development.

Furthermore, economists have long called for economic policies that are more disposed to economic growth and job creation and hence the revision of monetary policy and a worldwide review of the mandate of central banks. Ball and Mankiw (2002) base their arguments on the Phillips Curve, which posits that the unemployment rate and changes in inflation rate move in opposite directions in a temporary trade-off. These authors note that the Phillips Curve makes monetary policy appear simple. Select a little more inflation and unemployment would fall. Alternatively, opt for higher rates of unemployment and the rate of inflation will decline. It is thus, believed that policymakers have to choose between inflation and unemployment; this requires them to abandon their old-fashioned ideas about price stability. Allow some inflation, these economists argue, and the labour market would operate more efficiently, employment would rise and the economy would grow faster. Gbosi (2001) adds that the central bank should take the effects on real economic activity into account in its decisions on monetary policy, and believes that this would provide solutions to macroeconomic problems (inflation and unemployment).

Taylor (1975) maintained that monetary policy affects economic activity in the short run and that there is no long run trade-off between the inflation and unemployment rates. He supported the acceleration model or the natural rate and used data on unemployment and inflation in the United States of America over four decades to buttress his argument. Taylor showed that apart from intentional efforts to lower or raise inflation from any given point, monetary policy should aim directly at whatever the central bank perceives to be the full, real activity of the employment rate. According to him, central banks have an important role to play in designing monetary policy because the economy is subjected to shocks. Once a shock occurs, a central bank might respond in one of two ways – implementing an expansionary monetary policy or a contractionary one. This was enshrined in what is now known as the Taylor Curve that plots the frontier of the feasible set of outcomes in terms of the variance of inflation and output gap and is consistent with the central bank's dual mandate.

Price stability also enables the monetary authorities to focus on other objectives such as reducing fluctuations in real economic activity and managing financial and liquidity crises. According to Poole and Wheelock (2008), price stability is the most powerful tool that any central bank has to promote economic growth, employment and financial stability. It is unlikely to succeed in limiting fluctuations in economic activity or curtailing financial crises unless the price level is stable. Price stability is both essential and desirable because an increase in the price level imposes substantial economic costs on society, thereby diverting resources from productive activities to non-productive ventures. In McDonough's (1997) opinion, price stability is a means to an end – to promote sustainable economic growth. The monetary authorities can target low price levels over the long term and lock in inflation expectations. McDonough (1997) reminded those that might differ from his position that establishing price stability as the primary goal of monetary policy means that a central bank would no longer be concerned with productivity or job growth; a stable price and financial environment would enhance a monetary policy's ability to prevent cyclical occurrences within the economy. It is important to note, that by ensuring a stable price environment, monetary policy fosters economic growth through job creation and output growth.

However, some analysts believe that there is a limit to what the monetary authorities can achieve in stimulating economic growth. Hoskins (1993) maintains that monetary policy cannot directly deliver high levels of employment and output. Theoretical and some empirical analyses show that, monetary policy can raise output and lower unemployment in exchange for higher inflation. He added that what monetary policy could accomplish is maximum sustainable prices and currency through the monetary base. This means that the monetary authority can promote sustainable economic growth, but not full employment.

Conversely, some economists hold the firm belief that the monetary authorities can achieve maximum employment if the mandate is given. Groshenny's (2010) study of the dual mandate of the Reserve Bank of New Zealand provides evidence that, the discretionary component of this bank's monetary policy was successful in reducing the risk of high unemployment between 2002 and 2006. He estimated the natural rate of unemployment and the unemployment gap to assess the monetary policy adopted by the reserve bank using a Dynamic Stochastic General Equilibrium (DSGE) model to estimate the degree to which deviations by the reserve bank from Taylor's rule contributed to stabilizing unemployment around the natural level. The findings reveal that the reserve bank's mandate of promoting maximum sustainable employment was achieved through its monetary policy and did not totally deviate from Taylor's rule.

Taylor's rule, introduced by John Taylor in 1993, employs a parameter for interest rate adjustment in order to set and fine-tune prudent rates that will stabilize the economy in the short-term and sustain long-term growth based on three factors: (i) actual versus targeted inflation levels, (ii) actual employment versus full employment levels and (iii) the appropriate short-term interest rate consistent with full employment. This rule was designed to provide "recommendations" for how a central bank should set short-term interest rates as economic conditions change to achieve both its short run goal to stabilize the economy and its long run goal for inflation. Its influence was investigated with regard to US monetary policy, especially deviation from the rule since 2003, which Taylor attributed to financial imbalances and the subsequent crisis in the country (Taylor, 2012). Ilbas *et al.* (2013) postulate that, deviation from Taylor's rule depends on the particular shocks hitting the economy. Federal Reserve Bank staff advised the Federal Open Market Committee that Taylor's rule might be well suited for supply shocks, but that greater emphasis on the output gap would be better suited to demand shocks that accounted for their new monetary dual role (mandate).

2.8 An Overview of the Industrial Sector in Brazil

Brazil's attempts to industrialize during the colonial period were hampered by the colonial masters' (the Portuguese) fear that local industry might compete with their established domestic industries. Industry was thus prohibited in Brazil in order to protect Portuguese products. The colonists invested in railroads, shipyards and banks to ensure delivery of their products (Nam, 2008). The textile, clothing, food products, beverages, and tobacco industries experienced asymmetrical expansion due to foreign groups' stakes and everyone in Brazil was forced to observe how to weave. Brazilian foreign policy favoured agriculture rather than industrialization, which discouraged investment in industry.

In the post-colonial period, Brazil had two options. The first was to strengthen linkages with already industrialized and developed nations to secure a steady share of the market. The second was to embark on industrialization. Brazil opted to embrace industrialization in order to achieve greater economic independence, create jobs and shift from high-volume intensive production to skills-intensive high-value production (Reich, 2010). Policy makers acknowledged that the country could no longer rely solely on exporting primary goods and that it was necessary to promote economic diversification. This resulted in full-scale industrialization and less foreign dependency.

2.8.1 Industrial Sector Reform in Brazil

A sound and competitive industrial sector is important for the overall performance and growth of an economy. Globally, the industrial sector has experienced revolutionary change ranging from nationalization, to deregulation, privatization, liberalization and technological innovations. The Brazilian case is no different, with various reforms having been carried out in both the public and private sectors to address market failures or anti-competitive behaviour that can have implications for productivity, efficiency, consumer welfare and economic growth.

Amendments were made to the constitution to address inefficiency and attract foreign investment. The services, industrial, manufacturing, and agricultural sectors, among others, were privatized. The main objective of the National Privatization Program (NPP) was to promote the sale of government-owned assets. This would enhance the infrastructural make-up of the country and act as a standby in the economic transition phase to boost industrialization. By 1997, around 50 companies had been privatized and were making a reasonable profit.

Within a short space of time, Brazil changed its economic and commercial structure, promoting stability. An economic reform program known as "Plato Real" was introduced in 1994 to introduce the new currency, the Real. Alongside privatization and restructuring of Brazilian banks, this largely controlled inflation and promoted economic stability (Baer and Nazmi, 2000).

In the 1990s, reforms were also introduced in the electricity sector to boost industrial production. According to De Almeida and Pinto Jr (2005), the privatization of public-owned companies and the opening up of the oil and gas industries to private investors paved the way for private sector participation and attracted private capital. Historically, the federal government focused on generation and transmission companies. The structure of the electricity company run by the government was modified to allow for greater participation. Today, 59 companies operate in the electricity generation sector and 64 in the distribution sector. The fruits of this endeavour can be seen in the fact that 93% of Brazilian households have access to electricity and the entire urban population has access to a power supply that has made a significant contribution to the growth of industrial production.

2.8.2 An Overview of the Performance of the Industrial Sector in Brazil

Modern researchers have identified industrial growth and diversification as the roots of sustainable economic growth and development. In Brazil, industrial production is measured by the output of businesses in manufacturing, mining, and utilities. Statistics released by the Instituto Brasileiro de Geografia e Estatística (IBGE) show that, industrial production in Brazil averaged 2.03% from 1992 to 2015, and reached an all-time high of 20.12% in March 2010 and a record low of -17.47% in January 2009 due to the global recession. It also decreased by 9% in August 2015. The performance of the industrial sector can be measured in terms of its contribution to the following:

(i) Exports/International Trade

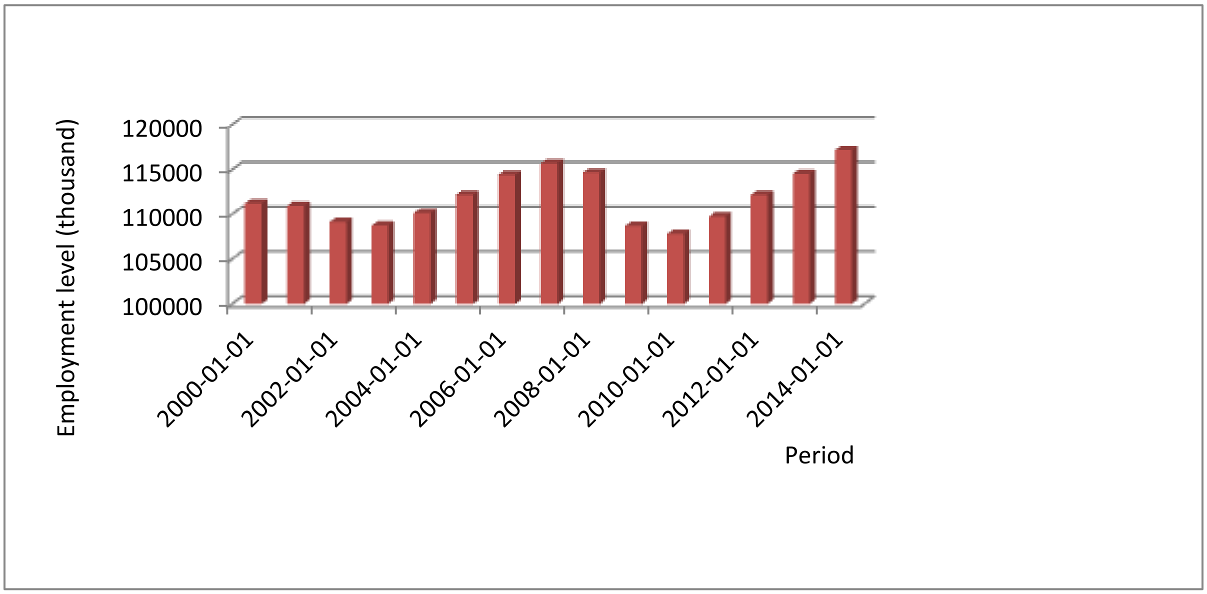
Trade liberalization and performance have increase export growth in Brazil. After decades of import substitution, Brazil embraced trade restructuring and liberalization in the 1990s. The average import tariff fell from 32.2% in 1990 to 10.8% in mid-2004 (OECD, 2005). In 2003, exports grew by 21% and imports only by 2% (UNCTAD, 2003). According to Maia *et al*. (2005), the Brazil's total trade flows in 2004 were equivalent to 26.6% of GDP, while in 1990, this figure was only 11.1%. The export volume index rose from 191.5% in 2011 to 192.5% in 2013. However, the ease of doing business decreased from 123% in 2013 to 120% in 2014. On a general note, exports have trended upwards, the trade account has been in surplus, and it has continued to improve since 2001.

(ii) Employment from 2000 - 2014

Brazil is the fifth largest country in the world and is an excellent example of industrialization and structural change in Latin America (Aldrighi and Colistete, 2013). In the first half of the 20th century, the agricultural sector was the backbone of the country's economy, with nearly 70% of land suitable for cultivation. Agriculture was responsible for approximately 6% of Brazil's GDP and employed more than 18% of the country's workforce. Exports of coffee and other primary products were the major drivers of economic growth. However, post-World War 11, rapid industrial growth was accompanied by expanding markets, externalities, and improved knowledge that raised standards in Brazil's manufacturing industry. Firms began to adopt foreign technology and enhanced their capacity. Industrial efficiency increased marginally and total production rose significantly, which culminated in an increase in total employment. Aldrighi and Colistete (2013) note, that, manufacturing employment increased and maintained a relative share of total employment of around 12% to 13%. Conversely, agriculture's share of total employment dropped from 26.0% in 1995 to 17.4% in 2009. The services sector gained ground and increased its contribution to total employment from 54.3% in 1995 to 62.1% in 2009. Nonetheless, low wages and the cost of importing technology affected the overall performance of the industrial sector in Brazil.

Figure 2.2 shows the trend in manufacturing sector employment from 2000 to 2014. It reveals an upward and downward pattern from 2000 to 2009. A high level of job losses was recorded during the global recession (2008 to 2010). However, manufacturing employment picked up gradually from 2011 to 2014.

Figure 2.2: Manufacturing employment, 2000 to 2014



Source: Author's computation from IBGE data

(iii) Gross Domestic Product (GDP)

A country's GDP is one of the leading indicators to measure the performance of its economy. GDP represents the total value of goods and services produced within the borders of a country during a specific period, usually a year or a quarter. When GDP growth is strong, firms hire more workers and can afford to pay higher wages, which leads to increased consumer spending on goods and services. Firms also have the confidence to invest more when economic growth is strong, and investment lays the foundation for economic growth in the future. On the other hand, when GDP growth is very low or the economy goes into a recession, the opposite occurs (workers may be retrenched and/or paid lower wages, and firms are reluctant to invest).

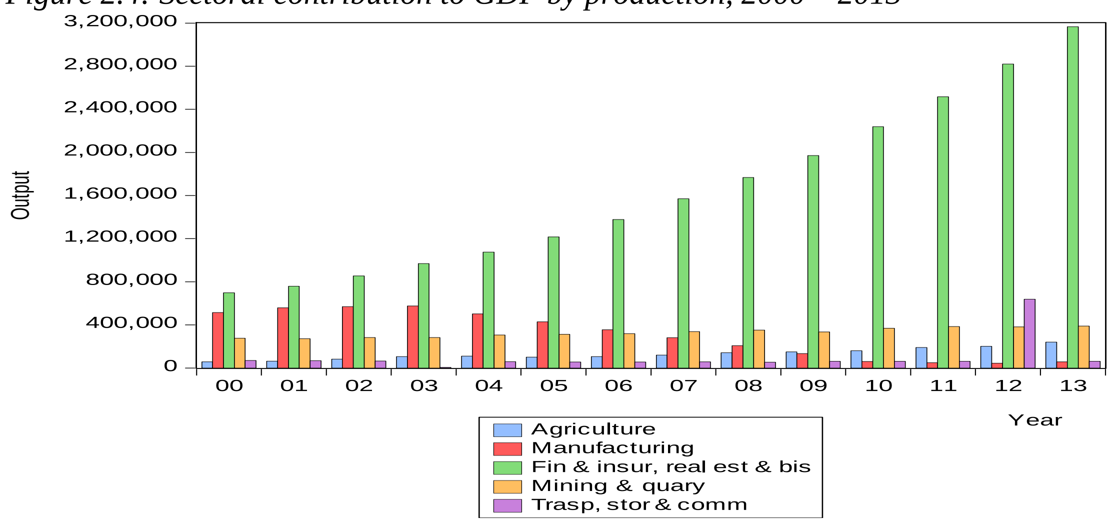
The Brazilian Institute of Geography and Statistics (IBGE) (Instituto Brasileiro de Geografia e Estatística) publishes GDP figures on an annual and quarterly basis. As shown in figure 2.3, in the 10-year period before the global financial crisis (1999 to 2008), the country's GDP grew 3.4% per year on average. This growth partly was driven by global demand for Brazilian commodities. However, after experiencing high growth in 2007 and 2008, Brazil's economy shrank by 0.3% in 2009 as demand for its commodity-based exports fell and foreign credit waned. However, the country recovered strongly the following year, growing by 7.5%, its highest growth rate in 25 years (Focus Economics, 2015). Since then, Brazil's economic growth has slowed, partially due to rising inflation.

Figure 2.3: Trend of GDP Growth, 1994 – 2013

Source: Author's drawing from IBGE data

The country's economy grew at an average of 2.1% annually from 2011 to 2013. Domestic credit as a percentage of GDP grew from 58.1% in 2011 to 69.1% in 2014 while GDP per capita increased from 11,306 in 2010 to 11,567 in 2014. Figure 2.4 shows the sectoral contribution to GDP in Brazil from 2000 to 2013. It reveals that finance and insurance, real estate and the business sector made the highest contribution, while the manufacturing (industrial) sector has witnessed a declining trend.

Figure 2.4: Sectoral contribution to GDP by production, 2000 – 2013



Source: Author's computation from IBGE data

2.9 An Overview of the Industrial Sector in Russia

In Russia, industrial production measures the output of businesses in the industrial sector such as manufacturing, mining, and utilities. The country is one of the most industrialized of the former Soviet Socialist Republics. Its industrial sector covers a wide range of sectors, such as oil and gas, mining, energy, agriculture, automotive, defence, manufacturing and communication. In 2010, Russia's industrial production growth rate was estimated at 8.3%, down from 11% in 2009 due to the global financial crisis (Economy Watch, 2010). At the beginning of 2011, the Russian economy showed strong resilience in all its sectors. Since 2000, Russia has initiated a policy of nationalization in order to prevent the collapse of key industries and protect its workers' interests against foreign capital (Lohr, 2003).

Various economic reforms were introduced in the 1990s in an attempt to industrialize the economy. In October 2010, the country announced the 2011 to 2015 privatization plan for its major industries, a move that is in line with its modernization plans. Key sectors that have undergone substantial privatization and liberalization include the oil industry, which was broken up into a dozen companies, the banking sector, the agricultural sector, the natural gas industry, the transportation sector, and manufacturing industry, among others.

2.9.1 Industrial Sector Reform in Russia

Russians justifiably expect that their country should focus on restoring economic growth and development through economic freedom and industrial sector reforms. The country has undergone significant changes since the collapse of the Soviet Union with the main aim of reviving stagnating industry (Ouvarovskii, 2007), and moving from an isolated, centrally planned economy towards a more market-based and globally integrated one. Economic reforms in the 1990s privatized much of Russian industry with the notable exceptions of the energy and defence-related sectors (Hare and Muravyev, 2003). The country has abundant natural resources including oil, natural gas and metals. It has a large and sophisticated arms industry, which manufactures high-tech military equipment like fifth generation fighter jets.

However, protection of property rights remains weak and the private sector is still subject to heavy state interference. Russia's manufacturing sector is generally uncompetitive in world markets and is geared toward domestic consumption. The country's reliance on commodity exports makes it vulnerable to boom and bust cycles that follow volatile swings in global prices. The economy, which averaged 7% growth during the period 1998 to 2008 as oil prices rose rapidly, was one of the hardest hit during the 2008 to 2009 global financial crisis as oil prices plummeted and foreign credits that Russian banks and firms relied on dried up (Gaddy and Ickes, 2010). Slowly declining oil prices over the past few years and difficulties in attracting FDI have contributed to a noticeable slowdown in GDP growth rates. In late 2013, the Russian Economic Development Ministry reduced its growth forecast through 2030 to an average of only 2.5% per year, down from its previous forecast of between 4.0% and 4.2%. In 2014, following Russia's military intervention in Ukraine, prospects for economic growth declined further, with expectations that GDP growth could drop to as low as zero.

Finally, the Russian nuclear industry underwent reform, with plans for rapid Russian/South African nuclear development. On 22 September 2014, Russia and South Africa signed an intergovernmental agreement on a strategic nuclear partnership, which may lead to the Russians constructing up to eight new nuclear reactors in South Africa by 2030, with the first coming online as early as 2023 (Rosatom, 2014). All these reforms are aimed at encouraging efficiency and boosting industrial production.

2.9.2 An Overview of the Performance of the Industrial Sector in Russia

Industrial production in Russia is reported by the Federal State Statistics Service (FSSS). From 2006 until 2013, it averaged 2.82%, reaching an all-time high of 12.60% in May 2010 and a record low of −16.90% in January 2009 due to the global financial crisis. In the 2000s, due to increasing demand and improved state finances, Russian industry emerged from the deep crisis in the aftermath of the disbanding of the Soviet Union. However, years of low investment continue to leave their mark on industry's capabilities and much equipment is in need of modernization.

Besides its resource-based industries, Russia has developed large manufacturing companies, notably in machinery, which are able to offer internationally competitive products for export. Improved technology has contributed to the country’s efforts to enhance productivity, and the efficiency and competitiveness of its industrial sector. Factor costs are being replaced by technological growth. This has contributed to production units' ability to respond quickly to changes in markets' demand patterns.

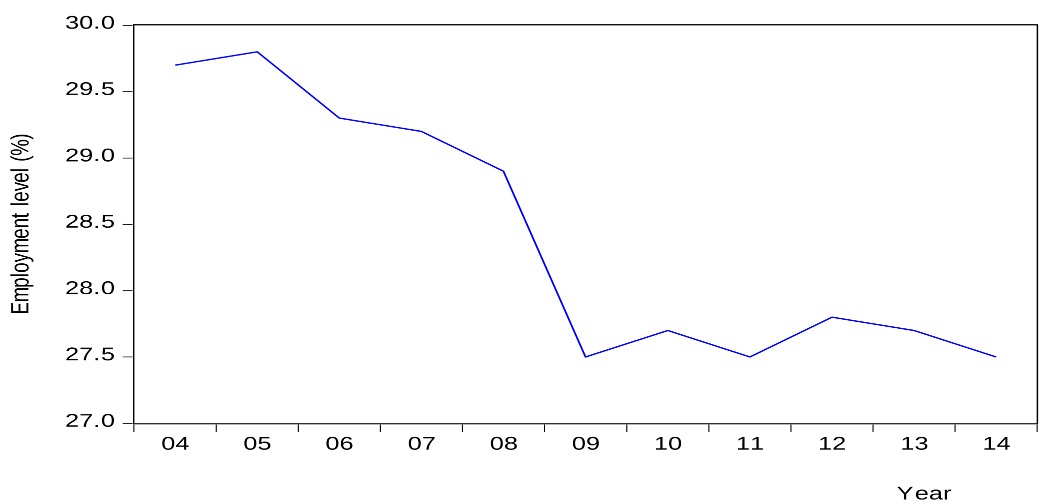
(i) Exports/International Trade

Exports from Russia amounted to US$331.5 billion in 2015, down -35.5% since 2011 and -33% from 2014 to 2015. Russia's top 10 exports accounted for 70.3% of the overall value of its global shipments. Based on statistics from the International Monetary Fund's World Economic Outlook Database, Russia's total GDP amounted to $3.474 trillion in 2015. Therefore, exports accounted for about 9.6% of the country's total economic output. 57.1% of Russian exports by value are delivered to European countries while 35.6% are sold to Asian importers. Another 3.2% is shipped to North America. Given Russia's population of 142.4 million people, its $331.5 billion worth of exports in 2015 translates to roughly $2,342 for every resident. Unemployment was recorded at 5.8% in December 2015 (Trading Economics, 2016).

(ii) Employment from 2004 - 2014

The employed are the total number of employees who work in the private or public sectors and receive payment in salaries, wages, commission, tips, piece rates, or pay in kind. The industrial sector in Russia includes mining and quarrying (including oil production), manufacturing, construction, and public utilities (electricity, gas, and water). Employment in the manufacturing industry in Russia was measured at 27.90% in 2009.

Figure 2.5: Manufacturing employment, 2004 to 2014



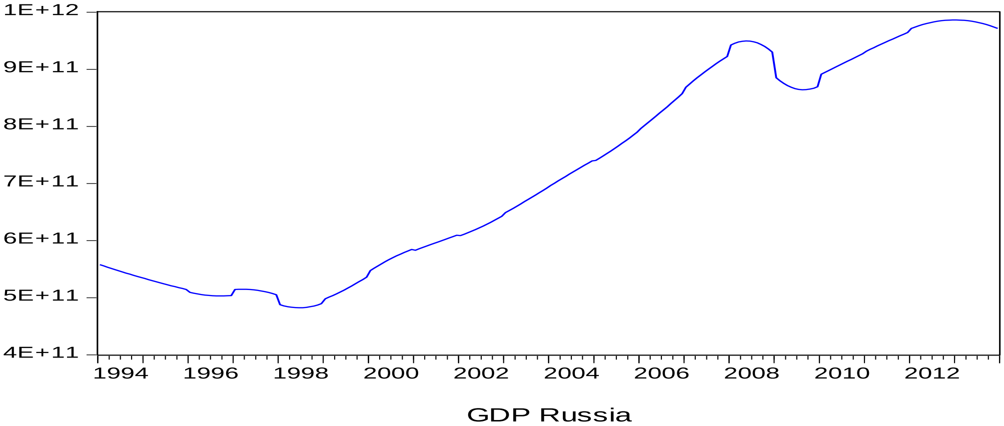
Source: Author's computation from WDI and FSSS data

Figure 2.5 shows the trend in manufacturing sector employment growth in Russia from 2004 to 2014. It reveals that manufacturing employment has fluctuated over the years, growing between 2004 to 2005, but declining from 2006 to 2009. It picked up in 2010 and moved downward and upward from 2011 to 2014. A high level of job losses was recorded during the global recession (2009).

(iii) Gross Domestic Product (GDP)

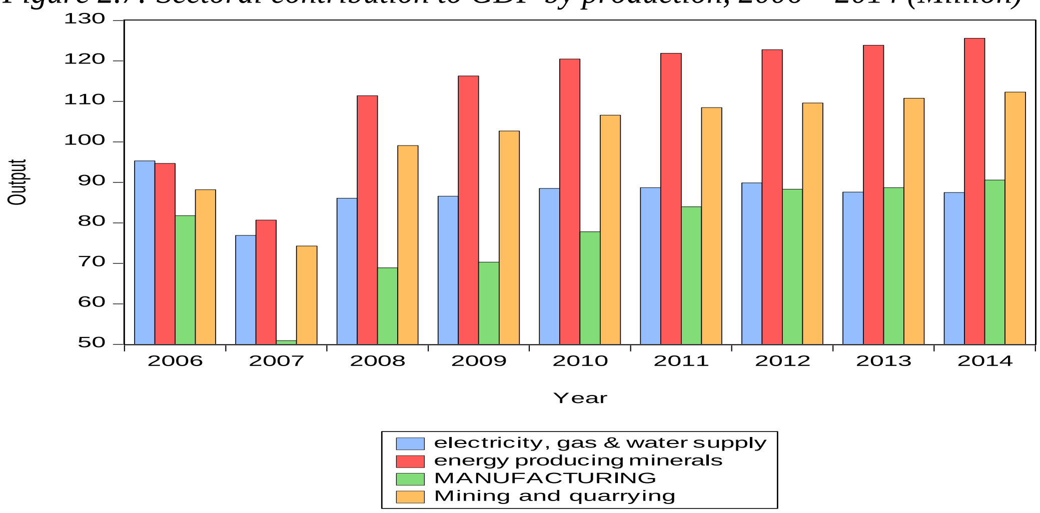
The Federal State Statistics Service (FSSS) and the World Bank publish GDP figures for Russia on an annual and quarterly basis.

Figure 2.6: Trend of GDP Growth, 1994 – 2013



Source: Author's drawing from FSSS data

Figure 2.7: Sectoral contribution to GDP by production, 2006 – 2014 (Million)



Source: Author's computation from FSSS data

As shown in figure 2.6, GDP contracted by 1.2% year-on-year from 1994 to 1998 before picking up gradually on an upward trend due to a drop in public consumption. However, this followed a decline of 3.8% in 2008 due to the global recession. Although it was reported that Russia's GDP was approximately US$1326.02 billion dollars in 2015, the country's exports decreased by 5.6% in the same year. Russia's GDP represents 2.14% of the global economy.

Figure 2.7 shows the sectoral contribution to GDP in Russia from 2006 to 2014. It reveals that the services sector (electricity, gas and water supply) and the energy producing and minerals sectors made the highest contributions to GDP.

2.10 An Overview of the Industrial Sector in India

The industrial sector in India has witnessed significant growth over the past few years, driven by increased investment in infrastructure and manufacturing production (Ahluwalia, 2002). The industrial sector, that is associated with the manufacturing sector, is of international significance to India's economy. In seeking the status of a global giant, India has expanded its manufacturing sector. The Government of India established the National Manufacturing Competitiveness Council (NMCC) to increase growth in manufacturing output and the sector's contribution to GDP by 2025. The sector's competitiveness is driving its growth. For instance, in 2010, India was ranked second in the world on the global manufacturing competitiveness index released by the US Council on Competitiveness and Deloitte. The country maintained this position for five years and continued to dominate the global manufacturing sector, setting benchmarks in global markets in terms of quality manufacturing after Japan. The growth of India's manufacturing sector outstrips that of other BRICS countries, which could be associated with the strength of the Indian domestic market.

The country's manufacturing sector contributes 16% to real GDP and employs about 12% of its workforce. Growth in this sector has matched the overall GDP growth rate in recent years. India's strong growth rate has been linked to changes in the nature of the country which evolved from a public sector dominated set-up to a more private sector driven, global economy with the aim of boosting industrial output.

2.10.1 Industrial Sector Reform in India

Economic development is the main objective of the Indian government. The government has identified industrial development as a priority. In 1951, the Indian government announced that the country had to become an industrialized nation as quickly as possible in order to meet the needs and growth of the economy. Sharma (2014) notes that industrialization plays an important role in the growth of developing countries since it enables them to resolve the problems of unemployment, poverty, backwardness, low productivity and a low standard of living, among others. India adopted a post-independence industrial plan that emphasized industrialization as an important instrument for sustained economic growth.

Prior to 1980, the industrial reform plan focused on large-scale industries under state ownership and central planning. It also embraced import substitution, rigid price systems and a total restriction on private ownership. This policy was successful in that in the mid-1980s, there was substantial growth in the industrial sector as compared to the late-1970s and 1960s when long-term constraints on India's economic growth were recorded. The new industrial reform policy sought to reduce state control of output and investment and relax trade license requirements. Moreover, import duties were dropped on a wide range of industrial inputs and foreign investment was liberalized in the 1990s. This policy reform was successful and industrial output growth was boosted. However, the policy was confronted by infrastructural impediments and fluctuations in the overall economic outlook.

In the 2000s, the tenth plan for industrial development was launched to build on past achievements and to accelerate the global competitiveness of Indian industry. It recognized the strength of this sector as a locus to stimulate economic growth. The main thrust has been to increase the domestic and international competitiveness of the industrial sector and its contribution to GDP. Significant improvement in industrial production led to growth in output increasing from 5% in the 1990s to 9.4% during the period 2006 to 2007 (Reddy and Chittedi, 2007).

Finally, an eleventh industrial plan (2007 – 2012) was adopted to achieve the 10% annual growth rate that was targeted in the tenth plan. Industrial reform is currently being re-oriented to support vibrant private sector participation in order to achieve maximum output growth, employment generation and an improved standard of living. This has been largely successful and overall, the industrial growth rate in India has been on a high trajectory.

2.10.2 An Overview of the Performance of the Industrial Sector in India

Industrial production in India as measured by the Index of Industrial Production (IIP) provides an understanding of the link between industrialization and development. Industrialization represents a shift from agricultural to industrial production. This occurs when investment focuses on the manufacturing sector. It is generally acknowledged that this type of investment has positive externalities that go far beyond the productivity gains achieved in other sectors, and makes a significant contribution to productivity and growth in other industries, thus stimulating overall economic growth. In India, the performance of the industrial (manufacturing) sector can be measured in terms of its contribution to (i) exports/international trade, (ii) employment, and (iii) GDP.

(i) Exports/International Trade in India

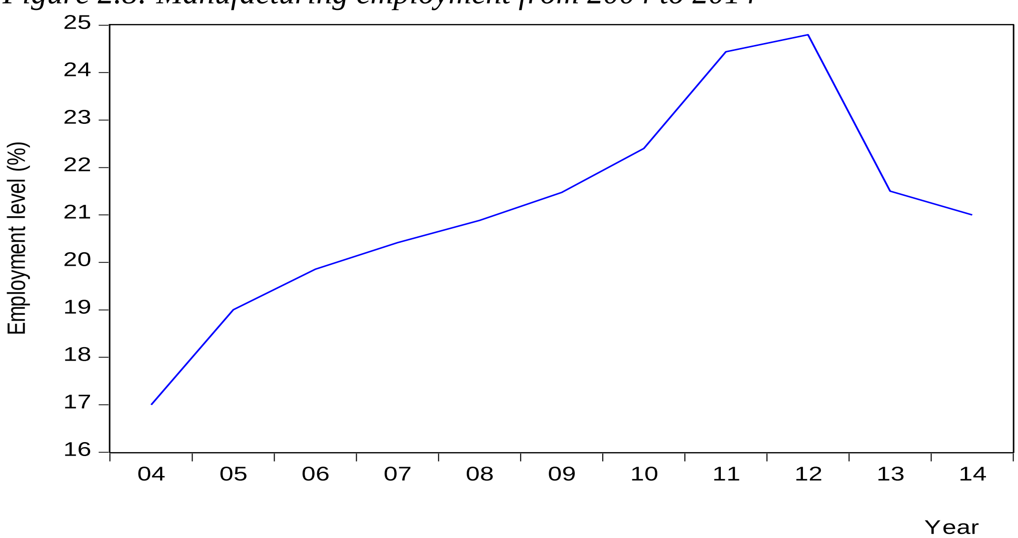
Exports from India amounted to US$264 billion in 2015. However, total exports were down by 12.4% since 2011 and by 16.9% from 2014 to 2015. India’s top 10 exports accounted for 58.1% of the overall value of its global shipments. Based on statistics from the International Monetary Fund’s World Economic Outlook Database, India’s total GDP amounted to $8.027 trillion in 2015. Therefore, exports accounted for about 3.3% of total economic output. 49.4% of Indian exports by value are delivered to Asian countries while 18.7% are sold to European importers. India ships another 17.1% of its exports to North American customers with 9.7% of the exports arriving in Africa. Given India’s population of 1.252 billion people, its total value of US$264 billion in exports in 2015 translates to about $211 for every resident. According to the CIA World Fact Book, the country’s unemployment rate stood at 7.1% in 2015.

(ii) Employment from 2004 - 2014

Employment has featured as one of the most important items on the development agenda in India. Approaches to achieve this have varied significantly during different periods in the past 30 years. In the initial years of development planning, the vision was for a reasonably high economic growth rate together with an emphasis on labour intensive sectors like small-scale industry. Labour intensive production was favoured to generate jobs. However, comprehensive data on consumption, employment and unemployment released by the National Sample Survey Organization (NSSO) in the 1970s revealed high poverty rates, resulting in the official approach changing in favour of employment intensive sectors and the launch of various employment and poverty alleviation programmes. These were generally of two types: financial and other assistance for productive self-employment, and offering supplementary wage employment to the underemployed. These programmes were largely successful and have been modified by successive governments. However, the employment challenge in India involves not only generating employment for the unemployed, and providing alternative jobs to the underemployed, but also increasing productivity and income levels. This resulted in a shift to the modern industrial (manufacturing) sector.

Figure 2.8 shows the trend in manufacturing sector employment in India from 2004 to 2014. It reveals that manufacturing employment was on an upward trend from 2004 to 2012. Naudé *et al* (2013) note, that, India is the only country in BRICS where manufacturing employment's share of total employment increased marginally. However, it declined from 2013 to 2014 when large job losses were recorded due to massive revenue losses and almost 20% losses in electricity transmission and distribution (T&D).

Figure 2.8: Manufacturing employment from 2004 to 2014

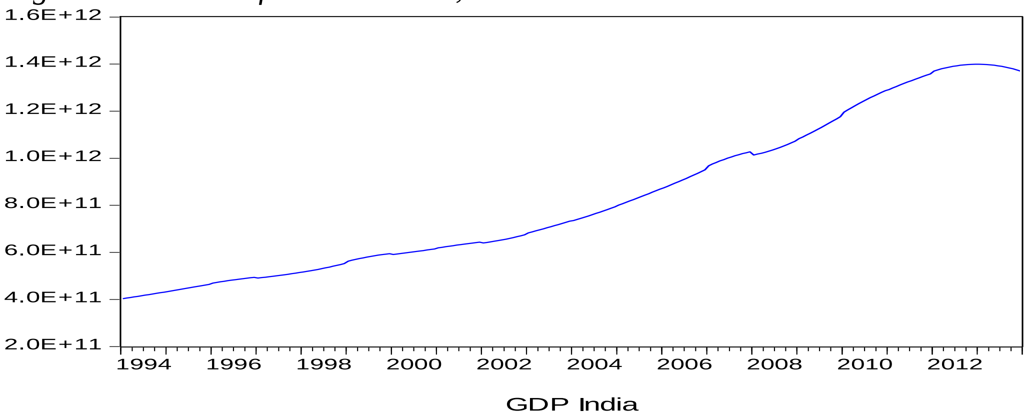


Source: Author's computation from World Bank data

(iii) Gross Domestic Product (GDP)

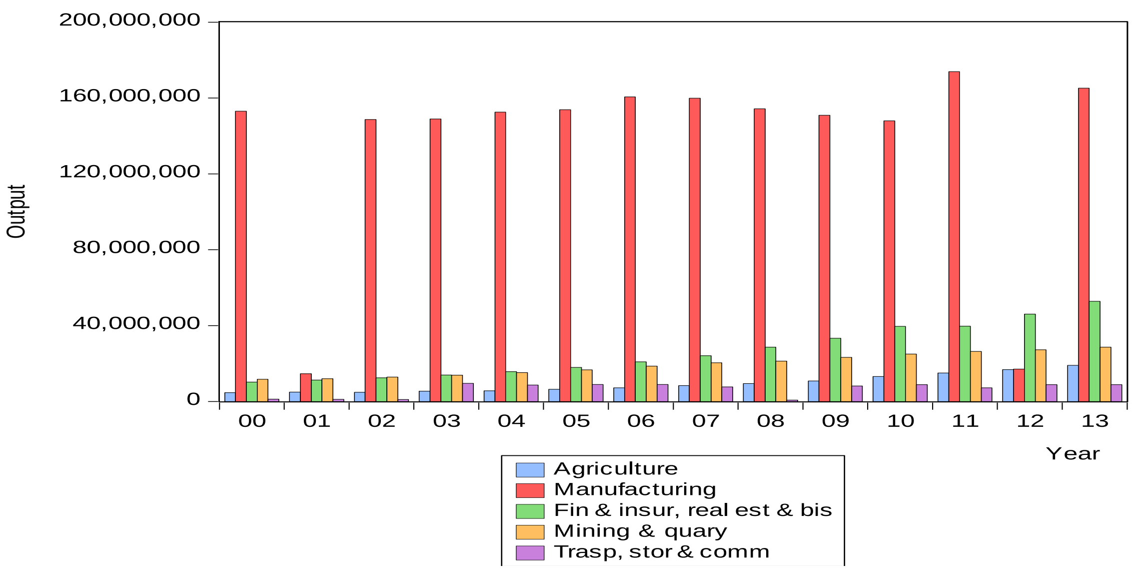
India's GDP represents 3.34% of global aggregate GDP. According to the Ministry of Statistics and Programmes Implementation (MOSPI) and the World Bank, GDP in India was estimated at US2073.54 billion dollars in 2015. In 2016, the Indian economy grew by 7.9% year-on-year in the first three months compared to 7.2% in the previous quarter. Figure 2.9 shows that the India's economy has enjoyed a stable growth rate. This confirms the claim of Naudé *et al*. (2013) that India is the only country where the share of manufacturing value added to GDP increases considerably and consistently.

Figure 2.9: Trend of GDP Growth, 1994 – 2013



Source: Author's drawing from MOSPI data

Figure 2.10: Sectorial contribution to GDP by production, 2000 – 2013



Source: Author's computation from MOSPI and World Bank data

The figure 2.10 shows various sectors' contributions to GDP from 2000 to 2013. It further confirms Naudé *et al*'s (2013) observation that "India is the only country among the BRICS where the share of manufacturing in the country's GDP has increased significantly. In other countries in the bloc, there are marginal declines, evidence of declining trend of manufacturing sector contribution to GDP (dis-industrialization)". Among other major sectors in India, finance and insurance, real estate and business as well as mining and quarry have recorded increased contributions to GDP. On the other hand, the agriculture, transport, storage and communication sectors have recorded fluctuating trends and have made a very small contribution to GDP.

2.11 An Overview of the Industrial Sector in China

China has an industrialized economy, with most economic activities highly dependent on industries and their products. The country has among the most diverse industrial production in the world and its goods and services spread are exported across the globe. Industrial output has increased rapidly and contributed 44.4% value added to GDP in 2015. Having gone through several economic and industrial reforms with the aim of stabilizing the economy, China's industries recorded large gains in output, employment and exports (Rawski, 1994). The industrial sector in China comprises the mining, manufacturing, automobile, agriculture, energy, and steel and services industries.

China's manufacturing sector has enjoyed fast growth and is among the top performers in the world with a clear comparative advantage over other countries (Banister, 2007). The manufacturing is the backbone of the economy and the centre of economic growth. It is the main channel for employment creation in cities and towns and gives the country its competitive edge. According to Bannister (2005), the private manufacturing sector has thrived in both urban and rural areas since the late 1990s due to collaboration between foreign funded and locally owned companies.

However, Banister and Cook (2011) note, that the global downturn of 2008 depleted the Chinese export market resulting in a decline in employment and manufacturing output. Employment in the sector has improved gradually since 2009 and currently shows fast development. The reforms adopted in this sector serve as the basis for economic transformation.

2.11.1 Industrial Sector Reform in China

China's industrial sector reform has come a long way. From the 1950s to the 1970s, obsolete technology hampered progress. In 1978 the country embarked on industrial sector reform termed "Socialism with Chinese characteristics", which brought about significant increases in industrial output. The reforms occurred in two stages. The first entailed moving from agriculture to a modern industrial sector. The manufacturing sector was opened up and focused on developing China's best assets such as coal, textiles and manufacturing. Industrialists were granted permission to start businesses and invest in the country. To broaden the process, manufacturing reforms were also introduced in the rural areas of the country. However, most industries remained state-owned, which limited the success of this stage.

The second stage in the 1980s to 1990s involved privatizing and contracting out of most state-owned industries to correct the anomalies in the first stage. Price controls were removed, embargoes were lifted and protectionist policies and regulations were abolished. This resulted in an immense change in economic activities and the private sector (both domestic and foreign) grew significantly, accounting for as much as 70% of China's GDP by 2002 (Allen *et al.,* 2005). Indeed, China overtook Japan as the largest economy in Asia. However, despite these successes, some state monopolies persisted in sectors such as petroleum and banking as well as other important industries.

A further round of holistic industrial sector reform was launched in 2005 and is still underway. It aims to totally liberalize this sector. A more accommodating monetary policy was adopted in order to ease the cost of doing business in the country. Steps were also taken to limit the appreciation of the Renminbi (RMB) against the US dollar (Morrison and Labonte, 2013) and an increase in money supply. China pegged its currency against the US dollar until 2005 when it moved to a managed peg system to allow the currency to gradually appreciate until 2008.

However, appreciation of the RMB was halted in 2010 due to the effect of the global financial crisis. On 19 June 2010, the Central Bank of China adopted a flexible exchange rate regime in order to enhance its value. This aims to support the growth of the industrial sector and avoid sharp fluctuations in the exchange rate. It is believed that a stable exchange rate will reduce uncertainty; investors will be in a better position to make long-term investment decisions and industrial output growth will be boosted.

2.11.2 An Overview of the Performance of the Industrial Sector in China

According to the National Bureau of Statistics of China (NBSC), industrial production averaged 12.59% between 1990 and 2016. It rose by 6.2% in June 2016, higher than the 6% growth recorded in May 2016. Manufacturing output grew by 7.2% in 2016, followed by electricity, gas and water supply that all grew by 4%. While the mining sector contracted by 2.4%, investment by private firms rose by 2.8% year-on-year, slowing down from 3.9% growth between January and May 2016. The performance of the industrial sector can be measured in terms of its contribution to (i) exports/ international trade, (ii) employment, and (iii) gross domestic product.

(i) Exports/International Trade

Exports from China amounted to US$2.282 trillion in 2015, an increase of 20.2% since 2011, but 2.6% less than the level recorded between 2014 and 2015. China's top 10 exports accounted for 67.6% of the overall value of its global shipments. The International Monetary Fund's World Economic Outlook Database shows that its total GDP amounted to $19.51 trillion in 2015. Therefore, exports accounted for about 11.7% of total economic output. 50.3% of Chinese exports by value are delivered to Asian countries while 20.8% are sold to other Asian importers. China ships another 17.7% to North American clients and 4.8% to Africa. Given China's population of 1.367 billion people, its exports valued at US$2.282 trillion in 2015 translates to roughly $1,669 for every resident. According to Trading Economics, the unemployment rate was 4.05% in December 2015.

(ii) Employment from 2004 - 2014

China is the most populous country in the world with a very large workforce. Employment is thus the government's first priority. This informed the need for in industrial reforms and technological innovation. The government has implemented various industrial policies to promote employment and achieve sustainable economic growth. These include adjusting the industrial structure, harmonizing economic development between rural and urban areas, reforming its political and economic system and improving social security, among others. According to the World Bank (2015), employment in the manufacturing sector has been on an upward trend (see Figure 2.11). However, during the global recession (2008 – 2010), employment declined marginally, with a high number of job losses. Conversely, manufacturing employment reached its highest peak in 2011, but declined from 2012 to 2014 due to massive indebtedness among companies.

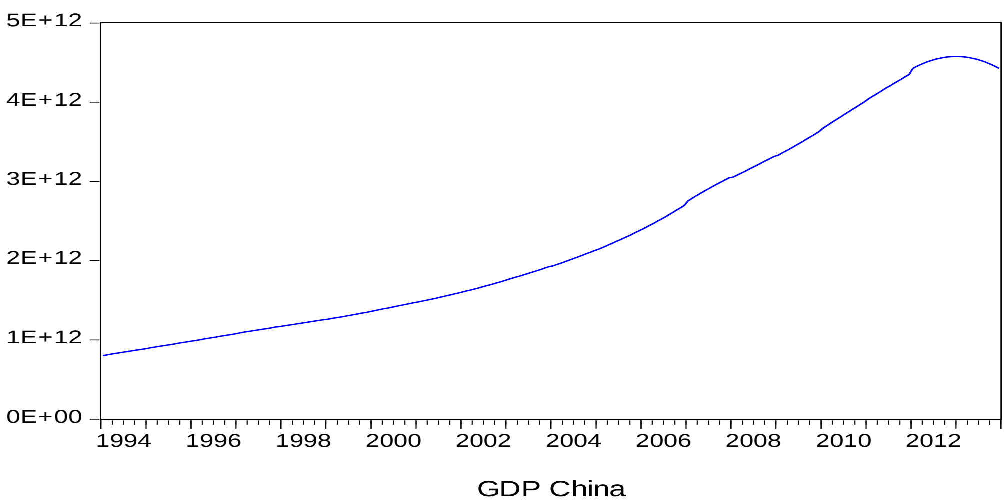
Figure 2.11: Manufacturing employment from 2004 to 2014

Source: Author's computation from WDI data

(iii) Gross Domestic Product (GDP)

The National Bureau of Statistics (NBS) of China records China's annual GDP growth rate and the World Bank Group also reports on GDP growth.

Figure 2.12: Trend of GDP Growth, 1994 – 2013

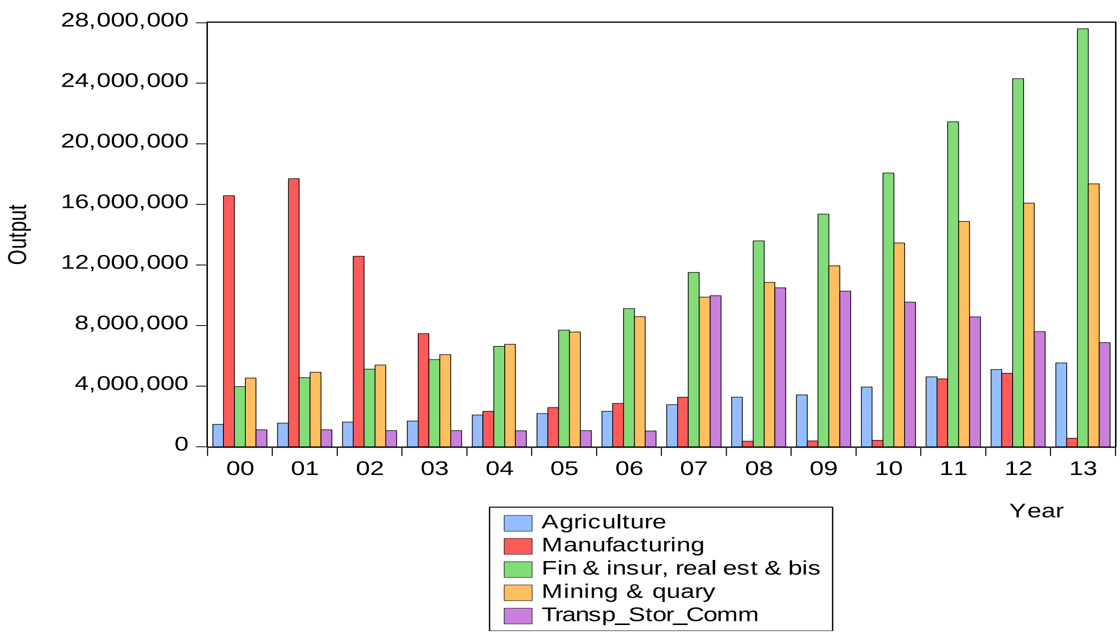


Source: Author's drawing from NBS data

Figure 2.12 show the trend of GDP growth in China from 1994 to 2013. China been the most industrialized country among the BRICS also trend on a positive note. GDP was estimated at US10866.44 billion dollars in 2015. This represents 17.53% of the global economy, with China being the second largest economy after the US. Driven by a rapid increases in industrial output, Chinese real GDP grew by 7.3% in 2014. However, it declined by 6.9% in 2015 and at the same rate in 2016.

Figure 2.13 shows sectoral contributions to GDP in China for the period 2000 to 2013. It reveals that the finance and insurance, real estate and business sectors made the highest contributions to GDP while the manufacturing sector's share declined from 2002 - 2013.

Figure 2.13: Sectoral contribution to GDP by production, 2000 – 2013



Source: Author's computation from NBS and World Bank data

2.12 An Overview of the Industrial Sector in South Africa

The industrial sector is a labour absorbing segment of an economy, including agriculture, construction, banking, fisheries, forestry, mining and manufacturing. It should serve the needs of citizens and stimulate economic growth and sustainable development. According to Trapido (1971), the peculiarities of South African society, where class, ethnic, linguistic and national cleavages overlap, tend to obscure the process that led to industrialization. The Chamber of Mines of South Africa (2000) notes that the discovery of rich deposits of diamonds and gold laid the foundation for the transformation of the South African economy from an agricultural to a more modern industrialized economy. Simon (2003) states, that, that the growth of an economy depends on the growth and survival of industries and firms. The South African economy is open to industrialization; the government's transformation agenda is thus achievable if policy is well implemented.

The agricultural and manufacturing sectors in South Africa have growth potential. However, Rodrik (2008) notes, that, the country's economy is more open to international trade and that this opens the manufacturing sector up to increased competition, irrespective of whether firms are import or export-oriented. On the flip side of the coin, there are numerous investment opportunities in South African businesses the market for the country's goods could expand to Africa and other countries. The success of the industrial sector in developing countries largely depends on how well enterprises manage technological processes (Lall, 2003). The traditional model of comparative advantage also determines the rate of growth (Ros, 2000, 2001). The specialization pattern in manufacturing and production will also determine economic growth.

2.12.1 Industrial Sector Reform in South Africa

A sound and competitive industrial sector is important for the overall performance and growth of an economy. Globally, the industrial sector has experienced revolutionary change in the past two decades ranging from nationalization, to deregulation, privatization, liberalization and technological innovation. The South African case is no different and various reforms have been implemented in both the public and private sectors to address market failures or anti-competitive behaviour that can have negative implications for productivity, efficiency, consumer welfare and economic growth.

Joffe (1995) identifies three key policy variables in South Africa's industrial policy framework: (i) fostering the role of market incentives, (ii) strengthening underlying capacities in human resources and technology and (iii) providing appropriate industrial institutional environments to facilitate industrial restructuring. In December 1995, the South African government announced plans for privatization initiatives to transform the economy and address joblessness as well as reduce government debt and readjust the state's role in the economy (Habib and Padayachee, 2000).

The country's agricultural sector has also witnessed a shift to mechanization. A number of shifts have taken place in this sector, including changes in marketing structures and trade liberalization that included the deregulation of marketing through revision of the Marketing Act of 1968 and other legislation, including large parts of the farming sector; a change in tax treatment of agriculture, reduced income tax concessions and subsidies to farmers which previously led to over investment in capital equipment; a decrease in direct budgetary expenditure on agriculture as subsidies became unsustainable; and the ratification of farm commodities (Sandrey and Vink, 2012). According to Stats SA, about 63 000 formal non-agricultural jobs were created between April and October 2010 in line with the drive to improve productivity, increase exports and create jobs. Porter (1990) states, that, national policies and reform should seek to create an environment characterized by demanding consumers, domestic competition, strong supplier linkages, and good infrastructure.

Guided by the National Industrial Policy Framework (NIPF) adopted in 2007 by the Cabinet, the industrial policy for growth and development was set out in the Industrial Policy Action Plan (IPAP 1) to generate a new industrialization path, promote a labour-absorbing industrial sector and intensify the sector's contribution to ensuring that South Africa becomes a knowledge economy. The IPAP 2 for 2010/11 – 2012/13 was adopted in 2010. It set out key interventions over a three-year rolling period, updated annually, with a 10-year outlook for desired economic outcomes (Department of Trade and Industry policy document, 2010).

The government's (policymakers including the monetary authorities) contribution to job creation has been to develop a policy package to facilitate employment and promote an environment for private sector growth and investment. Government also makes a direct contribution through public-sector hiring and targeted job-creation programs. The New Growth Path (NGP) launched by the Ministry of Economic Development in November 2010 aims to create 5 million jobs over 10 years and to broaden the market for South African goods and services. The following sector targets and job drivers are identified in this document:

- Infrastructure development and housing – 250 000 jobs a year by 2015;

- Agriculture and agro-processing – 500 000 jobs per year by 2020;
- Mining – 140 000 jobs per year by 2020;
- Manufacturing (IPAP) – 350 000 jobs per year by 2020;
- Tourism – 225 000 jobs per year by 2020;
- "Green economy", "knowledge economy" and "social economy" – 660 000 jobs per year by 2020;
- Health, education and policing – 100 000 jobs per year by 2020;
- Regional integration – 150 000 jobs per year by 2020.

Furthermore, the IPAP 2013/14 - 2015/16 (IPAP 3) was launched to contribute to industrial development in Africa with a focus on infrastructure, productive capacity and regional integration (Department of Trade and Industry policy document, 2013). It is informed by the long term vision of the National Development Plan (NDP) and complemented by and constitutes a key pillar of the programs set out in a series of 'drivers' and 'packages' in the NGP. Government policies set out in the IPAP and other documents include:

- diversify the economy: provide strong support for value added manufacturing, especially in globally competitive non-traditional tradable goods and services;
- Promote a labour-absorbing industrialization path with systematic employment creating linkages;
- An industrialization model focused on the inclusion of historically disadvantaged people and regions;
- Contribute to industrial development in Africa, focusing on infrastructure, productive capacity and regional integration;
- Long-term intensification of South Africa's industrialization process and movement towards a knowledge-based economy.

2.12.2 Overview of the Performance of the Industrial Sector in South Africa

In South Africa, industrial production measures the output of businesses in the manufacturing sector. Industrial production data are reported by Statistics South Africa. South Africa's industrial production averaged 1.7% growth in May 2013, after reaching an all-time high of 10.4% in May 2002, and a record low of -23.2% in April 2009 due to the global recession. In view of this, there is a need for comprehensive industrial strategic planning for the strategic positioning of the economy. According to Kholopane (2008), when human resource practices are applied properly in an integrated fashion, they will promote machine efficiency and hence increase a company's productivity. The performance of the industrial sector can be measured in terms of its contribution to (i) exports/international trade, (ii) employment, and (iii) gross domestic product.

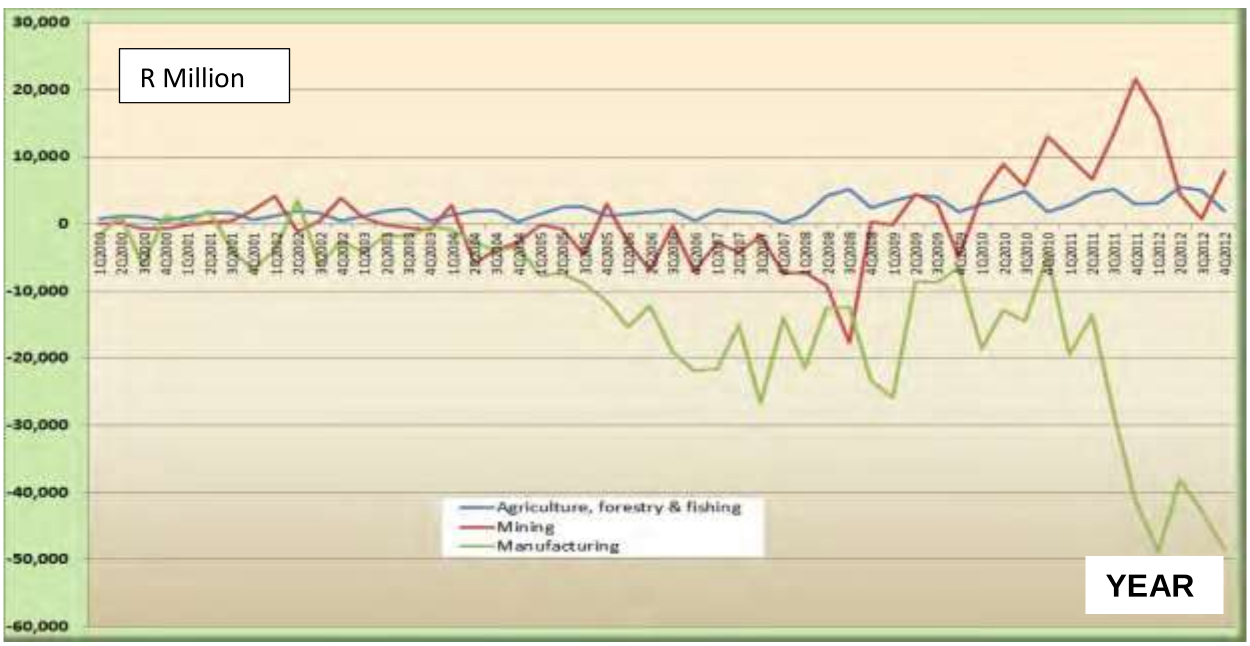
(i) Exports/International Trade

The South African government policies combine the pursuit of export led growth and trade liberalization (Bhorat *et al*., 2002). However, growth has been slow in Africa's largest economy as a result of the 2010/2011 depression in the Euro zone (one of South Africa's major trading partners) and labour unrest in the country's mining sector. According to Kaplan (2004), lower growth rates are also manifested in the poor export performance of the industrial (manufacturing) sector in South Africa. Over the past two decades, South Africa's share of global and developed countries' manufactured exports has declined. The mining industry continues to operate under severe pressure; these problems were aggravated by events at the Lonmin Platinum Mine in Marikana in August 2012, when a wage dispute turned violent and the South African Police Service opened fire on protesting miners (Albert and Sing, 2013). However, production gradually resumed towards the end of the fourth quarter of 2012.

South Africa's exports and imports of agricultural products grew significantly in past decades, which can be attributed to farmers' quick adjustment to the effects of deregulation (Liebenberg and Pardey, 2010). Productivity grew rapidly at 3.98% in the 1980s due to mechanization of farming processes and the use of fertilizers, herbicides and pesticides, among others. Farmers were no longer severely constrained by state intervention and inputs were less costly after the deregulation of the sector (Thirtle and Von Bach, 1993). After 1994, the growth rate improved due to positive net farm income (Wiebe *et al.*, 2001), but became stagnant around 2008 due to declining output growth and increasing use of inputs (Conradie *et al.,* 2009). It turned positive from 2010 as shown in the trade balance sector (see figure 2.10). However, unlike most developed economies, the services sector represents less than 40% of economic output; with mining represents about 8% and accounting for almost 50% of export revenue. Intermediate goods represent 20% of export revenue; and capital goods and intermediate goods represent almost 40% and more than 18% of imports, respectively (Devarajan and Van Der, 2000). The growth of the manufacturing sector has been varied and has followed the trend shown in figure 2.14 from 2000: Q1-2012: Q4. The following conclusions can be reached regarding industrial export growth in South Africa:

- South African manufacturing/industrial exports are relatively capital or technology intensive compared to other developing countries (Tsikata, 1999; Allenye and Subramanian, 2001).
- South African manufacturing/industrial exports are becoming increasingly capital and skill-intensive (Bell and Farrel, 1997; Edwards and Schoer, 2002).
- South African export growth during the 1990s is poor relative to other emerging economies and few exports are concentrated in 'dynamic' products (Edwards and Schoer, 2002; Alves and Kaplan, 2004; Van Seventer and Gibson, 2004).

Figure 2.14: Trade balance by sector (R Million) Q1 2000 – Q4 2012

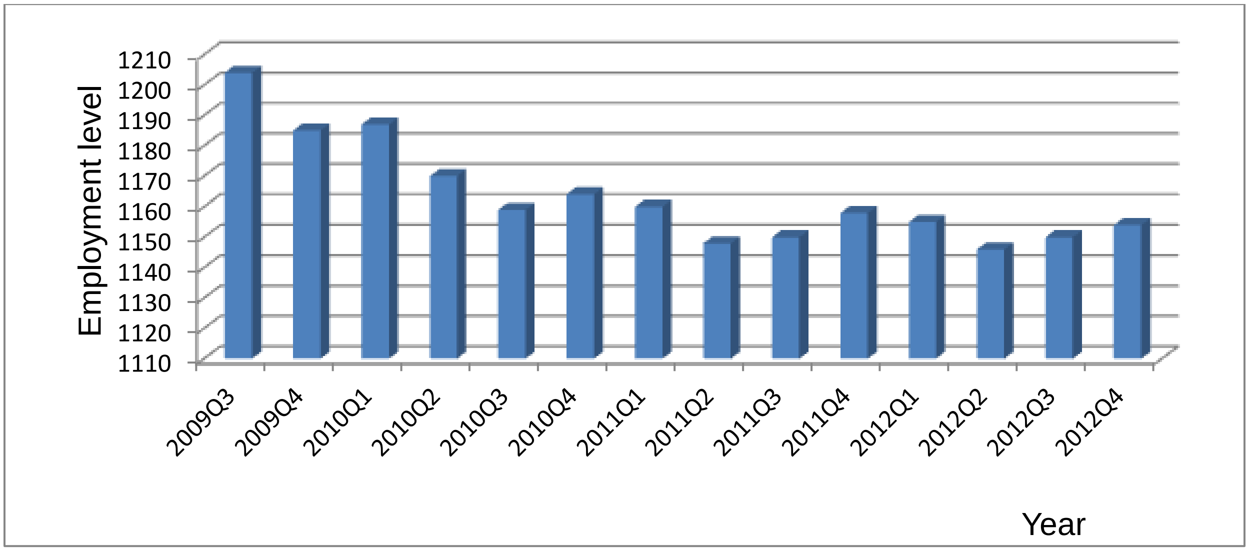


Source: Quantec

(ii) Employment from 2009 - 2013

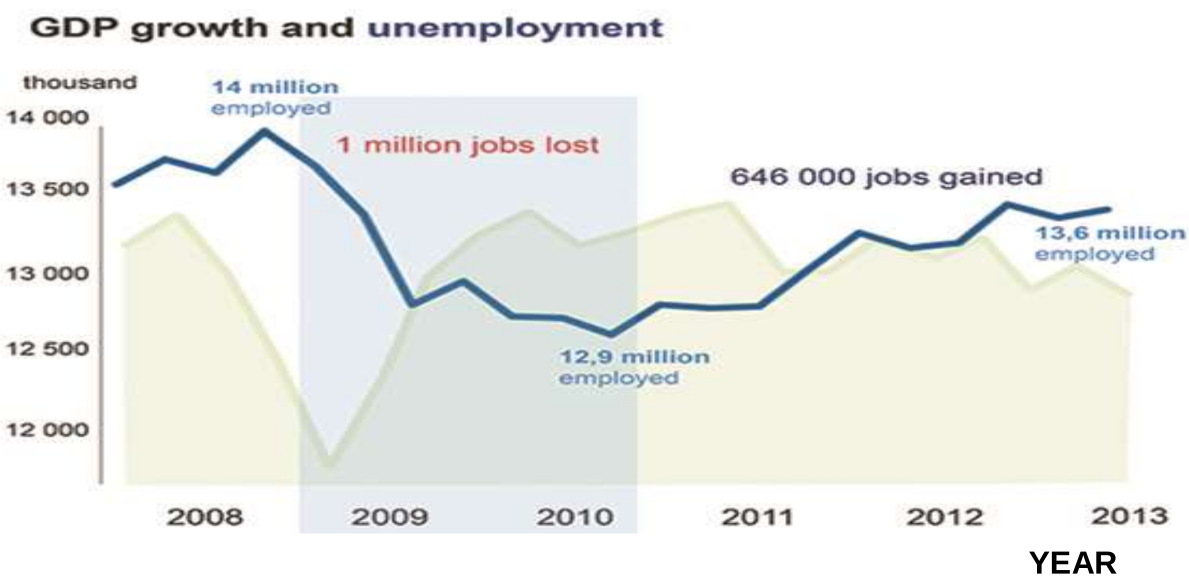
The low rates of growth in the manufacturing sector, and particularly low rates of growth in labour-intensive sectors, combined with rising capital intensity overall to result in consistent declines in manufacturing sector employment. Prior to 1990, industrial/manufacturing sector employment exhibited a slow but persistent rise, with cyclical fluctuations. Since 1995, manufacturing employment has been on a persistent downward trend that has not reversed even in the upsurge (Kaplan, 2004). With the very rapid rate of manufacturing growth between 2001 and 2002, manufacturing employment rose marginally.

Figure 2.15: Manufacturing employment, Q3 2009 to Q4 2012 ('000)



Source: Author's computation from Stats SA data

Figure 2.16:



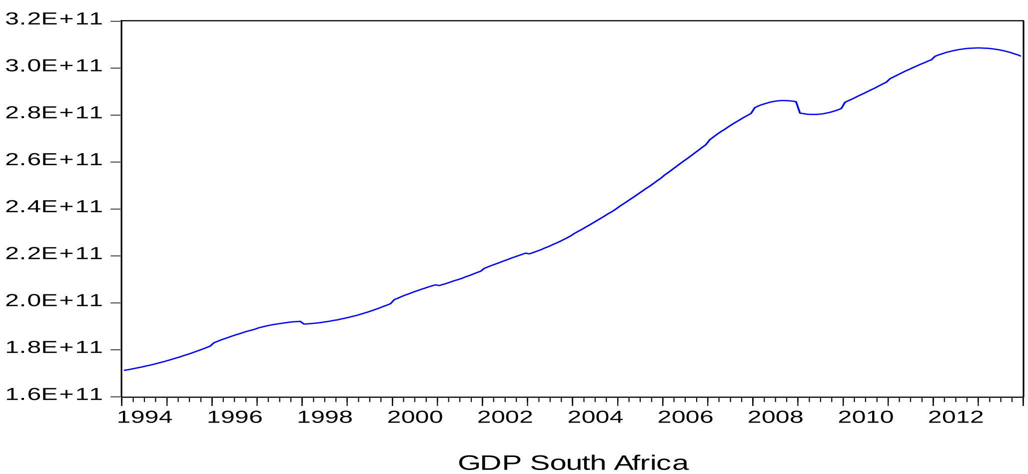
Source: Statistics South Africa

However, it fell significantly in 2003. This downward trend persisted during the global recession (2008-2010) but there was a turnaround in the first quarter of 2012. Recent figures from Statistics South Africa show that the unemployment rate has changed marginally from 25.2% (2013 first quarter estimate) to 25.60% (2013 second quarter estimate) and 24.70% (2013 third quarter estimate). Figure 2.15 shows the trend in the employment rate in the manufacturing sector from 2009: Q1 - 2012: Q4, while figure 2.16 presents total growth rates and the total employment rate in the economy. Between 2009: Q3 - 2009: Q4, about 19,000 jobs were lost in the manufacturing sector due to the impact of the global recession. The trend in this sector has been varied but has become more stable since the second quarter of 2012.

(iii) Gross Domestic Product (GDP)

Statistics South Africa publishes GDP estimates every quarter and the total annual growth rate every year. According to the data released and shown in Figure 2.17, the GDP contracted during the global recession. However, it picked up at the end of 2010. The first quarter report of 2013 (January to March), the GDP growth rate slowed to 0.9% compared to the previous quarter (October to December 2012) that showed an annualized growth rate of 2.1% and 3.2% in the fourth quarter of 2011 (Joana, 2013) after the global recession. Before the global financial crisis of 2008, the South African economic growth rate was much higher (on average more than 5% per year).

Figure 2.17: Trend of GDP Growth, 1994 – 2013

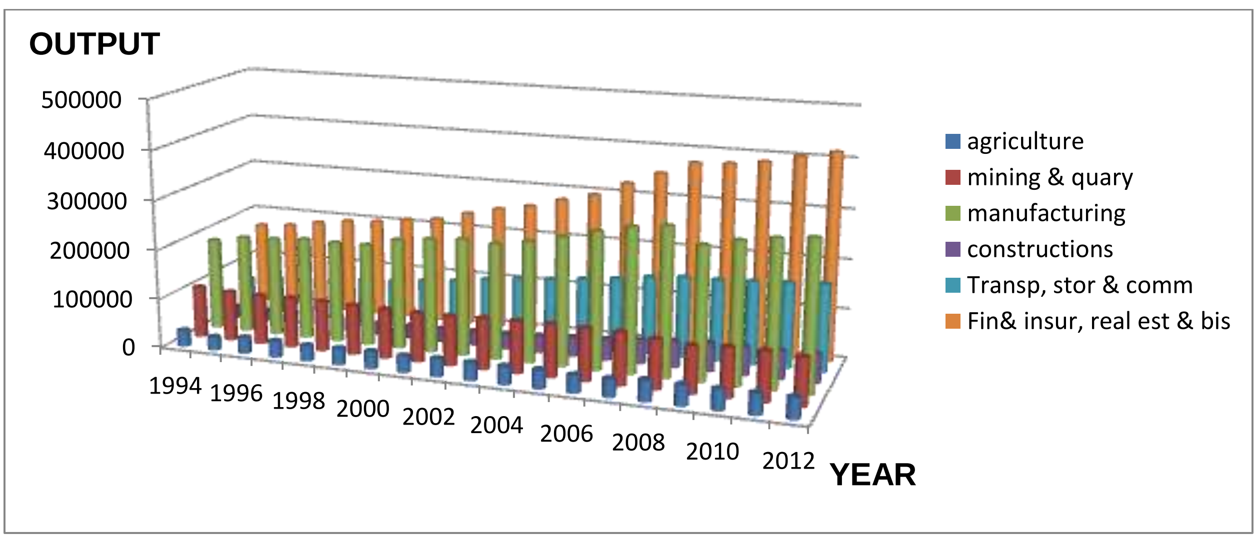


Source: Author's drawing from data released by Statistics South Africa

Figure 2.18 shows sectorial contributions to GDP from 1994 to 2012. The agricultural and construction sectors made the lowest contributions while the financial sector made the highest, followed by the manufacturing sector. According to OECD (2006), agriculture contributes less than 4% to GDP but accounts for 10% of total reported employment. Aggreko (2012) notes, that, the construction sector has a workforce of about 430,000. The largest contributors to growth in the first quarter of 2013 were the finance, real estate and business services sectors, which expanded from R7 billion in the last quarter of 2012 to about R161 billion in the first quarter of 2013. According to Stat. SA, the following sectoral figures contributions to GDP are released:

- Agriculture, forestry and fishing expanded from R4 billion in the fourth quarter of 2012 to R14 billion in the first quarter of 2013
- Construction expanded from R4 billion in 2012 to R31 billion in 2013
- Wholesale, retail and motor trade and catering and accommodation decreased by R15 billion to R115 billion in 2012
- Transport, storage and communication decreased by R5 billion in the third and fourth quarters of 2012, to R63 billion in the first quarter of 2013
- Mining and quarrying decreased by R3 billion in the last quarter of 2012 to R63 billion in the first quarter of 2013.

Figure 2.18: Sectorial contribution to GDP by production, 1994 – 2012 (R Million)



Source: Author's computation from SARB data

The key findings for the second quarter of 2013 released by Statistics South Africa show that:

- The manufacturing industry contributed 1.7% to GDP based on a growth rate of 11.5%
- Finance, real estate and business services contributed 0.8% to GDP based on growth of 3.5%; and
- The wholesale, retail and motor trade, catering and accommodation industries contributed 0.4% based on growth of 3.2%.

2.13 Challenges Facing the Industrial/Manufacturing Sector in BRICS countries

In recent years, industries (manufacturing) have been facing serious organizational challenges brought about by a number of factors in both the international and domestic markets. The challenges faced by the industrial sector and the generally poor relative aggregate output in BRICS countries are due to:

- Stiff competition: Globalization creates increased competition local industries in the BRICS countries especially from the US.
- Labour disputes: some BRICS countries, especially South Africa, Brazil and India have to cope with labour disputes in which organized labour has opposed, in principle, some of government initiatives, such as privatization, inflation targeting, minimum wages and government's ways of handling manufacturing sector disputes.
- High production/input costs: Issues ranging from high labour costs, to energy price hikes, the increasing cost of raw material and taxation, transfer pricing and customs costs have caused companies to reconsider their options. Energy costs and regulatory considerations place constraints on their operations in BRICS countries due to technological imports.
- Skills gap: A report by the World Economic Forum in collaboration with Deloitte, highlighted the skills shortages facing the global industrial sector, and noted that 10 million positions were unfilled in 2012. The unemployment rate in all the BRICS countries (especially South Africa) is high and is driven by a lack of skills to take up available vacancies. Andrew Macki (Deloitte South Africa's manufacturing industry leader) noted that the lack of skills is adding to the woes of the manufacturing sector and has grown by more than 2% in the past five years (Nick, 2012).

- Crime, poverty and inequality: While perceptions about crime, poverty and inequality differ according to race and area of residence, such challenges in BRICS countries lead to exclusion from the labour market (Bhorat, 2004).
- Exchange rate volatility: Various interest groups have recognized that exchange rate instability is a significant factor militating against the development of the industrial sector, export growth and job creation in the BRICS countries.
- Impact of external shocks: The sharp deterioration in the global economic environment also poses a major challenge to the growth of the industrial sector in BRICS countries. Their open economies and need for external financing expose these countries to the risk of capital outflows. A sudden outbreak of global risk aversion or market turbulence could trigger an undesirable turn of events that would render the financing of those countries' twin deficits - budget and current accounts - much more difficult.
- High interest rates: The high cost of borrowing also affects output growth in BRICS countries. Mallick and Sousa (2012) note the persistent effects of high real interest rates on output growth in these countries.

2.14 Overcoming the Industrial Sector's Challenges

The international community has embraced a broad approach to overcome the challenges confronting industrial growth. However, if governments or policymakers in BRICS countries wish to have a major impact in transforming their economies through industrialization, they need to take visionary decisions. They have to understand the current economic situation, the potential needs and evolution within the economy, and the agenda of all relevant stakeholders (investors). Appropriate strategies need to be formulated and platforms have to be built to execute and monitor the outcomes and the impact of any policy.

2.15 Conclusion

This chapter focused on theoretical issues, the monetary policy system and the conduct of the monetary authorities in the BRICS countries. It also presented an overview of regime shifts and the need for debate on monetary policy frameworks. Various monetary policies and regime shifts have been adopted in BRICS countries in order to stimulate industrial sector growth. The discussion showed that similar strategies have been adopted to stimulate the industrial sector and meet the potential needs of these countries. The BRICS countries have drifted towards inflation targeting and a floating exchange rate in order to achieve the purpose of their coming together (partnering for development, integration and industrialization). It was also noted that these countries confront similar challenges in terms of industrial growth and suggestions were advanced on ways to overcome these challenges. The following chapter presents the methodology employed and the data on which this study is based, as well as setting out the rationale for the selection of the macroeconomic variables used.

CHAPTER THREE

MONETARY POLICY SHOCKS AND INDUSTRIAL PRODUCTION IN BRICS COUNTRIES

3.1 Introduction

Over the years, controversies have surrounded the relationship between monetary policy and industrial production. For example, there has been a question that is often asked that does monetary policy explain variations in industrial output, prices and real output? If yes, what is the process through which this occurs? The effective management of any economy depends on a clear understanding of the shocks that impact the economy, their effects on macroeconomic variables and the process through which the action taken by policymakers in response to the shocks impact the economy. While this issue has been studied extensively in different groups of countries such as the European Union (Peersman and Smets, 2001; Peersman, 2004; Angeloni *et al*., 2003; Fountas and Papagapitos, 2001), OECD countries (Dedola and Lippi, 2000; Britton and Whitley, 1995), G-7 countries (Corsetti *et al*., 2008; Kim and Roubini, 2000) and Europe (Favero *et al*., 1999; Giuliodori, 2005), as far as we are aware, no similar study has been conducted on the BRICS countries. This chapter therefore investigates how monetary policy shocks in the BRICS countries affect the growth of industrial output.

According to Mallick and Sousa (2013), the monetary authorities in the BRICS countries aim to achieve full employment equilibrium, rapid industrial growth, price stability and external balance. Changes in monetary policy occur through a process commonly known as the monetary policy transmission mechanism. This is how overall economic conditions are affected by monetary policy decisions. There are different views on how the process works.

Some empirical studies argue in favour of the traditional Keynesian framework, which holds that the transmission process occurs through interest rates (Smets and Wouters, 2002; Angolani *et al.*, 2003; Loayza and Schmidt-Hebbel, 2002; Boivin *et al.,* 2010). Ncube and Ndou (2011), Zhensheng (2002), Halls (2001) and Bayangos (2010) advocate for the credit channel of monetary transmission while Adolfson (2001) and Acosta-Ormaechea and Coble (2011) highlight the exchange rate channel. In addition, Kabundi and Ngwenya (2011) provide a rationale for both the direct and exchange rate channels of monetary policy transmission while

Mishkin (2001), Elbourne (2008), Disyatat and Vongsinsirikul (2003), Alfaro *et al.* (2003) and Borio and Zhu (2012) state that monetary policy pass-through effects on the real economy occur through asset prices and lending rates. These divergent views suggest that the nature of the monetary transmission mechanism in the BRICS countries can only be determined empirically. This study, therefore, contributes to the literature on the BRICS countries by analysing how industrial output, GDP and prices in these countries respond to monetary policy shocks and investigating how the transmission process operates. Specifically, the study examines (i) whether monetary policy shocks have significant effects on industrial output in the BRICS countries; (ii) the process through which operating tools of monetary policy affect monetary policy goals; and (iii) the impact of foreign interest rates on industrial output.

3.2 Channels of the Monetary Transmission Mechanism and Theoretical Framework

The theoretical framework for the monetary policy shocks and industrial production in BRICS countries is rooted from the monetary policy transmission mechanism and linked to the $PSVAR$ methodology employed in this section. The monetary policy transmission mechanism indicates how changes in monetary policies are transmitted to real sectors of the economy. It shows the process through which changes in monetary policy instruments impact on prices and real output growth. According to Ireland (2005), channels of monetary transmission operate through the effects that monetary policy has on interest rates, exchange rates, equity and real estate prices, bank lending, and firms' balance sheets. This affects the decisions made by firms, households, financial institutions and investors, which alter the price level and economic activities. For instance, changes in the official repo rate directly affect money-market interest rates and, indirectly affect the lending and deposit rates that commercial banks charge their customers. Channels of monetary policy transmission can be generalised into five groups, namely, interest rate, money effect, exchange rate, asset price and credit channels.

3.2.1 The Interest Rate Channel

In this channel, an increase in the repo rate is transmitted to other short-term money-market rates and consequently leads to a higher cost of borrowing, and hence a fall in private investment and consumption (Mollentze, 2000). This in turn changes expectations of future interest rate as the long term-interest rate depends in part on market expectations of the future course of short-term interest rates. With its monopoly on issuing of money, the central bank lends funds to commercial banks and charges interest, determining the interest rate in the economy. Commercial banks, in turn, provide funds to investors. Accordingly, there is a direct link between interest rates and investments. Any impact of interest rates on the level of investment is then transmitted to output and prices. A primary characteristic of this transmission mechanism is the importance of the real interest rate as a driver of investment and consumer decisions, rather than the nominal interest rate. Keynes noted that this channel operates through a business's decision on investment spending, but other researchers that followed him (Mishkin, 1995) recognized that consumers' decisions about housing and durable expenditure are inherent in investment decisions. According to Faure (2005b: 226), the real interest rate is an important mechanism through which monetary policy can stimulate the economy even if nominal interest rates are zero.

3.2.2 The Money Effect Channel

The central bank controls money growth to stimulate output and control prices. An increase in money supply would cause interest rates to fall. The money effect channel of monetary policy transmission downplays the role of interest rates and liquid asset adjustment, reducing the process to a direct link between changes in aggregate money supply and absorption (Bolnick, 1991). This approach presumes that a money supply shock creates a wedge between money supply and money demand, which triggers adjustments in portfolio holdings that in turn alter spending decisions. According to Meltzer (1995), this occurs because prices and output respond to monetary impulses following households and businesses' failure to anticipate or correctly perceive all of the future implications of past and current actions. These misperceptions primarily occur due to the existence of a time lag between observing the impulses and being able to distinguish between permanent and transitory impulses and real and nominal shocks (Ngalawa and Viegi, 2011).

3.2.3 The Exchange Rate Channel

Bhuiyan (2008) and Rogoff (1995) argue that monetary policy shocks are transmitted to real output through the exchange rate channel, amongst others. As a result, monetary policy affects exchange rates, which in turn affect net exports and overall output. Expansionary monetary policy (an increase in money supply) leads to a fall in interest rates, which in turn leads to domestic funds being attracted to foreign currency deposits, thus leading to a depreciation of the exchange rate. The fall in the exchange rate makes domestic goods cheaper than foreign goods, resulting into an increase in net exports, and leading to an increase in output. Conversely, an increase in the value of the domestic currency vis-à-vis other currencies makes domestic goods more expensive relative to foreign goods, thereby causing a fall in net exports and hence in aggregate output (Mishkin, 1995).

3.2.4 The Credit Channel

The credit channel is a bank-lending channel of monetary transmission through which funds are made available to borrowers for investment. It works through the effects of bank lending on economic activities. The bank-lending channel is the process through which the monetary authorities stimulate a growth in money supply through providing bank loans, i.e., an increase in the quantity of money in circulation via loan disbursement rather than the price of credit. According to Mishkin (1995), contractionary monetary policy will lead to a fall in bank deposits, which subsequently affects banks' capacity to extend loans to investors. This adversely affects investment and results in a fall in total output. Conversely, the central bank can reduce the reserve requirement of commercial banks to enable them to increase their lending capacity to customers/investors. In this channel, the banks play the specific role of providing loans and advances through overdrafts, cash credit, discounting of bills and loans and advances, among others, and are well suited to solving asymmetric information problems.

Besides lending, the credit channel can also operate through the balance sheets of commercial banks. The balance sheet channel focuses on the supply of funds from all financial intermediaries to borrowers (no special role for banks). An example of this channel is a co-operative society (informal financial market). The channel arises due to asymmetric information problems in credit markets. However, the functioning of this channel is also weak due to practices such as those related to third party lending (Dabla-Norris and Floerkemeier, 2006).

3.2.5 The Asset Price Channel

An expansionary monetary policy stance can also increase firms' financial and physical asset prices. According to Dabla-Norris and Floerkemeier (2006), expansionary monetary policy can increase the net worth of firms and hence the value of collateral, company cash flow, and a firm's creditworthiness. An increase in money supply (expansionary monetary policy) leads to a fall in interest rates, and hence, an increase in the prices of stocks and securities. This leads to an increase in financial wealth, lifetime income, consumption, and hence output.

3.3 Research Methodology

Following Prasad and Espinoza (2012), Ciccarelli *et al.* (2013) and Davoodi *et al.* (2013) that carried out a panel-data study on Gulf Cooperation Council (GCC) countries, the Euro area and East Africa, we pool cross-sectional data and employ Panel data estimation in this study owing to a number of distinctive characteristics of the BRICS economies. For instance, these countries have similar monetary policy regime shifts and have drifted towards inflation targeting and a floating exchange rate system. The BRICS countries have witnessed regime shifts characterized by episodes of monetary instability, swinging from very high inflation to financial instability (Mallick and Sousa, 2012). All the BRICS central banks target inflation and have moved from a fixed exchange rate system to a floating exchange rate one. While Brazil, India and South Africa have officially adopted inflation targeting, Russia has shown commitment to complete the shift to a floating exchange rate system and an inflation targeting regime by 2016 (see Bank of Russia website). China has also shifted to a new managed floating exchange rate system with an unofficial inflation target of 4% (see People's Bank of China website). The range adopted and targeted in each country is shown below:

Table 3.1: Inflation Targeting Rates in BRICS Countries

Country	**Central bank Name**	**Target**	**Date Adopted**
Brazil	Central Bank of Brazil	3.0% - 6.0%	July 1999
Russia	Bank of Russia	4.5% +/-1.0%	2016
India	Reserve Bank of India	2.0% - 6.0%	January 2016
China	People's Bank of China	4.00%	N.A
South Africa	South African Reserve Bank	3.0% - 6.0%	February 2000

Source: Author's compilation from data released by each country's Central bank and Central Bank News Inflation Targets Table for 2015

In addition, BRICS member states have established the BRICS Development Bank. At their Fifth Annual Summit held in Durban, South Africa, on 27 March 2013, the BRICS leaders decided to establish a development bank with the aim of creating an alternative source of funding to the World Bank and IMF. It is envisaged that it will foster greater financial and developmental cooperation among member countries and promote their monetary union (Griffith-Jones, 2014).

Furthermore, the BRICS countries are prone to the same external shocks due to the dominant influence of the Dollar on their economies (Adler and Tovar Mora, 2012). Global trade and investment flows and payments are currently mainly intermediated and settled through the use of the US Dollar. Goods sold within and outside the BRICS countries are usually priced and settled in US Dollars and involve exchange rate and payment risks. The global financial crisis that started in the US in 2007 resulted in a sharp fall in BRICS countries exports and imports in the first quarter of 2009 (Havlik, 2009).

It is also observed that all BRICS member countries are EMEs with a per capita income lower than the average per capita income in the G7 countries (Calderón and Yeyati, 2009).

Finally, countercyclical monetary and fiscal policies tend to be pro-cyclical. According to Coulibaly (2012), previously, both fiscal and monetary macroeconomic policies tend to be procyclical or, at best, acyclical in BRICS EMEs as against the tendency towards countercyclical policies. This partly explains the higher volatility of output normally seen in BRICS EMEs compared to the advanced economies (Aguiar and Gopinath, 2007). However, the BRICS EMEs have recognized the need to grow out of this policy bias and have therefore made countercyclical policies more feasible (Mohanty, 2012).

3.3.1 Why Panel Data Estimation?

In this study we pooled cross-sectional time series data due to some of the advantages attached to the choice of panel data analysis. Mahembe (2014:95), Hasio (2014), Gujarati (2004) and Baltagi (2008) outline several advantages of using panel data over time-series analysis. First, they argue that panel data offers more explanatory data and variability, but less collinearity among the variables, as well as additional degrees of freedom and is more efficient than time-series or cross-sectional data (Baltagi, 2008:7). Second, they state that panel data can control for heterogeneity in individual data (Baltagi, 2008:6). Third, it is maintained that panel data is well suited to the study of dynamic adjustment (Baltagi, 2008:7). Fourth, panel data is able to determine and measure effects that are not detectable in pure cross-section or time-series data (Baltagi, 2008:8). Fifth, it is argued that panel data allows for the creation and analysis of more complex behavioral models (Baltagi, 2008:8), such as economies of scale and technological change (Gujarati, 2004:639). Finally, the authors point out that macro panel data removes the problem of non-standard distributions that are emblematic of unit roots tests in time-series analysis (Baltagi, 2008).

3.3.2 Research Techniques

This study follows Prasad and Espinoza (2012), Ciccarelli *et al.* (2013) and Davoodi *et al.*'s (2013) $P-VAR$ analyses of monetary policy transmission mechanisms in the GCC countries, Euro area and East Africa to formulate a $P-SVAR$ model for the BRICS countries. The $P-SVAR$ is employed to capture the dynamic behaviour of the variables in the model and to provide more efficient estimation of the parameters. $P-SVARs$ have the same structure as $P-VAR$ models, in the sense that all variables are assumed to be endogenous and interdependent, except for those identified as exogenous. The $P-SVAR$ is built with the same logic applied in the standard $P-VAR$ except for the structural restrictions, which are imposed on the former, making it a different and much more powerful tool to address macroeconomic policy. The $P-SVAR$ methodology suggests the imposition of restrictions on the contemporaneous structural parameters only, for reasonable economic structures to be derived. The restrictions restrict attention to rotations that produce shocks that satisfy an anticipated sign in the responses of key variables (Dungey and Fry, 2009). The work of Buckle *et al*. (2002) lays the foundation for the traditional $SVAR$ that forms the hybrid approach to structural identification of the restrictions which is employed for the $P-SVAR$. The traditional restrictions are denoted by "$f_{21}-f_{98}$" and "0" (see system of equations 3.6) for the contemporaneous and sluggish lagged relationships, respectively. This $P-SVAR$ is also employed because it is suited to capture both static and dynamic interdependencies by treating the links across units in an unrestricted manner, and can account for cross sectional dynamic heterogeneities.

While various studies have used $P-VARs$ and VARs/SVARs to study the monetary transmission process in different groups of countries and individual countries, respectively, no study that we are aware of has used a $P-SVAR$ to study a bloc of countries worldwide. This study, therefore, contributes to the literature by employing a $P-SVAR$ to study the relationship between monetary policy shocks and industrial output in the BRICS countries. Mallick and Sousa (2009) used a sign restriction VAR to determine output growth in the BRICS countries while Ivrendi and Yildirim's (2013) study on Brazil, Russia, India, China and Turkey's (BRICS_T) economies used an $SVAR$. Assenmacher-Wesche and Gerlach's (2008) study in OECD countries employed a $P-VAR$; Mehrara and Mohaghegh (2011) use a $P-VAR$ to analyse oil exporting countries; Sousa and Zaghini (2007) used an $SVAR$ for each of the G5 countries; Canova and Ciccarelli (2004) studied G7 countries using a panel VAR; and Love and Zicchino (2006) carried out a study in 36 countries using a panel VAR. All these studies served as a guide upon which this study built the $P-SVAR$.

The analyses and interpretation of the real effects of monetary policy shocks on industrial output and the impact on the economy as well as the impact of external shocks on macroeconomic variables are carried out using the generalised impulse response functions of the $P-SVAR$ in levels in order to avoid the loss of information that is usually associated with differenced data (Uhlig, 2005; Peersman and Smets, 2002; and Vonnak, 2005). However, the $P-SVAR$ may not perform the same tasks as dynamic simultaneous equation models. They nonetheless have the further advantage of avoiding some of the difficulties that characterise the traditional VAR approach and are well suited for structural analyses, thereby making inferences more reliable (Berkelmans, 2005; Ibrahim and Amin, 2005).

3.3.3 Model Specification and Set-up of the P-SVAR

The $P-SVAR$ in this study is estimated using eight endogenous variables, namely, real GDP, industrial output (IP), imports (IMP), exports (EXP), exchange rates (EX), inflation rates (IF), interest rates (IN) and money supply (MS) and one exogenous variable namely, the international interest rate proxied by the Federal Funds Rate (FFR). The exogenous variable is included to capture the open economy status of the BRICS countries as well the international flow of funds as investors will always be willing to invest in an economy with higher expected returns.

Suppose the BRICS countries can be represented by the following structural panel equation:

$$BY_{it} = K_{io} + A_1Y_{it-1} + A_2Y_{it-2} + \cdots + A_pY_{it-p} + \Pi X_t + H\varepsilon_{it} \tag{3.1}$$

where B is an invertible $(k \times k)$ matrix describing the contemporaneous relationship among the variables; Y_{it} is a $(k \times 1)$ vector of endogenous variables such that $Y_{it} = Y_{1t,} Y_{2t,} \dots Y_{nt}$. K_{io} is a $(k \times 1)$ vector of constants representing country specific intercept terms; A_j is a $(k \times k)$ matrix of coefficients of lagged endogenous variables (for every $j = 1 \dots p$); Π and X_t are vectors of coefficients and exogenous variable, respectively, capturing external shocks; H is a $(k \times k)$ matrix whose non-zero off-diagonal elements allow for direct effects of some shocks on more than one endogenous variable in the system; and ε_{it} is a vector of uncorrelated error terms (white-noise structural disturbances).

The $P - SVAR$ presented in equation (3.1) cannot be estimated directly due to the feedback inherent in the $SVAR$ process (Enders, 2004). The structure of the system incorporates feedback which makes it difficult to estimate because the endogenous variables are allowed to affect each other in the current and past realisation time path of BY_{it}. Nonetheless, the information in the system can be estimated and recovered by estimating a reduced form $SVAR$ implicit in the equations (Ngalawa and Viegi, 2011). Pre-multiplying equation (3.1) by an inverse of B gives:

$$Y_{it} = B^{-1}K_{io} + B^{-1}A_1Y_{it-1} + B^{-1}A_2Y_{it-2} + \cdots B^{-1}A_pY_{it-p} + B^{-1}\Pi X_t + B^{-1}H\varepsilon_{it} \tag{3.2}$$

One can denote

$$B^{-1}K_{io} = C_i,\ B^{-1}A_1 \dots\dots B^{-1}A_p = D_i \dots\dots D_p,\ B^{-1}\Pi = \alpha \text{ and } B^{-1}H\varepsilon_{it} = \mu_{it}. \tag{3.3}$$

Hence, equation (3.3) becomes:

$$Y_{it} = C_i + D_1Y_{it-1} + D_2Y_{it-2} + \cdots \dots \dots\dots + D_pY_{it-p} + \alpha X_t + \mu_{it} \tag{3.4}$$

The difference between equations (3.1) and (3.4) is that the first is called a $P - SVAR$ or primitive system where all variables have contemporaneous effects on each other while the second is called a reduced form $P - SVAR$ or a $P - SVAR$ in standard form in which all the right-hand side variables are predetermined at time t and no variable has a direct contemporaneous (immediate) effect on another in the model. In addition, the error term (μ_{it}) is a composite of shocks in Y_{it} (Enders, 2004). Equation (3.4) can be rewritten in short form as:

$$Y_{it} = C_i + B(L)Y_{it} + G(L)X_{it} + \mu_{it} \tag{3.5}$$

where Y_{it} and X_{it} are $nx1$ vectors of variables given by

$$Y_{it} = (GDP, IP, IMP, EXP, EX, IF, IN, MS) \tag{3.5.1}$$

$$X_t = (FFR) \tag{3.5.2}$$

Equation (3.5.1) is a vector of the BRICS countries' endogenous variables used in the study; and equation (3.5.2) represents the vector of the exogenous variables that controls for external shocks. C_i is a vector of constants representing country intercept terms. $B(L)$ and $G(L)$ are matrices of polynomial lags that capture the relationship between the endogenous variables and their lags. $\mu_{it} = B^{-1}H\varepsilon_{it}$ is a vector of random disturbances, which can also be rewritten as $B\mu_{it} = H\varepsilon_{it}$.

Equations (3.4) and (3.5) share the same features as both are reduced form $P-SVARs$ derived from the primitive $P-SVAR$ system of equations (3.1) where all variables have contemporaneous effects on each other and are assumed to describe the BRICS economies. To recover the information in the structural equation, we impose restrictions in matrices B and H in system of equations (3.6).

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ f_{21} & 1 & f_{23} & f_{24} & f_{25} & 0 & 0 & 0 & 0 \\ f_{31} & f_{32} & 1 & 0 & 0 & f_{36} & 0 & f_{38} & 0 \\ f_{41} & f_{42} & 0 & 1 & 0 & 0 & 0 & 0 & f_{49} \\ f_{51} & f_{52} & 0 & f_{54} & 1 & f_{56} & 0 & 0 & f_{59} \\ f_{61} & f_{62} & 0 & 0 & 0 & 1 & f_{67} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & f_{78} & 0 \\ f_{81} & 0 & 0 & 0 & 0 & 0 & 0 & 1 & f_{89} \\ f_{91} & f_{92} & f_{93} & f_{94} & f_{95} & f_{96} & f_{97} & f_{98} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{FFR} \\ \mu_{it}^{logGDP} \\ \mu_{it}^{logIP} \\ \mu_{it}^{logIMP} \\ \mu_{it}^{logEXP} \\ \mu_{it}^{logIF} \\ \mu_{it}^{IN} \\ \mu_{it}^{logMS} \\ \mu_{it}^{logEX} \end{bmatrix} = \begin{bmatrix} b_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & b_8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & b_9 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{FFR} \\ \varepsilon_{it}^{logGDP} \\ \varepsilon_{it}^{logIP} \\ \varepsilon_{it}^{logIMP} \\ \varepsilon_{it}^{logEXP} \\ \varepsilon_{it}^{logIF} \\ \varepsilon_{it}^{IN} \\ \varepsilon_{it}^{logMS} \\ \varepsilon_{it}^{logEX} \end{bmatrix} \tag{3.6}$$

The first matrix on the left hand side of system of equations (3.6) is the B matrix which pertains to the non-recursive restrictions in the model while the first matrix on the right hand side shows the H-matrix, also known as the diagonal matrix. The terms μ_t^{FFR}, μ_{it}^{logGDP}, μ_{it}^{logIP}, μ_{it}^{logIMP}, μ_{it}^{logEXP}, μ_{it}^{logIF}, $\mu_{it}^{IN}, \mu_{it}^{logMS}$ and μ_{it}^{logEX} are residuals in the reduced form disturbances to both the foreign and the domestic variables and further represent unexpected movements (given information in the system) of each variable; and ε_t^{FFR}, $\varepsilon_{it}^{logGDP}$, ε_{it}^{logIP}, $\varepsilon_{it}^{logIMP}$, $\varepsilon_{it}^{logEXP}$, ε_{it}^{logIF}, ε_{it}^{IN}, ε_{it}^{logMS} and μ_{it}^{logEX} are the structural shocks associated with the respective equations.

For the scheme to be exactly (just) identified, this study follows the method introduced by Amisano and Giannini (1997) in which the $P-SVAR$ needs $2n^2 - n(n+1)/2$ or 117 restrictions on the B and H matrices collectively (where n is the number of variables). Since H is assumed to be a diagonal matrix, 72 exclusion restrictions are imposed on it whereas 45 restrictions are required to be imposed on the B matrix for the system to be exactly identified. Since our non-recursive $P-SVAR$ imposes 42 zero restrictions on B, the system is over-identified and 30 free parameters in the B matrix and 9 in the H matrix have to be estimated (see system of equations 3.6).

The way variables influence each other is based on economic theory and also depends on their position in the identification scheme. The domestic variables are deemed not to affect the international variables and the transmission of international shocks to the domestic economy can be very rapid (Berkelmans, 2005). The non-zero coefficients (f_{kj}) in the matrices indicate that variable j affects variable k instantaneously. For example, row 1 measures the external pressure on the economy that is captured by international interest rates. This is proxied by the FFR as the United States acts as a leader in setting monetary policy (Grilli and Roubini, 1996; Elbourne, 2008) and is also the most industrialised economy in the world (Reinhart and Rogoff, 2008). The second and third equations represent real GDP and industrial output. Based on macroeconomic accounting identity that GDP is a function of IP, IMP and EXP, it is postulated that real GDP responds instantaneously to FFR, IP, IMP and EXP only, while f_{31} f_{32}, f_{36} and f_{39} indicate that industrial output responds contemporaneously to FFR, GDP, IF and EX. The fourth and fifth equations characterise the domestic and international goods market for imports and exports. Imports respond contemporaneously to FFR, GDP and MS only, while exports respond contemporaneously only to FFR, GDP, imports, inflation rate and exchange rate.

In the sixth and seventh equations, f_{61}, f_{62} and f_{67} indicate that the inflation rate responds contemporaneously to FFR, GDP and IN while, f_{78} shows a contemporaneous relationship of the interest rate to money supply. Rows 8 and 9 of the matrix represent money supply and exchange rate. f_{81} and f_{89} allow for contemporaneous relationships between money supply on the one hand and FFR and EX on the other, while exchange rate (row 9) is assumed to respond instantaneously to all the variables (Elbourne and de Haan, 2006).

3.3.4 Data and Data Sources

Monthly time series data covering a period of 20 years from 1994:1 to 2013:12 for the five emerging economies in BRICS are employed in this study. The study period and cut-off dates are dictated by data availability and efforts to stay current. The data are from the individual countries' central banks' statistical bulletins, the World Bank's World Development Indicators (WDI), IMF's International Financial Statistics (IFS) and the statistics offices of each country. The choice of the domestic variables (with the exception of money supply) is in line with Ibrahim and Amin (2005) while the incorporation of the international interest rate (the Federal Funds Rate) as an external variable is consistent with Maturu (2007) and Elbourne's (2008) studies. In addition, this study borrows from Bhuiyan (2008) and Afandi (2005) that used a $SVAR$ model with 9 variables (one for the external sector and eight for the domestic sector). The model in this study is a large $P - SVAR$ capable of capturing all the key macroeconomics interactions in the BRICS countries. Other large $SVARs$ similar to this study are Sattler *et al*. (2007) and Dungey and Pagan (2000) that use 11 variables and Dungey and Fry (2009) that employs 12 variables. All variables are expressed in natural logarithms except the FFR and the domestic interest rates.

3.3.5 Non-stationarity and Unit Root Test

This study follows Vonnak (2005), Ibrahim and Amin (2005), Uhlig (2005), Peersman and Smets (2005), Fève and Guay (2006) and Elbourne (2008), among others that specifically estimated $SVARs$ and $VARs$ in levels. These studies argued that this approach prevents efficiency loss or loss of vital information about the data sets that are usually associated with a differenced $SVARs$ and $VARs$. The procedure also has the advantage of producing consistent parameter estimates irrespective of whether or not the time series are integrated, causing it to produce a more robust result than a cointegrated $SVAR$ or VAR model (Afandi, 2005). Moreover, Berkelmans (2005) argues that the inclusion of lagged variables in the SVARs or $VARs$ will enable the residuals to be stationary even with $I(1)$ variables. Recent studies on the impact of monetary policy on economic activities have also followed this procedure (see, among others, Sharifi-Renani, 2010; Mordi and Adebiyi, 2010; Farzanegan, 2011; Ncube and Ndou, 2011; Ngalawa and Viegi, 2011).

3.3.6 Definition of Variables

The FFR is the US short term interest rate at which depository institutions in the country borrows from and lend their central bank balances to one another, usually overnight. The variable is included in our model to control for the stance of the global economy that is likely to affect the performance of the BRICS economies, as “the FFR is a good indicator of monetary policy action” (Bernanke and Blinder, 1992). In addition, the FFR is a good indicator of the global business cycle that serves as an important driver of domestic business activities through which the FFR affects the economy. Several studies have followed this line of thought (Kuttner and Mosser, 2002; Elbourne and De Haan, 2006; Elboune, 2008; Afandi, 2005; Maturu, 2007).

Real Gross Domestic Product (GDP) is the value of economic output at constant national prices for each country annually at 2005 base year. This variable is included to examine the impact of monetary policy on total output in line with Berkelmans (2005) and Dungey and Pagan (2000). On the other hand, industrial output (IP) is the contribution of the industrial sector’s output to GDP. This is used to further examine how monetary policy shocks affect industrial sector performance in the BRICS countries as the sector provides a locus to stimulate the growth of the economy and achieve specific outcomes such as employment creation and economic growth. In our study, the role industry plays in stimulating the economy is further elaborated in line with Elbourne and De Haan (2006). Furthermore, GDP and industrial production are included to assess the validity of the view that the stabilisation of output and inflation can be left to monetary policy to achieve Pareto optimality (Mishkin, 1995; Erceg, *et al.*, 2000).

The GDP and industrial production (output) data are only available in quarterly frequency, and not in monthly frequency. To obtain the monthly frequency data for the two variables, we interpolated the quarterly data using interpolation and frequency conversion methods. The interpolation of low frequency to high frequency data is a standard approach in the literature (Ngalawa and Viegi, 2011; Cheng, 2006; Borys *et al*., 2009; Morgese *et al*., 2008 and Davoodi *et al*., 2013).

Imports (IMP) are the total value of goods and services imported in each country while exports (EXP) are the total value of goods and services exported. The inclusion of both variables is in line with Dungey and Fry (2009) to determine the trade relationship among the BRICS countries and assess the extent of interaction between business cycles and the process through which it stimulates the economy. On the other hand, the CPI is used as a proxy of the price level for each country across different consumption goods and services. It also serves as a control variable that is linked to monetary policy decisions especially with regard to interest rates through which economic stability is achieved. The interest rate (IN) is the average monthly real repo rate set by the central bank of each individual country as a monetary policy indicator (Agung, 1998; Disyatat and Vongsinsirikul, 2003; Bernanke and Blinder, 1992; Iturriaga, 2000) and will enable us to assess the process through which it is used to counter inflation and manage the movement of intermediate targets of monetary policy. In n the event of inflation, central banks increase repo rate as this acts as a disincentive for banks to borrow from the central bank. This ultimately reduces the money supply in the economy and thus helps in arresting inflation.

Money supply (MS) is the entire stock of currency and other liquid instruments in each country at a particular time. $M2$ is employed in this study (in line with Ngalawa and Viegi, 2011) for all the BRICS countries except for India where $M3$ is used due to non-availability of $M2$. The money supply will enable this study to determine and assess the process through which the monetary authorities employ operating tools of monetary policy to achieve their targets. The exchange rate (EX) on the other hand is the price of each country's currency expressed in another country's currency. The US Dollar exchange rate is used as the benchmark in this study due to its wider acceptability and the fact that it is the most traded on the foreign exchange market (Ibrahim and Amin, 2005). This variable will assist in investigating how variations in the value of the US Dollar affect selected variables in the BRICS countries (Bacchetta and Van Wincoop, 2000 among others).

3.4 Estimation and Results

3.4.1 Lag Length Test

Five different lag lengths selection criteria have been used in SVAR estimation by a number of researchers: the Akaike Information Criteria (AIC), Final Prediction Error (FPE), Sequential

Modified LR test, Schwarz Information Criterion (SC) and the Hannan-Quinn information criterion (HQ). This study tests for various lag lengths using the five different lag selection criteria to allow for adjustments in the model and the attainment of well-behaved residuals. The AIC, FPE and Sequential Modified LR test suggested an optimal 4-lag length while the SC selected 2-lags and the HQ chose 3-lags for the $P - SVAR$. We decided to choose the more general model suggested by the AIC, FPE and Sequential Modified LR tests because they offer more accurate and more robust dynamics without necessarily shortening the estimation sample too much, which would compromise with degrees of confidence. The lag length also allows for no serial correlation in the residuals (Ngalawa and Viegi, 2011; Elboure, 2007). The study is further guided by previous studies including Sharifi-Renani (2010) and Elbourne (2008), among others, that use 4-lags.

3.4.2 Diagnostic Tests on the P-SVAR Model

Since the model with 4-lags is selected as the best model, we then test for the $P - SVAR$ serial correlation, heteroskedasticity and normality in order to demonstrate the suitability and robustness of the model. The benchmark null hypotheses that are tested for the serial correlation, heteroscedasticity and normality tests are:

- $H0: \alpha = 1$, there is no serial correlation, no heteroskedasticity and the residuals are normally distributed.
- $H1: \alpha \neq 1$, there is serial correlation, heteroskedasticity and non-normality of residuals.

Table 3.2: Serial Correlation LM Test

Null Hypothesis: no serial correlation at lag order h		
Lags	LM-Stat	Prob
1	1001.330	0.0000
2	799.6220	0.0000
3	713.6328	0.0000
4	428.3116	0.0000
5	309.5593	0.0000
6	427.4639	0.0000
7	325.0468	0.0000
8	500.1648	0.0000
9	452.0233	0.0000
10	568.6087	0.0000
11	603.1811	0.0000
12	1903.626	0.0000

"***" "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively

Table 3.3: Heteroscedasticity Test

Heteroscedasticity Test: joint test		
Null Hypothesis: no Heteroscedasticity		
Chi-sq	Df	Prob.
12840.73	1575	0.0000

"***" "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively

Table 3.4: The P-SVAR Normality test

Com	Skewness				Kurtosis				Jarque-Bera		
	Skew	Chi-sq	Df	Prob	Kurtosis	Chi-sq	df	Prob	Jarque	df	Prob
1	-1.393225	384.9798	1	0.0000	8.885828	1717.714	1	0.0000	2102.694	2	0.0000
2	0.621891	76.70515	1	0.0000	31.51913	40328.14	1	0.0000	40404.84	2	0.0000
3	1.652639	541.6912	1	0.0000	32.79836	44027.13	1	0.0000	44568.82	2	0.0000
4	-0.039530	0.309922	1	0.5777	15.58306	7850.703	1	0.0000	7851.013	2	0.0000
5	0.951916	179.7186	1	0.0000	8.212675	1347.277	1	0.0000	1526.996	2	0.0000
6	1.148847	261.7703	1	0.0000	8.769384	1650.421	1	0.0000	1912.191	2	0.0000
7	-6.831809	9256.933	1	0.0000	72.94448	242573.1	1	0.0000	251830.0	2	0.0000
8	0.240273	11.45000	1	0.0007	3.208164	2.148564	1	0.1427	13.59856	2	0.0000
9	0.412038	33.67212	1	0.0000	10.38960	2707.559	1	0.0000	2741.231	2	0.0000
Joint		10747.23	9	0.0000		342204.2	9	0.0000	352951.4	18	0.0000

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Table 3.2 shows that there is no serial correlation (similarity between observations) in the model. Table 3.3 presents the heteroscedasticity test results for the model. The probability value confirms that the model is free from heteroscedasticity (a process in which the variability of a variable is unequal across the range of values that are predicted).

The normality test is conducted on the basis of the three known tests, which are skewness, kurtosis and Jarque-Bera. The results show that 98% of the variables in the model passed the normality test, both individually and jointly (see Table 3.4). The test results further show that the residuals are normally distributed and the data sets are well modelled. This is shown by the probability values at 1% level of significance. The implication is that the data distribution and the residuals of the model for the BRICS countries are normally distributed. Overall, the null hypothesis of no serial correlation, no heteroscedasticity and normality of the residuals cannot be rejected. These results show that our model is consistent and favourable in analysing monetary policy shocks and industrial output in the BRICS countries and that the data sets are suitable for the estimation.

3.5 Impulse Response Analyses

This section details the impulse response functions for the system and forms the building block for future developments in the model. The impulse response functions show the responsiveness of the dependent variables (endogenous variables) in the $P - SVAR$ system to a shock (innovation) in the model. According to Sharifi-Renani (2010), the impulses are the orthogonalized standard deviations of estimated residuals of the models. Therefore, the impulse responses are constructed for all the variables in the model to allow us identify the response of the economy to monetary policy shocks. In order to achieve a suitable analysis of the impulse response functions, they are divided into periodical bases covering a 9-year horizon (as shown on the horizontal axis in Figures 3.1 to 3.3) to highlight the response of the economy to the shocks and identify the process through which it occurs.

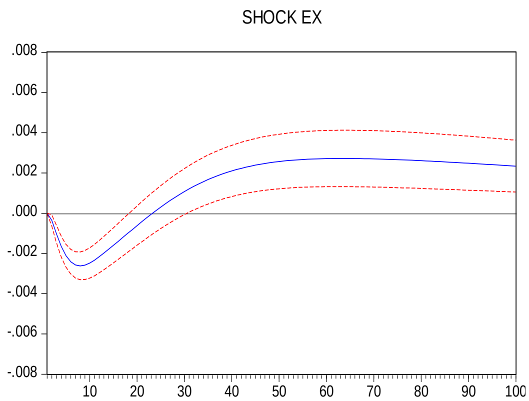
3.5.1 Impulse Responses of Industrial Output to Monetary Policy Shocks

Figure 3.1 presents the impulse responses of industrial output to a one standard deviation shock in monetary variables (exchange rate, interest rate and money supply) and the rate of inflation.

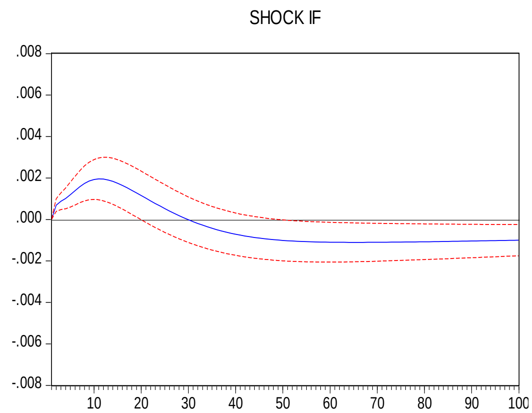
The figure shows that an exchange rate shock (depreciation/devaluation) initially reduces industrial output, bottoming out after seven months and thereafter increasing significantly over a relatively long period, peaking after about five years. The rise in industrial output following a decline in the value of the local currency is in line with economic theory, which states that an exchange rate depreciation/ devaluation boosts exports and output growth (Haddad and Pancaro, 2010). The process is such that an expansionary monetary policy (increase in money supply) leads to a fall in the real interest rate, which in turn leads to local deposits being attracted to foreign currency deposits (people are willing to borrow in local currency), thus, leading to a fall in the exchange rate. The fall in the exchange rate makes domestic goods cheaper than foreign goods, resulting in an increase in net exports, leading to increased output. Conversely, higher value of the domestic currency makes domestic goods more expensive than foreign goods, thereby causing a fall in net exports and hence in aggregate output (Miskin, 1995).

Figure 3.1: Impulse responses of industrial production to exchange rate, interest rate, money supply and inflation shocks

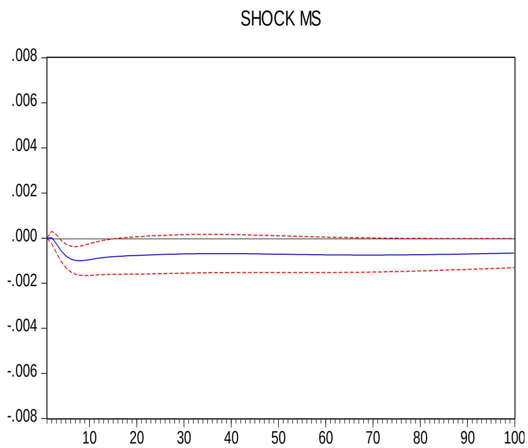
Response of IP to EX shock



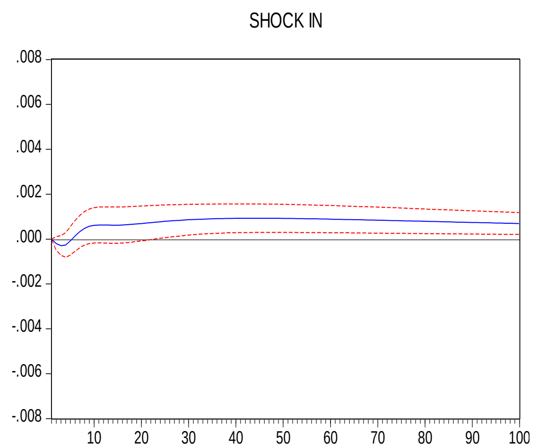
Response of IP to IF shock



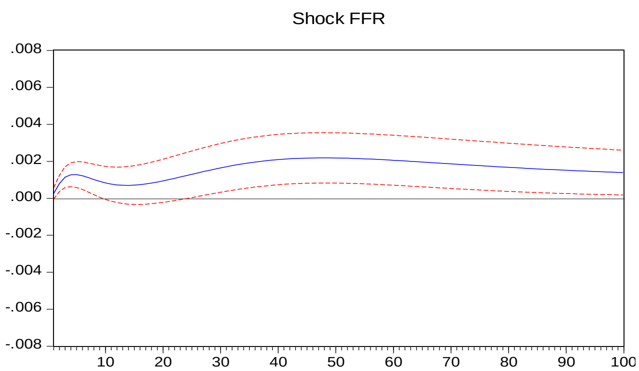
Response of IP to MS shock



Response of IP to IN shock



Response of IP to FFR shock



The initial decline in industrial output (following an exchange rate shock) may be explained by high local currency costs of imported intermediate inputs which cannot be offset by high local currency revenue from the export of final goods because the period is not long enough for firms to produce considerably more output by, among other things, increasing plant size.

The figure also shows that a positive inflation shock significantly increases industrial output, peaking after about 11 months and declining thereafter. The initial increase in industrial output caused by an inflation shock may be a result of information asymmetry in the economy. If producers observe only their prices and not the general price level, they will not know whether a change in the price of their goods reflects a change in the goods' relative price or a change in the aggregate price level (Romer, 2012). Therefore, they will attribute part of the price change to an increase in the price level and part of it to an increase in relative prices. They will respond by increasing output, to some extent, as a rational response to their belief that relative prices have probably increased. When they eventually realise that the rise in their prices is the result of an increase in the general price level, they will reduce production to its original level and industrial output reverts to equilibrium. Figure 3.1 shows that this occurs after about two years.

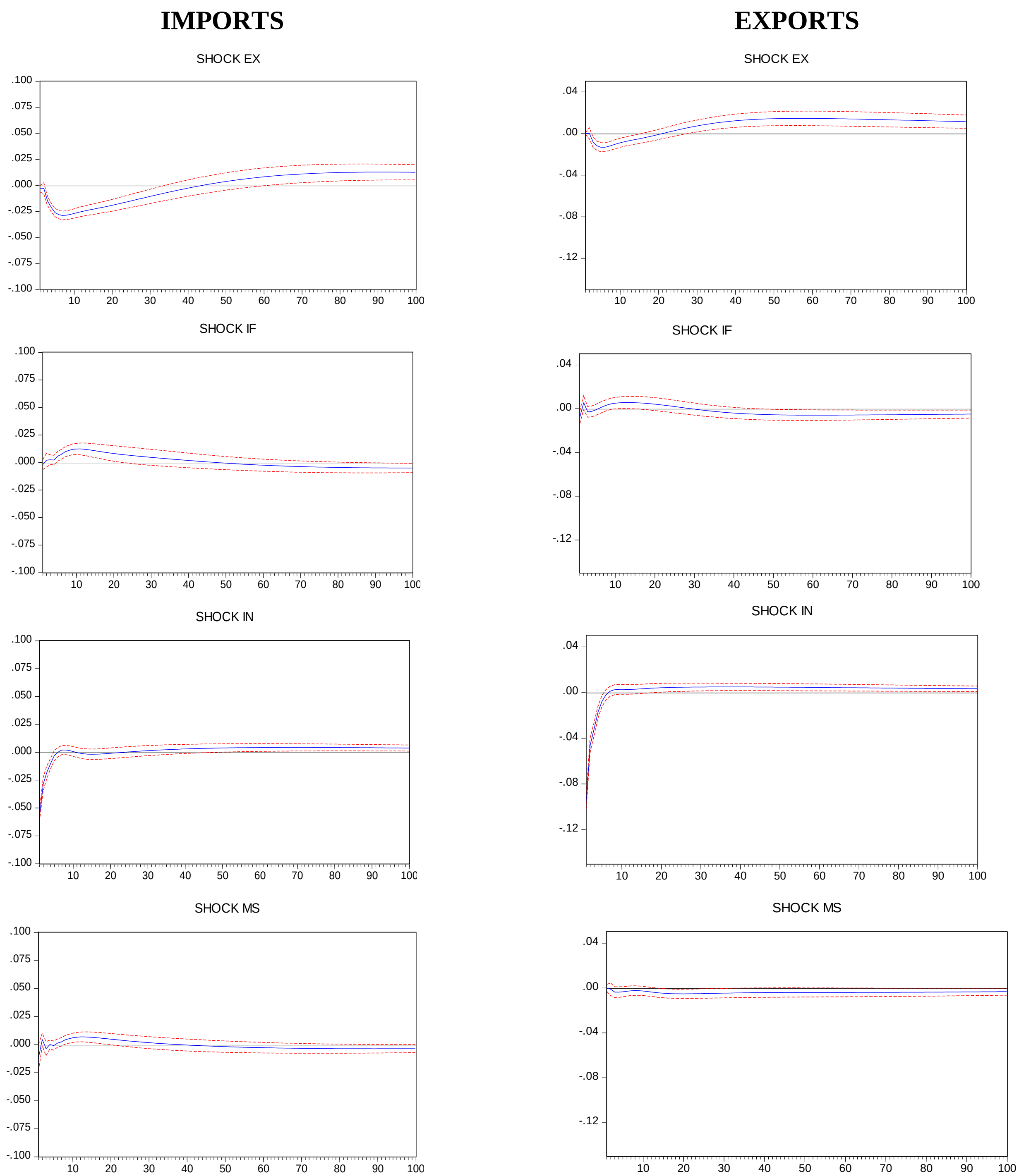
It is also observed in Figure 3.1 that industrial output does not respond significantly to a positive interest rate shock (representing monetary tightening) until after about two years when it starts increasing, albeit marginally and that this remains persistent after eight years. The initial non-response can be a result of structural rigidities in the BRICS countries industrial sector. The increase in industrial output observed after two years is, nonetheless, surprising. A possible explanation is that following a rise in the expected rate of return (reflected by the increase in real interest rates), the BRICS countries start attracting capital inflows which trickle to the industrial sector, the impact of which shows after two years. The persistent response that follows is consistent with the findings of Lopes' (2004) study of monetary policy and external vulnerability in Brazil. In addition, a monetary policy shock characterized by an unexpected increase in money supply causes industrial output to initially decrease, bottoming out after seven months. Thereafter, industrial output remains generally constant. This outcome may be due to slight differences in the monetary policy regime shifts and frameworks in each country (Mallick and Sousa, 2012).

Finally, the spill over effect of a 1% increase in world interest rates (as proxied by FFR) is also reflected in a positive, significant reaction of industrial output (IP). This shows that an unanticipated shock from the external environment can decrease industrial production over a given period. This might not be unconnected to investors' desire to move funds to an economy with higher returns. The impulse response shows that global shocks increase and decrease industrial growth and transmit across EMEs with more contractionary effects (Di Giovanni and Shambaugh, 2008). This is in line with Berkelmans (2005) who maintained that the transmission of international shocks to domestic variables can be rapid, has a significant impact on real GDP and also transmits to industrial output. The foregoing discussion reveals that the exchange rate is an important determinant of industrial output. Inflation also leads to a positive industrial output response within a relatively short period. The impact of money supply and interest rate shocks is, however, marginal. These results are similar to those of Bhattacharya *et al*.'s (2011) study on monetary policy transmission mechanisms in EMEs.

3.5.2 Impulse Responses of Imports and Exports to Monetary Policy Shocks

In Figure 3.2, the left-hand column describes the specific process through which policy-induced changes impact on imports while the right-hand side shows the results obtained from responses through which policy-induced changes impact on exports. Both variables allow us to determine the impacts that monetary policy shocks have on the openness of the BRICS economies and their trade relationship with the rest of the world. Overall, the impulse responses suggest that the impact of monetary policy shocks on imports and exports are significantly amplified through the exchange rate for all years. This is consistent with Nicita's (2013) finding that the exchange rate plays an important role in a country's trade performance. This result shows that in BRICS countries, relative valuations of currencies and their volatility will often have important effects on their trade relationships, the balance of payments and overall economic performance. The policy implication is that policymakers in BRICS countries need to pay attention to the exchange rates of their countries and those of other countries, as the effect of exchange rates on international trade is significant. Their multilateral cooperation strategies on exchange rate should be uniform in order to support floating exchange rates, which may be accompanied by other policy actions to stimulate industrial production and promote international trade.

Figure 3.2: Impulse responses of Imports and Exports to exchange rate, interest rate, money supply and inflation shocks



The figure also shows that prices were important only in the first to second year in terms of imports. They are, however increasingly important for exports between the tenth month and the twentieth month which significantly peak again after about the third year and persist for all years. This shows that prices exert a profound influence and significantly impact on trade in the economy.

In line with Fatima and Scholar (2013), this study validates the existence of a significant relationship between inflation (prices) and openness in BRICS countries.

The analysis shows that prices promote exports and depress imports. This further conforms to economic theory that states that large volumes of imports in relation to exports can distort a nation's balance of trade and may lead to a depreciation of its currency. In turn, as shown in this study, the value of a currency is one of the most important determinants of a nation's economic performance. Finally, interest rate and money supply are statistically insignificant and do not show an effective process through which monetary policy shocks impact import and export growth in the economy. This shows that the exchange rate is an important determinant of trade openness in EMEs. Inflation also leads to a significant industrial export growth over a relatively long period.

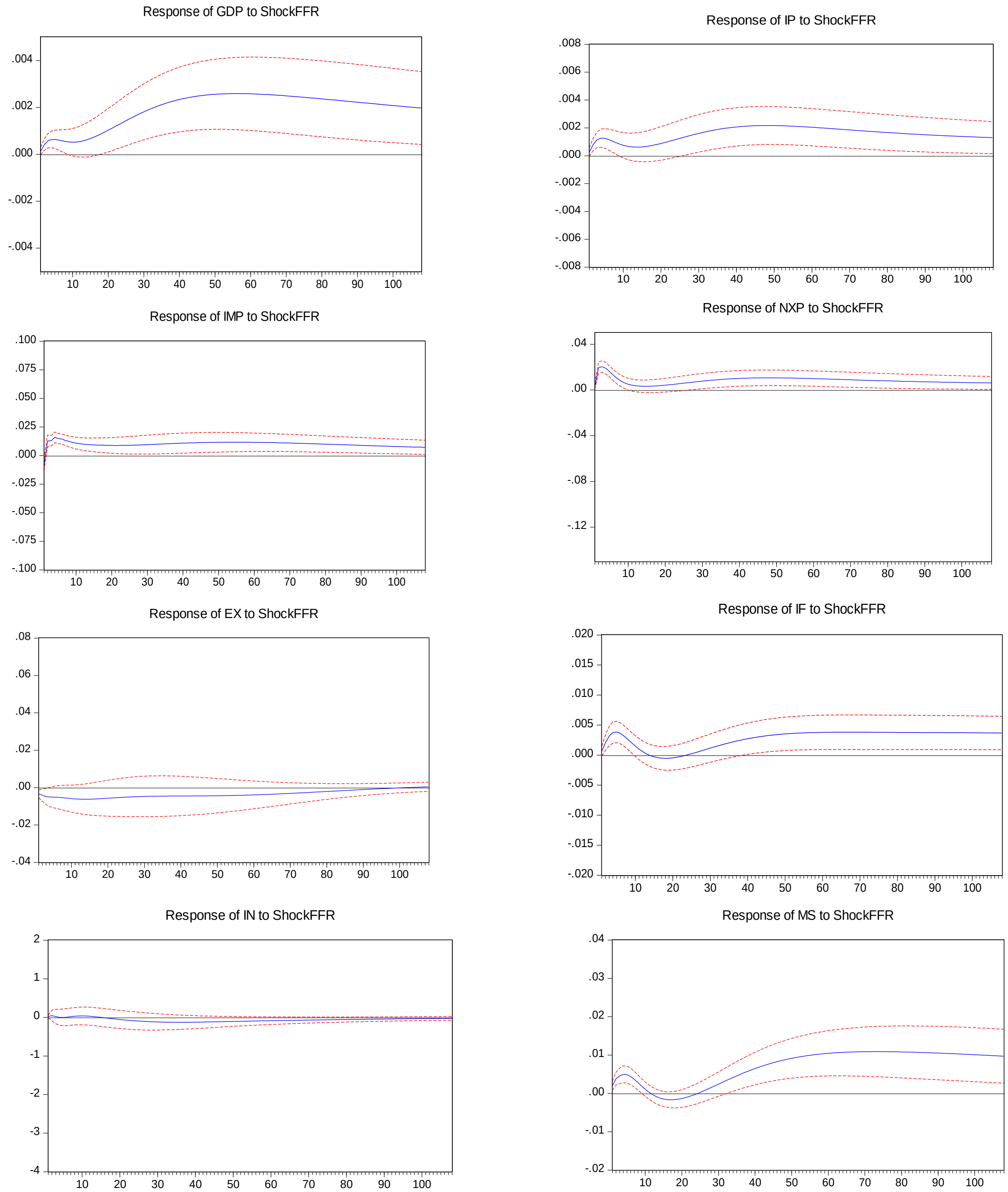
3.5.3 Impulse Responses of Selected Macroeconomic Variables to External Shocks

One of the objectives of this study is to analyse how external shocks impact macroeconomic variables and how the shocks spread over to other prices, leading to overall price level changes within the economy. Figure 3.3 shows a one standard deviation structural response of all the macroeconomic variables in the model to an external shock that impacts the economy. The international interest rate (proxied by the FFR) captures the external shocks in the model. Therefore, the response of each variable to FFR is analysed.

Firstly, the response of GDP to external shocks shows an increase and a decrease with a significant positive impact for the whole period under study. Figure 3.3 shows that external interest rates serve as a determinant of domestic economic activities, consistent with Krznar and Kunovac (2010). There is an increase in the real GDP from the first to the fifth year after which it starts declining to the end of the ninth year, following an FFR shock. The spill over effect of a 1% increase in world interest rates on domestic GDP is also reflected in a positive, significant reaction of industrial output (IP). This shows that an unanticipated interest rate shock from the external environment decreases industrial production over a relatively long period.

As revealed by Di Giovanni and Shambaugh (2008), the impulse responses show that global shocks increase and decrease industrial sector growth and transmit across EMEs with more contractionary effects. This is in line with Berkelmans (2005), who argues that the transmission of international shocks to domestic variables can be rapid and has a significant impact on real GDP as well as industrial output.

Figure 3.3: Impulse responses of Selected Macroeconomic variables to a Foreign Interest Rate Shock



Moreover, foreign interest rate shocks have a significant impact on the degree of openness and trade relationship among the BRICS countries and the rest of the world. They lead to a sharp response in terms of imports and exports, although not as sharp as in the case of GDP and industrial output. Thanks to diversification, that the foreign interest rate shock causes imports to fall within a short period before peaking and trending steadily on a positive note. It is, however, observed that the significant export reduction arising from the foreign interest rate shock is very pronounced. A large decline in exports is noted over a relatively long period from the first to the second year and also from the fourth to the ninth year, which may lead to balance of a payment deficit. This conforms to analysis and expectations that an unexpected increase in foreign interest rates leads to more imports and less exports. Appreciation of the US dollar against BRICS' currencies has an immediate negative impact on export volume (Sariola, 2009). Conversely, foreign interest rate shocks have an insignificant impact on the exchange rate and interest rates for the entire period under study. This gives credence to the idea that monetary policy is interested not only in optimal monetary conditions but also in external stability (Knedlick, 2006), supports Mallick and Sousa's (2012) argument in favour of optimal monetary conditions, and shows that the interest rate is independent of the FFR rate in EMEs. The policymaker's overriding objective on interest rates is regularly cantered on expected inflation and output growth.

Nonetheless, the relevance of external shocks propagates and has a spill over effect on domestic prices. The shocks result in significant increases and decreases in prices. In line with the argument that many economies are affected by external conditions (Di Giovanni and Shambaugh, 2008), price is initially on an upward trend in the first year but insignificantly declines and becomes negative between the second and third years and later becomes significantly positive for the entire study period. This might not be unconnected to the open nature of the BRICS economies where volatility is independent of domestic economies. Ratti and Vespignani's (2015) study of the drivers of global interest rates found that around 46% of movements in central bank interest rates is attributed to changes in global monetary aggregates (15%), oil prices (13%), global output (11%) and global prices (7%). Increases in global interest rates are associated with reduced global prices and eventually a reduction in output. This shows that interest rates in large countries have a strong impact on economic conditions in other countries. Moreover, the propagation effects of external shocks also transmit to money supply in the economy. We observe that the response of money supply to an external foreign interest rate shock follows a similar trend (increasing and decreasing) as prices since the relationship between inflation and money supply is always found to have similar key determinants (Sola and Peter, 2013).

3.6 Variance Decomposition

According to Raghavan and Silvapulle (2008), variance decomposition describes what percentage of a shock to a specific variable is related to either its own innovations or those associated with other dependent variables, at various forecasted time periods in a model. It analyses the relative importance of shocks in explaining variations among variables. In the context of this study, variance decomposition helps to determine the relative percentage of shocks to all the variables in assessing the impact of monetary policy shocks on industrial output growth in BRICS countries. It will further help to reveal the significant impact of the external shocks on all the variables in the model. This study allows variance decompositions for 60 months in order to ascertain the effects of the shocks when the variables are allowed to affect each other over a relatively long period of time. Thus, the analyses cover a 5 year horizon.

3.6.1 Variance Decomposition of Industrial Sector Performance (IP)

Table 3.5 presents the variance decomposition of industrial output. It reveals that the contribution of interest rate shocks to variations in industrial output is very small, ranging from 0.41% after one year to 0.81%, 1.34%, 1.78% and 2.10% after two, three, four and five years, respectively. Similarly, a very small proportion of the variations in industrial output is attributed to money supply shocks. Table 3.5 shows that after one, two, three, four and five years, money supply shocks account for 1.47%, 1.60%, 1.67%, 1.77% and 1.89% of the variations in industrial output, respectively. The contribution of GDP shocks, which may reflect industrial output itself, is highest among the shocks that explain fluctuations in industrial output. Table 3.5 reveals that GDP growth accounts for 67.02%, 50.62%, 43.08%, 37.99% and 34.33% of the variations in industrial output in the first, second, third, fourth and fifth years, respectively.

The contribution of international interest rates (proxied by the FFR) to variations in industrial output in the BRICS countries increases from 2.13% at the end of a year to 4.19% and 9.12%

after three and five years, respectively. Imports and exports shocks explain a moderate proportion of the variations in industrial output.

Table 3.5: Variance Decomposition of Industrial Production

Period	Standard Error	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock IF	Shock IN	Shock MS	Shock EX
12	0.02	2.13	67.02	3.42	5.67	4.52	5.19	0.41	1.47	10.13
24	0.03	2.09	50.62	13.05	8.39	10.95	5.29	0.81	1.60	7.14
36	0.03	4.19	43.08	16.60	8.18	14.01	4.09	1.34	1.69	6.78
48	0.03	7.00	37.99	16.05	7.21	14.67	3.88	1.78	1.77	9.60
60	0.04	9.12	34.33	14.64	6.34	14.33	4.11	2.10	1.89	13.10

The shock on imports accounts for 5.67%, 8.39%, 8.18%, 7.21% and 6.32% after the first, second, third, fourth and fifth years, respectively. A shock on exports, on the other hand, accounts for 4.52%, 10.95%, 14.01%, 14.67% and 14.33% of the variations in industrial sector output after one, two, three, four and five years, in that order.

To understand the role of the monetary authorities in influencing industrial output we further investigate the contribution of operating tools of monetary policy to intermediate monetary policy targets and relate the same to the foregoing discussion, with industrial output as a monetary policy goal. Table 3.6 presents variance decomposition of exchange rates, which have been observed to have a preponderant effect on industrial output.

Table 3.6: Variance Decomposition of Exchange Rates

Period	Standard error	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock IF	Shock IN	Shock MS	Shock EX
12	0.17	1.05	2.94	6.17	0.81	3.07	3.48	0.46	6.08	75.89
24	0.23	1.29	4.98	7.54	1.34	5.56	5.46	0.75	5.96	67.09
36	0.26	1.39	6.57	8.21	1.98	7.02	6.34	0.69	5.34	62.41
48	0.28	1.58	7.44	8.52	2.40	7.91	6.70	0.64	5.00	59.76
60	0.28	1.79	7.83	8.56	2.59	8.37	6.80	0.62	4.88	58.51

The table shows that interest rate shocks have a marginal effect on exchange rates, accounting for less than 1% of exchange rate fluctuations throughout the period under analysis (up to five years). Money supply, on the other hand, makes a relatively larger contribution to exchange rate fluctuations. The table reveals that a money supply shock accounts for 6.08% of the variations in exchange rates after one year. This contribution declines to 5.96%, 5.34%, 5.00% and 4.88% at the end of the second, third, fourth and fifth years, respectively. We can thus safely conclude that the effect of changes in money supply is more pronounced than the effect of interest rates on industrial output. While the direct effect is marginal in both cases, as observed in Table 3.5, the transmission process operating from money supply shocks to industrial output through exchange rates is pronounced (see Table 3.6). It is further observed in Table 3.6 that inflation and money supply have a comparable effect on exchange rate fluctuations. After about one year, inflation accounts for 3.48% of the fluctuations in exchange rates, which increases to 5.46%, 6.34%, 6.70% and 6.80% after the second, third, fourth and fifth years. This suggests that any policy aimed at fighting inflation by reducing money supply is likely to depress industrial production through appreciation of the local currency. If the monetary authorities are concerned about both inflation and industrial output, they face the dilemma of deciding on the optimal rate of inflation that does not excessively reduce industrial output.

Table 3.7 shows the contribution of all the variables in the model to variations in the rate of inflation. It reveals that most of the fluctuations in inflation are explained by exchange rate shocks. It is observed that 18.43% of the fluctuations in inflation rates are explained by exchange rate shocks after one year. This increases to 30.79%, 37.70%, 41.35% and 42.56% after two, three, four and five years, respectively. This shows that any policy adopted by the monetary authorities to weaken the domestic currency with a view to increasing industrial output will have inflationary effects.

Table 3.7 also reveals that changes in money supply have a large impact on variations in the rate of inflation, which weakens over time. After one year, money supply accounts for 28.6% of inflation rate variations. This declines to 25.02% after two years and 21.22% after three years, 17.84% after four years and 15.52% after five years. Thus, while money supply shocks have a sizeable effect on fluctuations in exchange rates, which in turn spur industrial output, they also have inflationary effects.

Table 3.7: Variance Decomposition of Inflation

Period	Standard Error	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock IF	Shock IN	Shock MS	Shock EX
12	0.04	3.64	9.99	2.74	27.63	4.84	1.65	2.44	28.60	18.43
24	0.05	2.39	11.38	2.98	18.67	3.41	2.18	3.15	25.02	30.79
36	0.06	2.25	9.27	4.72	14.10	3.17	3.73	3.78	21.22	37.70
48	0.07	3.57	7.93	5.28	11.18	3.32	5.54	3.95	17.84	41.35
60	0.08	5.27	7.50	5.41	9.37	3.66	6.67	3.99	15.52	42.56

How is monetary policy conducted in the BRICS countries? Table 3.8 presents the variance decomposition of interest rates. It is observed that inflation accounts for most of the fluctuations in interest rates in the BRICS countries, indicating that the monetary authorities primarily adjust interest rates in response to inflation expectations. It is estimated that 66.10% of the fluctuations in interest rates are explained by inflation rate shocks after one year. This declines to 58.55%, 56.44%, 55.50% and 55.02% after two, three, four and five years, respectively. We further observe that exchange rate shocks are the second most important factor that explains variations in interest rates.

Table 3.8: Variance Decomposition of Interest Rates

Period	Standard Error	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock IF	Shock IN	Shock MS	Shock EX
12	6.29	0.02	0.00	3.65	5.71	3.01	66.10	3.16	0.84	17.47
24	6.81	0.08	0.07	7.61	5.64	5.01	58.55	2.88	1.27	18.86
36	6.94	0.42	0.41	8.36	5.59	5.74	56.44	2.78	1.35	18.87
48	7.00	0.76	0.80	8.46	5.57	6.11	55.50	2.73	1.35	18.67
60	7.03	0.98	1.05	8.47	5.57	6.30	55.02	2.72	1.34	18.51

Table 3.8 shows that exchange rate shocks account for 17.47% of the fluctuations in interest rates after a year, 18.86% after two years, 18.87% after three years, 18.67% after four years and 18.51% after five years. This suggests that the monetary authorities in the BRICS countries also adjust interest rates to influence exchange rates, probably through capital flows as an intermediate target.

Table 3.9 shows the variance decomposition of money supply. It reveals that variations in money supply explained by inflation rate shocks are very small. It is observed that after one year, inflation rate shocks explain only 4.44% of the variations in money supply. This decreases to 3.18% after two years and 2.12% after three years before increasing slightly to 2.28% after four years and 2.75% after five years. This result indicates that the monetary authorities do not use money supply as a primary operating tool of monetary policy in the fight against inflation. As shown in Table 3.9, they adjust money supply primarily in response to industrial output fluctuations. The table reveals that industrial output shocks account for 1.60% of the fluctuations in money supply after one year, which increases to 19.55% after two years, 32.95% after three years and 33.48% after four years. This demonstrates that the monetary authorities' adjustment of money supply is highly likely to be a response to an industrial output shock rather than an inflation rate shock.

Table 3.9: Variance Decomposition of Money Supply

Period	S.E	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock IF	Shock IN	Shock MS	Shock EX
12	0.05	4.50	8.46	1.60	73.74	1.47	4.44	3.16	0.70	1.89
24	0.07	2.89	20.97	19.55	43.67	3.86	3.18	2.31	2.32	1.21
36	0.09	2.74	20.33	32.95	26.64	9.42	2.12	2.33	2.25	1.16
48	0.12	5.94	19.20	33.48	18.19	13.09	2.28	2.56	1.93	3.30
60	0.14	9.54	18.61	29.88	13.47	14.63	2.75	2.78	1.78	6.51

3.6.2 Variance Decomposition of Gross Domestic Product (GDP)

Table 3.10 presents the variance decomposition of GDP. It shows that deviations in GDP explained by money supply shocks, interest rate shocks and inflation rate shocks are very small from the first to the fifth year. However, trade shocks (export shocks and import shocks) account for a large variation in GDP for the same period. This result is further supported by the impact of exchange rate shocks on GDP. Exchange rate shocks account for 8.74%, 4.43%, 3.81%, 6.18% and 9.56%, respectively from the first to the fifth year of variations in GDP. These results show that international trade and the exchange rate have a significant impact on GDP growth in the BRICS countries. As further revealed in the table, external shocks (FFR shocks) increasingly account for a variation in GDP ranging from 1.86% to 12.46% (from the first period to the fifth period). This could suggest that economic activities in BRICS countries are constrained by the impact of external shocks in the production of goods and services and in stimulating GDP. Thus, policymakers react to global shocks that may arise from the open nature of the BRICS economies. Of note in the table is GDP's shocks to its own variations. While the highest variations in GDP are caused by its own shocks, the impact of GDP shocks on its variations decrease (from 56.44% to 24.63%) from the first to the fifth year. This suggests that variations in GDP arising from its own shock decreases over time. Conversely, industrial output accounts for significant, increasing impacts in causing much of the variation in GDP from the first to the third year (from 17.05% to 32.13%) but follows the same decreasing trend in the fourth and fifth years, respectively (about 28.80% and 25.16%) in causing fluctuations in GDP.

Table 3.10: Variance Decomposition of GDP

Period	Standard Error	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock IF	Shock IN	Shock MS	Shock EX
12	0.01	1.68	56.44	17.05	5.19	7.74	1.85	0.40	0.87	8.74
24	0.02	2.71	37.15	31.17	6.62	15.05	1.06	0.93	0.82	4.43
36	0.02	6.17	30.46	32.13	6.06	18.04	0.89	1.52	0.87	3.81
48	0.03	9.84	26.95	28.80	5.17	18.64	1.36	2.01	1.01	6.18
60	0.04	12.46	24.63	25.16	4.43	18.18	1.95	2.38	1.21	9.56

3.6.3 Variance Decomposition of Import Goods (IMP)

Table 3.11 shows the analysis of the variance decomposition of imports for the 5 year horizon. In the first period, export shocks account for the highest variations in imports at 28.86%, while all other variables jointly account for about 71.14%. External shocks, GDP shocks and industrial output shocks account for an increasing proportion of the variations in imports from the second to the fifth year, while imports' shocks to its own value (its own shocks) decreases at the end of the fifth year. The interest rate shock significantly decreases for the entire period in causing fluctuations in imports. On the other hand, the impact of exchange rate shocks, price shocks and money supply shocks increases in the second year but declines at the end of the third year and this trend continues until the fifth year. The overall analyses reveal that external shocks, GDP shocks and industrial production shocks account for an increasing variation in imports. Therefore, attention should be focused on these variables as a way of preventing trade deficits. There should be growth in real GDP, an increase in industrial production and policy that promotes external stability in order to prevent trade deficits.

Table 3.11: Variance Decomposition of IMP

Period	S.E	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock IF	Shock IN	Shock MS	Shock EX
12	0.16	6.94	8.61	5.21	4.70	28.86	3.39	16.44	1.30	24.52
24	0.21	6.42	12.01	11.40	4.35	24.08	4.28	9.97	1.59	25.85
36	0.24	6.85	14.55	15.02	4.75	23.93	3.74	7.71	1.29	22.12
48	0.26	8.05	16.13	16.32	4.95	24.30	3.24	6.79	1.12	19.06
60	0.27	9.41	16.86	16.33	4.90	24.28	2.96	6.37	1.09	17.76

3.6.4 Variance Decomposition of Export Goods (EXP)

As shown in table 3.12, interest rates account for the largest proportion of variations in exports from the first to the fifth year, indicating that the monetary authorities' policies and programs can stimulate export growth while variations in exports explained by prices and money supply shocks are very small for the entire period. However, the external shocks increasingly account for much of the variations in exports from 5.60% in the second year to 9.38% in the fifth year. Hence, it can be concluded that global shocks account for variations in export growth in the BRICS countries. Policymakers should thus adopt policies to stimulate export growth and avoid transmission of global shocks to the domestic economy. From the second year to the fifth year, GDP shocks account for 25.71%, 24.82%, 23.19% and 21.74% while the industrial output shocks account for 8.20%, 10.81%, 10.82% and 10.12% of the variations in exports. Furthermore, the impact of import shocks on variations in exports decreased from 8.07% to 6.55% (from the second year to the fifth year) while exchange rate shocks explained 3.47% to 11.37% (from the second year to the fifth year) of these variations. The policy implication is that policymakers should focus on exchange rate stability in order to stimulate export growth. This result is in line with that derived from the impulse response analysis of exchange rate shocks to exports. Finally, export shocks (its own shocks) explained 11.90% to 13.33% from the second year to the fifth year of the fluctuations in its own value (exports). Overall, from the first to the fifth year, it can be concluded that external shocks, exchange rate shocks, prices and money supply have increasing impact in explaining the variations in exports while the variations attributed to other variables decline over time.

Table 3.12: Variance Decomposition of EXP

Period	S.E	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock IF	Shock IN	Shock MS	Shock EX
12	0.16	7.05	21.00	2.72	6.60	9.32	0.87	47.76	0.35	4.28
24	0.19	5.60	25.71	8.20	8.07	11.90	1.30	34.68	1.03	3.47
36	0.21	6.34	24.82	10.81	8.01	13.49	1.15	29.41	1.41	4.51
48	0.22	8.00	23.19	10.82	7.26	13.73	1.46	26.08	1.61	7.82
60	0.23	9.38	21.74	10.12	6.55	13.33	2.00	23.71	1.76	11.37

3.7 Conclusion

This Chapter employed a $P - SVAR$ to investigate how monetary policy shocks in the BRICS countries affect industrial output and inflation. The study found that an exchange rate shock (devaluation) has the largest impact on industrial output. It initially reduces industrial output and later increases it significantly over a relatively long period. On the other hand, the impact of a positive inflation shock on industrial output is not pronounced in comparison to the effect of an exchange rate shock. It is nonetheless observed that an inflation rate shock significantly increases industrial output, peaking after about 11 months and declining thereafter. The study also found that industrial output does not respond significantly to a positive interest rate shock (representing monetary tightening) until after about two years when it starts increasing, albeit by a very small margin. The direct impact of a monetary policy shock on industrial output is also observed to be relatively small.

Further analysis revealed that interest rate shocks have a very marginal effect on exchange rates while money supply makes a relatively larger contribution to exchange rate fluctuations. It is argued, therefore, that the effect of changes in money supply on industrial output is more pronounced than the effect of interest rates. While the direct effect is marginal for both variables, the transmission process that starts with changes in money supply through exchange rate fluctuations to industrial output is relatively large; revealing that any policy aimed at reducing money supply in order to ease inflationary pressures will tend to depress industrial output. If the monetary authorities are concerned with both inflation and industrial output, they face the dilemma of deciding on the optimal rate of inflation that does not excessively reduce industrial output.

The study also found that a large part of the fluctuations in inflation rates is explained by exchange rate shocks, which suggests that any policy by the monetary authorities to weaken the domestic currency with a view to increasing industrial output will have inflationary effects. We also found that changes in money supply have a very large impact on variations in the rate of inflation, which weakens further over time. Thus, while money supply shocks have a sizeable effect on fluctuations in exchange rates which in turn spur industrial output, they also have inflationary effects.

The study also observed that inflation accounts for most of the fluctuations in interest rates in the BRICS countries, indicating that the monetary authorities primarily adjust interest rates in response to inflation expectations. After inflation rate shocks, exchange rate shocks are the second most important factor that explains variations in interest rates, connoting that the monetary authorities in the BRICS countries probably adjust interest rates to influence capital flows, which in turn affect exchange rates.

Variations in money supply explained by inflation rate shocks are very small, suggesting that the monetary authorities do not use money supply as an instrument in the fight against inflation. It was observed, however, that industrial output shocks account for a relatively large proportion of variations in money supply after one year. This suggests that the monetary authorities' adjustment of money supply is highly likely to be a response to an industrial output shock rather than an inflation rate shock.

Finally, we analysed how external shocks impact macroeconomic variables and how these shocks spread to other prices, leading to overall price level changes within the economy. The spill over effect of an increase in world interest rates on domestic GDP is also reflected in a positive, significant reaction of industrial output (IP). This shows that an unanticipated shock from the external environment decreases industrial production over a long period.

The results from the variance decomposition are more robust and are generally similar to the results obtained from the impulse response functions. The findings revealed that shocks from the external environment have a significant impact on all the macroeconomic variables except the exchange rate and interest rates due to the fact that monetary policies in BRICS countries are focused not only on optimal monetary conditions but also on external stability (Knedlick, 2006). Thus, the BRICS countries are likely to have independently maintained price stability in the interests of balanced and sustainable economic growth.

CHAPTER FOUR

MODELLING EXCHANGE RATES FOR THE BRICS COUNTRIES: APPLICATION OF THE GARCH, EGARCH AND APARCH MODELS

4.1 Introduction

In Chapter Three, it was established that variations in exchange rates have a large impact through which shocks transmit to other macroeconomic variables and influence industrial output in the BRICS countries. This chapter models variations in BRICS countries exchange rates amidst global shocks in order to understand exchange rate behaviour and establish if global oil prices and international interest rates (global shocks) have any impact on exchange rate variations in these countries. In line with the theoretical model built by Kamal *et al.* (2012) and Miletić (2015), this study adopts the symmetric GARCH (1,1) model along with two asymmetric EGARCH (1,1) and APARCH (1,1) models to model exchange rates in the BRICS countries. The use of these three different measures will help to determine the extent (if any) of differences in the estimations of the exchange rates in BRICS countries. Exchange rates expressed in terms of the local currency to the US dollar are employed for consistency. Four analytical procedures are involved in estimating these models. First, the residual test is carried out to establish the ARCH effect. Second, the unit root test is carried out for each of the variables to determine the time series properties of the dataset. Third, the regressions (GARCH, EGARCH and APARCH) are performed in order to determine the relationship between the variables employed. Finally, diagnostic tests are carried out to determine the model selection and ascertain the overall goodness of the models.

While various studies have modelled variations/volatility of exchange rates in many economies using different approaches such as the GARCH, EGARCH, GJR-GARCH, DGE–GARCH, TARCH and APARCH among others, to the best of researcher's knowledge, no study has modelled exchange rate variations amidst global shocks in the BRICS countries. In addition, the researcher is not aware of any study that has simultaneously employed the GARCH (1,1), EGARCH (1,1) and APARCH (1,1) models in a study of exchange rate variations in BRICS countries; this is thus this study's contribution to the literature. These approaches (GARCH, EGARCH and APARCH) have played a vital role in financial forecasting, risk management and financial decision-making as well predicting the stability of exchange rates.

4.2 Conceptual Background

Changes in exchange rates have implications for business and policy decisions. Variations due to unanticipated shocks have real economic costs for price stability, firm profitability and a country's financial stability (Benita and Lauterbach, 2007). The key research question is thus whether variations in the exchange rate affect output growth. Khosa *et al.* (2015) found, that, exchange rate volatility/variation has a significant negative effect on economic performance, especially industrial export growth in emerging markets. This is consistent with the findings of studies by Clark *et al.* (2004), Aghion *et al.* (2009), Héricourt and Poncet (2013), Chit *et al.* (2010) and Verheyen (2012), that concluded that, exchange rate volatility/variation can affect productivity growth and trade flows. The process by which manufacturers in the industrial sector produce goods and services locally and transport them across international borders is the basis for the trade that the BRICS's countries' agenda (partnering for development, integration and industrialization) aims to build among themselves and with the rest of the world.

In the 20th century, most countries sought to stabilize their currencies by imposing regulations and restrictions against exchange rate movements. Many experimented with different systems such as crawling bands, changes in the domestic interest rate (monetary measures), direct intervention in the foreign exchange currency market, and restrictions on capital flows in and out of the country. All these measures aim to prevent exchange rate variations (changes) and shocks.

These central bank policies were fairly successful in controlling exchange rate changes. However, there has been on-going debate on the appropriate exchange rate system in developing countries. Two opposing views emerged. The first supports the floating exchange rate system due to increased globalization and the need to gain an edge in the face of market restrictions or impositions arising from the fixed or managed exchange rate system. This school of thought argues that the fixed or managed exchange rate system has adverse effects on domestic policies and regulations (Stockman, 1999). For instance, the financial crisis in Asia and ensuing crises in Brazil and Russia occurred under a "managed exchange rate regime", which highlights the risk of undue central bank interference. As a result, countries such as Brazil, South Africa, Chile, Korea and Turkey, among others, allowed a free-floating exchange rate system while a floating exchange rate regime is currently in place in Russia and China (see Bank of Russia FX Policy, 2016) and China currently supports a mix of fixed and floating exchange rate systems.

The second school of thought notes that other countries selected an alternative "turning resolution" and "pegged" their currencies to the US Dollar or the Euro (Benita and Lauterbach, 2007). India, which is a member of BRICS, operates a crawling-pegged exchange rate system. Proponents of this system argue that even in a free-floating exchange rate system, most central banks still intervene in the foreign exchange market (Calvo and Reinhart, 2002) and the selling and purchase of currencies. They maintain a threshold or exchange rate band and through their monetary policy tools, they use interest rates to respond to deviations from their targeted levels for exchange rates (Monacelli, 2004).

Theoretically, variations in exchange rates can have a negative or positive impact on output growth. They can generate expenditure switching between foreign and domestic goods both at home and among trade partners, thus affecting net exports. They may further affect firms' profit margins with possible second-round effects on investment. Duasa (2009) sheds light on this effect and finds that variations in exchange rates significantly affect fluctuations in import prices. Furthermore, Kandil and Mirzaie (2005) reveal that the impact of exchange rate variations and exchange rate shocks is likely to determine economic performance either positively or negatively, as some countries are highly susceptible to external shocks such as the exchange rate. The nature of the shocks will depend on whether an increase or decrease (depreciation or appreciation) results and whether it is anticipated or not. Depreciation may stimulate economic activities through the initial increase in the price of foreign goods while appreciation decreases net exports through the initial decrease in the price of such goods.

4.3 Theory of Exchange Rate Determination and Policy Decisions

The model for exchange rate determination employed in this study is rooted in the Marshall-Learner Condition and the Monetary View of Exchange Rate Determination. The Marshall-Learner Condition propounded by Alfred Marshall and Abba P. Lerner is an extension of Marshall's theory of the price elasticity of demand for foreign trade. Oladipupo (2011) describes the Marshall-Learner Condition as the sum of the absolute long-term price-elasticities for exports and imports which has to be greater than unity (one) for it to cause improvement in the balance of trade. The Marshall-Learner Condition can be expressed as:

$$\Delta\forall = ABX(\alpha_{1n} + \alpha_{2n-1}) \tag{4.1}$$

where:

$\Delta\forall$ = the total change in the balance of trade.

A = the percentage of devaluation of a currency.

BX = the value of net exports expressed in terms of foreign currency.

α_{1n}= the first devaluing country's price elasticity of demand for imports.

α_{2n}= the second country's price elasticity of demand for exports from the devaluing country.

Therefore, for the Marshall-Learner Condition to be fulfilled, $\alpha_{1n} + \alpha_{2n} > 1$. This approach sets out the conditions in which changes in exchange rates will have some impact on balance of trade (balance of payments) and restore equilibrium. A further expression for restoration of the balance of payments equilibrium can be given as:

$$B = P_x^* X(s) - P_m^* M(s) \tag{4.2}$$

where:

B = the balance of payments.

P_x^*= the price of exports expressed in the home currency against the foreign currency.

P_m^* = is the price of imports in the foreign currency against the home currency.

s = notation for elasticity of exports and imports.

With equation 4.2, if

$P_x^* = P_m^* = 1$; we have $B = X(s) - M(s)$

therefore:

$$\frac{dB}{ds} = \frac{dX}{ds} - X(s) - \frac{dM}{ds} - M(\mathrm{s}) \tag{4.3}$$

Equation 4.3 can be re-expressed in terms of the home country's import elasticity of demand (s_m) and foreign demand elasticity for the home country's exports (s_x) where:

$$s_m = -\frac{dM}{ds}\frac{s}{M} \tag{4.4}$$

$$s_x = -\frac{dX}{ds}\frac{s}{X} \tag{4.5}$$

we get $\frac{dB}{ds} > 0$, e.g. a devaluation improves the balance of payments as long as $\frac{X}{sM}s_x + s_m - 1 > 0$. In addition, if trade is balanced ($\frac{X}{SM} = 1$), then trade improves if the price elasticity is high enough, e.g., $s_x + s_m > 1$. However, if the balance of payment is initially in deficit, then the sum of trade elasticity with s must be higher than unity.

On the other hand, the Monetary View of Exchange Rate Determination is a monetary policy approach to determine exchange rates between the home country and foreign countries. Frenkel and Johnson (2013) view the monetary approach to exchange rate determination as a dual relationship between money and other assets in the determination of balance of payments when the exchange rate is pegged, and in determining the exchange rate when it is floating. The model assumes a simple demand for money curve. The purchasing power parity or the law of one price that is the standard for import pricing in a theoretical model of an open economy (Schmitt-Grohé and Uribe, 2011; Benedictow and Boug, 2010) like those of the BRICS countries holds under this approach. The approach further assumes a vertical aggregate supply curve.

According to the absolute purchasing power parity, the exchange rate can be derived by dividing the home country's price level by that of the foreign country. For example,

$$P = eP^* \tag{4.6}$$

where

P = the domestic price level.

P^* = the foreign price level.

e = the exchange rate.

Assume the demand for money equation is given by

$$Md = kPy \tag{4.7}$$

Where

k is a constant, and y is the real income level. However, at the equilibrium, the demand for money (Md) must be equal to the supply of money (Ms). E.g.

$Md = Ms$

Therefore, at the point of intersection of the aggregate demand and the aggregate supply curve,

$$kPy = Ms \tag{4.8}$$

Or $P = Ms/ky$ (4.9)

Or $eP^* = P = Ms/ky$ (4.10)

Or $e = Ms/P^*ky$ (4.11)

At this point, external equilibrium is achieved in the economy. It is further clear from equation (4.11) that an increase in money supply within an economy would lead to appreciation of the domestic currency. However, policy decisions tend to infer the effect of policy variables such as interest rate changes and direct central bank intervention in exchange rate shocks for a pegged/managed exchange rate system, while in the case of a floating/flexible exchange rate system, the forces of demand and supply interplay with the shocks.

4.4 Methodology

4.4.1. Scope of the study and variables

The main objective of this study is to model variations of BRICS countries' exchange rates amidst global shocks in order to understand exchange rate behaviour and establish if global oil prices and international interest rates (global shocks) have any impact on exchange rate variations in these countries. The study uses monthly time series data covering the period $1994{:}01$ and $2013{:}12$. The study period is dictated by data availability. Four variables are examined to model the exchange rates. These can be grouped into domestic and foreign variables. The domestic variables are exchange rates (EX) and lagged exchange rates (EX(-1)) while the foreign variables are international interest rates (proxied by the FFR) and global oil prices (OP). This approach and the variables employed are in line with Ebaidalla (2013) and are consistent with the literature on modelling exchange rates.

4.4.2 Definition of variables and Data Sources

The Exchange Rate (EX), expressed in terms of the local currency per US dollar is employ in this study to modelled exchange rate and captures the trade relationship between each of the BRICS countries and the rest of the world. The lagged exchange rate is use to capture inertia in the exchange rate in line with (Khosa *et al*. (2015). Global Oil Price (OP) is the commodity global price index for oil and the FFR is the United States of America's short-term interest rate, i.e., the rate at which depository institutions in the country borrow and lend their central bank balances to one another, usually overnight. The variable is included to proxy international interest rates. Both oil prices and international interest rates are exogenous variables that are included to capture the impact of external shocks on exchange rates. They are used to control for economic activity in the global economy that is likely to affect the performance of a particular BRICS country. Several studies have followed this line of thought (Liu *et al*., 2015; Benita and Lauterbach, 2007; Elboune, 2008; Afandi, 2005; Maturu, 2007). In line with Nortey *et al.* (2015), monthly time series data are employed covering a period of 20 years from 1994:1 to 2013:12. The data are obtained from the individual countries' central banks' statistical bulletins and the statistics offices of each country.

4.4.3 Model specification

Three alternative methods of analyses are used to model the variations in exchange rates in BRICS countries: the GARCH, EGARCH and APARCH models. The study employs these three approaches to provide a comprehensive method to model exchange rate variations and global shocks in the BRICS economies; and to determine the extent (if any) of differences in the three estimations. Similar to Adeniyi (2011), Ebaidalla (2013) and Kin and Courage (2014), construction of our GARCH, EGARCH and APARCH models follows the conventional method where variance evolves over time. Assume the model is presented as:

$$EX_t = \beta_0 + \beta_1 EX_{t-1} + \beta_2 FFR_t + \beta_3 OP_t + \varepsilon_{t.} \qquad (4.12)$$

where $\varepsilon_{t \sim N\,(O,\,h_t)}$

$$h_t = C_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2 + \alpha_3 FFR_t + \alpha_4 OP_t + \mu_t \qquad (4.13)$$

Equation 4.13 states that conditional variance is a function of four terms: C_0 is a constant term, e_{t-1}^2 (the ARCH term) is the previous period's squared residual from the mean equation, h_t (the GARCH term) is the variance of the previous period's residual or exchange rate volatility of the Russian economy and two exogenous variables (FFR and OP). $\alpha_1 - \alpha_4$ are coefficients of the dependent variables.

4.4.4 The GARCH (1,1) Model

The GARCH process for modelling exchange rates can be given as:

$$\varphi_t^2 = \Psi + \sum_{j=1}^{q} \alpha_j \, \varepsilon_{t-j}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$$

$$\Psi > 0, \beta_i \geq 0, \alpha_j \geq 0 \quad i = 1 \ldots \ldots \ldots p, \quad j = 1 \ldots \ldots .. q$$

$$Y_t = \beta + \alpha X_t + \gamma h_t + \varepsilon_t$$

$$\varepsilon_t / \pi_t \sim N(0, h_t)$$

$$h_t = \sigma_o + \sum_{i=1}^{q} \delta_i h_{t-1} + \sum_{j=1}^{p} \tau_j \varepsilon_{t-j}^2$$

From the GARCH process above, the conditional variance is a linear function of q lags of the squares of the error terms (ε_t^2) or the ARCH terms and p lags of the past values of the conditional variances (σ_t^2) or the GARCH terms, and a constant ∀ (Bollerslev, 1986 and Kamal *et al*., 2012). Nonetheless, the inequality restrictions were imposed to guarantee a positive conditional variance in the equation. Hansen and Lunde (2001) demonstrate that the GARCH (1,1) process is sufficiently adequate to describe the features of the time series and hence, allows the conditional mean to depend on its own conditional variance.

4.4.5 The EGARCH (1,1) Model

The commonly used EGARCH (1,1) process for modelling exchange rates is given by:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \left[\frac{\mu_{t-1}}{\sigma_{t-1}}\right] + \beta_1 \sigma_{t-1}^2 + \gamma \frac{\mu_{t-1}}{\sigma_{t-1}}$$

EGARCH was developed by Nelson (1991) for an asymmetric response to exchange rate variations. The γ term accounts for the presence of leverage effects (large negative returns are more likely to forecast high variations than large positive returns), which makes the model asymmetric. When the asymmetric model for variations is applied, it is more likely to allow the variation and shock to respond freely when prices are falling due to the bad news than with corresponding increases due to good news (Kamal *et al.*, 2012). This means that the effect of good news (a positive lagged residual), may be different from the effects of bad news (a negative legged residual).

4.4.6 The APARCH (1,1) Model

Ding *et al*. (1993) introduced the APARCH model. The model takes the asymmetric coefficient and the leverage effect into account by changing the second order of the error term into a more flexible varying exponent. It represents a general class of models that include both ARCH and GARCH models. As specified by Ding *et al.* (1993), the APARCH (1, 1) model can be specified as follows:

$$y_t = x'_{1,t}\mu\varepsilon_t$$
$$\varepsilon_t = \sigma_t z_t$$
$$\sigma_t^{\delta} = x'_{2,t}\omega + \sum_{t=1}^{q} \alpha_1\, k(\varepsilon_{t-i})^{\delta} + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^{\delta}$$
$$k(\varepsilon_{t-i}) = |\varepsilon_{t-i}| - \gamma\varepsilon_{t-i}$$

where $x_{1,t}$ and $x_{2,t}$ are two vectors of monthly exogenous variables (including the intercept), and $\mu, \omega, \alpha_i's, \gamma_i's, \beta_j's$ and δ are parameters to be estimated. δ ($\delta > 0$) plays the role of a Box-Cox transformation of the conditional standard deviation σ_t, while γ reflects the leverage parameter. Again $\gamma > 0$ is leverage. In this model, $\varepsilon_{t-1} > 0$ captures "good news" and $\varepsilon_{t-1} < 0$ captures "bad news". Both have different effects on conditional variance. A positive value of γ means that past negative shocks have a deeper impact on current conditional exchange rate volatility than past positive shocks (Laurent, 2004; Thorlie *et al*., 2014).

4.4.7 Evaluation of Models and Model Selection Criteria

Following Bala and Asemota (2013), the empirical analysis of this study employs three conditional distributions to properly evaluate the GARCH (1,1) and APARCH (1,1) models for the BRICS economies. These include:

- the Normal Gaussian distribution
- the Student's t with fixed degrees of freedom

- the Generalized Error Distribution (GED)

4.4.7.1 The Normal Gaussian Distribution

Under this distribution, the distributional assumptions to be tested are: (1) there is no serial correlation; (2) residuals are normally distributed; and (3) there are no autoregressive conditional heteroscedasticity (ARCH) effects. The parameter $\theta = [\alpha,\ \beta, \gamma, \delta,\ \sigma,\ \pi,\ \tau,\ and\ \varphi\ ]$ is derived from the maximization of the log likelihood function:

$$logL = \sum_{t=1}^{N} l_t = -\frac{N}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{N} log\sigma_t^2 - \frac{1}{2}\sum_{t=1}^{N}\frac{\mu_t^2}{\sigma_t^2}$$

where N is the sample size, and

$$l_t = -\frac{1}{2}\log(2\pi) - \frac{1}{2}\log(\sigma_t^2) - \frac{1}{2}(y_t - x'_{t-1}\gamma)^2/\sigma_t^2$$

4.4.7.2 The Student's t with Fixed Degrees of Freedom

For the Student's t with fixed degrees of freedom (df), the log likelihood distribution function is assumed to take the following form:

$$l_t = -\frac{1}{2}\log\left[\frac{\pi\left[(v-2)\Psi\left(\frac{\rho}{2}\right)\right]^2}{\Psi[(\rho+1)/2]^2}\right] - \frac{1}{2}log\sigma_t^2 - \frac{[v+1]}{2}log\left[1 + \frac{[y_t - x'_t\gamma]^2}{\sigma_t^2[v-2]}\right]$$

where σ_t^2 represents variance at time t, and the degrees of freedom $(v > 2)$. $2 < v \leq \infty$ and $\Psi(.)$ is the gamma function (Thorlie *et al*., 2014). The lower the v, the fatter the tails.

4.4.7.3 The Generalized Error Distribution (GED)

Suppose the GED log likelihood distribution function can be presented in the following form:

$$l_t = -\frac{1}{2}log\left[\frac{\rho[1/r]^3}{\rho[3/r][r/2]^2}\right] - \frac{1}{2}log\sigma_t^2 - \left[\frac{\rho[3/r][y_t - x'_t\gamma]^2}{\sigma_t^2\rho[1/r]}\right]^{r/2}$$

where the tail parameter $r > 0$. The GED is normally distributed if $r = 2$ and fat-tailed if $r < 2$. Given, $y_t = x'_t\gamma + \mu_t$, then $\mu_t = (y_t - x'_t\gamma)$ (Bala and Asemota, 2013:96). Accordingly, all the necessary regularity conditions are assumed satisfied.

4.4.7 Unit Root Test

The unit root test is one of the pre-conditions for estimating GARCH and APARCH models as all variables must be stationary in order to avoid spurious results. The stationarity of the data is further necessary due to the fact that the majority of economic data exhibit a non-stationary trend which could lead to misleading results (Heymans *et al.*, 2014). This study employs the Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and Phillips Perron tests as they are valid for large sample sizes (Ogundipe *et al.*, 2014). These tests will be used to determine the order of integration of the variables employed. When a series is stationary in levels, it is said to be integrated to order zero (I(0)), that is, there is no unit root. If a variable is differentiated once in order for it to be stationary, it is said to be integrated to order 1, that is, I(1).

4.4.8 Diagnostic Tests and Model Selection Criteria

In order to determine the model selection criteria, this study employs the Akaike information criterion (AIC) and Schwarz information criterion (SIC). The lower the value of AIC and SIC, the better the model (Bala and Asemota, 2013). The normal Gaussian distribution, the Student's t with fixed degrees of freedom and the generalized error distribution models for the GARCH and APARCH models will be tested for normality, serial correlation and autoregressive conditional heteroscedasticity (ARCH effect) in order to determine which model is the best. The correlogram square residual (Q-test) is employed to test for serial correlation while the Jarque-Bera and ARCH tests are employed to test for the normality of the residual and conditional heteroscedasticity, respectively.

4.5 Results and Discussion

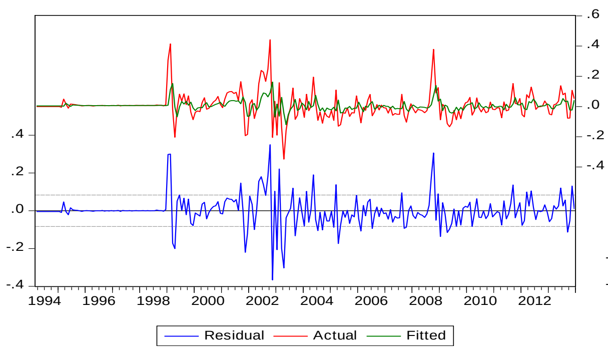
The empirical results obtained from various analyses of exchange rate variations are presented in this section. These results are obtained to model for the BRICS countries' exchange rate variations amidst global shocks. The parameter estimation methods of GARCH, EGARCH and APARCH are used with the given assumption to determine the best performance model for exchange rate variations in these countries.

4.5.1 The Test for the Residuals/ARCH Effects

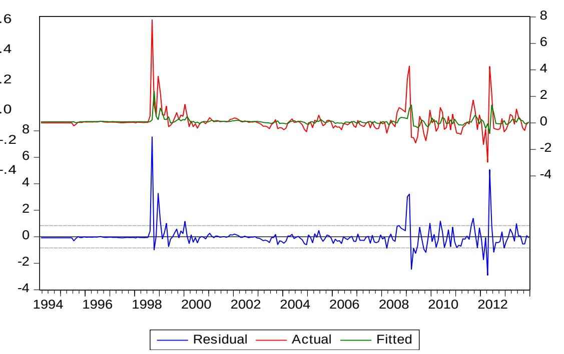
The starting point in the GARCH, EGARCH and APARCH models is to examine the residuals of the series of exchange rates for evidence of heteroscedasticity and determine whether they exhibit any volatility clustering. Using the LM-ARCH effect test as shown in Figure 4.1, the residuals display a prolonged period of low and high variations through which the exchange rate remains unstable. In Brazil, Russia and South Africa, prolonged periods of low exchange rate variations are followed by prolonged periods of low exchange rate variations and prolonged periods of high exchange rate variations are followed by prolonged periods of high exchange rate variations.

Figure 4.1: Results of the Residuals/ARCH Effects Test

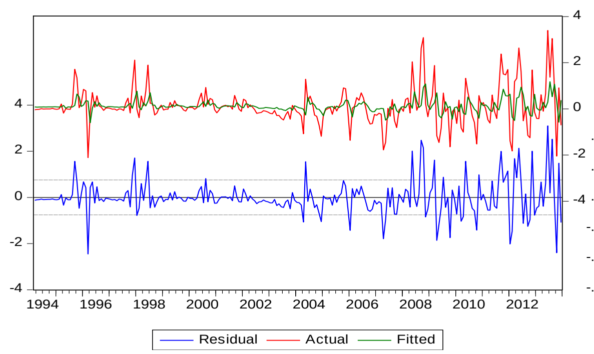
The ARCH Effects Test for Brazil



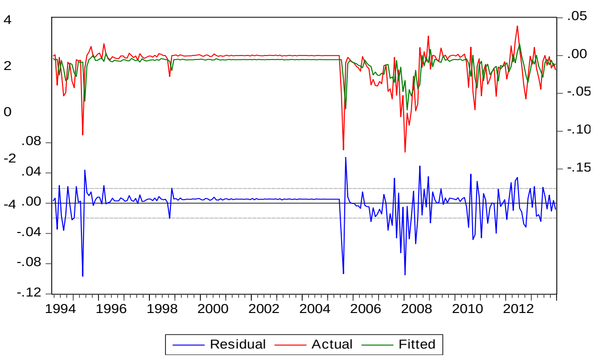
The ARCH Effects Test for Russia



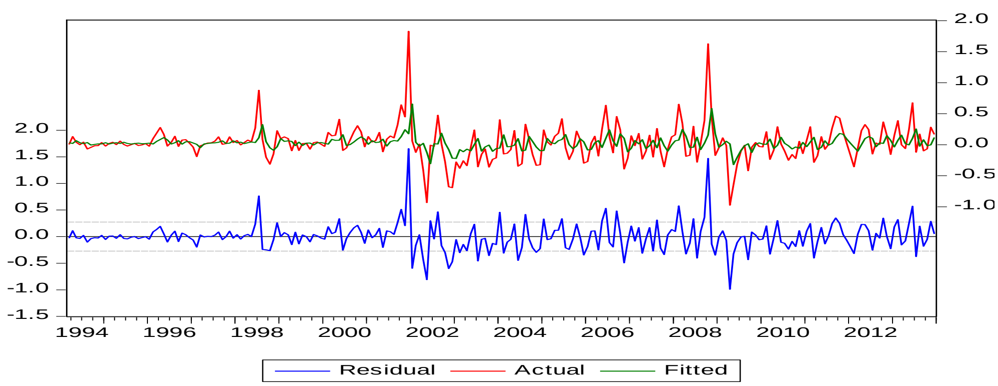
The ARCH Effects Test for India



The ARCH Effects Test for China



The ARCH Effects Test for South Africa



Source: *Author's computations using data released by WDI, IMF & statistics offices from BRICS countries*

In India and China, prolonged periods of high exchange rate variations are followed by prolonged periods of high exchange rate variations and prolonged periods of low exchange rate variations are followed by prolonged periods of low exchange rate variations. This suggests that the residual exhibits clustering changes, revealing the presence of ARCH effects.

4.5.2 Unit Root Test

Another condition for carrying out the GARCH, EGARCH and APARCH analyses is for the data set to be stationary. Tables 4.1 to 4.5 show the results of the DF, ADF and Phillips Perron tests for unit roots at individual intercept, and individual intercept and trend. At 1%, 5% and 10% levels, we reject the hypothesis that there are no unit roots in all the data sets using all three tests (except for the DF Test that finds no unit roots in the FFR). Analysis of all the variables differenced once shows that all variables are integrated of order 1 in all three tests (except for the DF Test that finds no unit roots in the FFR).

Table 4.1: The DF, ADF and P-P Unit Root Tests for Brazil

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.57447	0.0000***	I(1)	-10.54838	0.0000***
EX(-1)	I(1)	-10.54046	0.0000***	I(1)	-10.41242	0.0000***
FFR	I(0)	-3.563782	0.0004***	I(0)	-4.879805	0.0000***
OP	I(1)	-9.719862	0.0000***	I(1)	-9.816027	0.0000***

“***”, “**” and “*” represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.56906	0.0000***	I(1)	-10.56441	0.0000***
EX(-1)	I(1)	-10.52537	0.0000***	I(1)	-10.52115	0.0000***
FFR	I(1)	-5.394760	0.0000***	I(1)	-5.411639	0.0000***
OP	I(1)	-9.821088	0.0000***	I(1)	-3.971893	0.0108**

“***”, “**” and “*” represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	P-P (individual intercept)			P-P (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.55655	0.0000***	I(1)	-10.55169	0.0000***
EX(-1)	I(1)	-10.51264	0.0000***	I(1)	-10.50815	0.0000***
FFR	I(1)	-7.182428	0.0000***	I(1)	-7.221013	0.0000***
OP	I(1)	-9.820577	0.0000***	I(1)	-3.441577	0.0484**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Table 4.2: The DF, ADF and P-P Unit Root Tests for Russia

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-11.24232	0.0000***	I(1)	-11.29103	0.0000***
EX(-1)	I(1)	-11.21891	0.0000***	I(1)	-11.26775	0.0000***
FFR	I(0)	-3.563782	0.0004***	I(0)	-4.879805	0.0000***
OP	I(1)	-9.719862	0.0000***	I(1)	-3.419285	0.0007***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-11.31933	0.0000***	I(1)	-11.35206	0.0000***
EX(-1)	I(1)	-11.29594	0.0000***	I(1)	-11.32789	0.0000***
FFR	I(1)	-5.394760	0.0000***	I(1)	-5.411639	0.0000***
OP	I(1)	-9.821088	0.0000***	I(1)	-3.971893	0.0108**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	P-P (individual intercept)			P-P (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-11.36552	0.0000***	I(1)	-11.38995	0.0000***
EX(-1)	I(1)	-11.34146	0.0000***	I(1)	-11.36573	0.0000***
FFR	I(1)	-7.182428	0.0000***	I(1)	-7.221013	0.0000***
OP	I(1)	-9.820577	0.0000***	I(1)	-3.441577	0.0484**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Table 4.3: The DF, ADF and P-P Unit Root Tests for India

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.82543	0.0000***	I(1)	-10.89205	0.0000***
EX(-1)	I(1)	-10.81660	0.0000***	I(1)	-10.86066	0.0000***
FFR	I(0)	-3.563782	0.0004***	I(0)	-4.879805	0.0000***
OP	I(1)	-9.719862	0.0000***	I(1)	-3.419285	0.0007***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.96937	0.0000***	I(1)	-10.96133	0.0000***
EX(-1)	I(1)	-10.87961	0.0000***	I(1)	-10.88488	0.0000***
FFR	I(1)	-5.394760	0.0000***	I(1)	-5.411639	0.0000***
OP	I(1)	-9.821088	0.0000***	I(1)	-3.971893	0.0108***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	P-P (individual intercept)			P-P (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.86002	0.0000***	I(1)	-10.84219	0.0000***
EX(-1)	I(1)	-10.83954	0.0000***	I(1)	-10.83507	0.0000***
FFR	I(1)	-7.182428	0.0000***	I(1)	-7.221013	0.0000***
OP	I(1)	-9.820577	0.0000***	I(1)	-3.441577	0.0484**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Table 4.4: The DF, ADF and P-P Unit Root Tests for China

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	2.584191	0.0104**	I(1)	-6.297767	0.0000***
EX(-1)	I(1)	2.530389	0.0121**	I(1)	-6.271538	0.0000***
FFR	I(0)	-3.563782	0.0004***	I(0)	-1.836322	0.0676*
OP	I(1)	-9.719862	0.0000***	I(1)	-3.419285	0.0007***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-6.113500	0.0000***	I(1)	-6.322852	0.0000***
EX(-1)	I(1)	-6.104932	0.0000***	I(1)	-6.304136	0.0000***
FFR	I(1)	-5.394760	0.0000***	I(1)	-5.411639	0.0000***
OP	I(1)	-9.821088	0.0000***	I(1)	-3.971893	0.0108**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	P-P (individual intercept)			P-P (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-9.544814	0.0000***	I(1)	-9.787083	0.0000***
EX(-1)	I(1)	-9.526681	0.0000***	I(1)	-9.760699	0.0000***
FFR	I(1)	-7.182428	0.0000***	I(1)	-7.221013	0.0000***
OP	I(1)	-9.820577	0.0000***	I(1)	-3.441577	0.0484**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Table 4.5: The DF, ADF and P-P Unit Root Tests for South Africa

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.68783	0.0000***	I(1)	-2.162020	0.0316**
EX(-1)	I(1)	-10.65137	0.0000***	I(1)	-2.161443	0.0317**
FFR	I(0)	-3.563782	0.0004***	I(0)	-1.836322	0.0676*
OP	I(1)	-9.719862	0.0000***	I(1)	-3.419285	0.0007***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.68031	0.0000***	I(1)	-10.65760	0.0000***
EX(-1)	I(1)	-10.65151	0.0000***	I(1)	-10.62828	0.0000***
FFR	I(1)	-5.394760	0.0000***	I(1)	-5.411639	0.0000***
OP	I(1)	-9.821088	0.0000***	I(1)	-3.971893	0.0108**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variable	P-P (individual intercept)			P-P (individual intercept and trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
EX	I(1)	-10.74524	0.0000***	I(1)	-10.72290	0.0000***
EX(-1)	I(1)	-10.71632	0.0000***	I(1)	-10.69348	0.0000***
FFR	I(1)	-7.182428	0.0000***	I(1)	-7.221013	0.0000***
OP	I(1)	-9.820577	0.0000***	I(1)	-3.441577	0.0484**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

4.5.3 Interpretation of Results for Brazil

4.5.3.1 Results of the GARCH (1,1) Model for Brazil

The GARCH parameters in Table 4.6 show the calculated values for the coefficients and P-values of the Normal Gaussian distribution, Student's t distributions and the GED values for the monthly exchange rates in Brazil. The results show that the GARCH term, the ARCH term and the two exogenous shocks are important factors affecting exchange rates in Brazil. At 1%, all variables are statistically significant. The significant values of the GARCH (1) and the ARCH (1) terms imply that exchange rate variations are affected by their GARCH and ARCH terms. In addition, the exchange rate at $t-1$ also significantly affects exchange rate variations in Brazil. This indicates that the past period of exchange rates variations also significantly affects the current exchange rates. This finding is consistent with Bala and Asemota (2013). In addition, the two exogenous variables employed to capture the impact of global shocks can influence exchange rates in Brazil. This is consistent with Kin and Courage's (2014) finding that global oil prices impact exchange rates. The negative coefficients of the international interest rates and global oil prices for all the models show that an increase in global interest rates and oil prices will lead to depreciation of the currency. Alternatively, the negative sign shows that an increase in oil prices and global interest rates will affect exchange rates, which in turn will cause a decrease in GDP and verse versa (Liu *et al.*, 2015). This concurs with Aguirre *et al.* (2007) who studied the impact of exchange rate volatility on Brazilian manufactured exports and found that exchange rate volatility had a significantly negative effect on Brazilian manufactured exports.

Table 4.6: Results of the GARCH (1,1) Model for Brazil

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	-6.21E-05	0.9887	-0.001026	0.7826	-2.28E-05	0.9955
DEX(-1)	0.359774	0.0000	0.359476	0.0000	0.372295	0.0000
Variance Equation						
γ	0.002779	0.0001	0.002514	0.0000	0.002467	0.0001
ARCH(-1)	0.233330	0.0000	0.312995	0.0005	0.242132	0.0006
GARCH(-1)	0.347540	0.0022	0.292613	0.0015	0.334083	0.0030
DFFR	-0.006674	0.0000	-0.005817	0.0000	-0.005875	0.0000
DOP	-0.000148	0.0006	-0.000134	0.0008	-0.000131	0.0021
Model Selection						
AIC	-2.580050		-2.876796		-2.710025	
SIC	-2.477924		-2.774670		-2.607899	

Table 4.7: Results of model Selection for the GARCH (1,1) for Brazil

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.0003	0.1032	0.0131
ARCH Effect Test	No ARCH Effect	0.0033	0.1066	0.0140
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

Considering the model selection criteria among the Normal Gaussian distribution, Student's t distribution and the GED values, the Student's t distribution is found to perform better than the Normal Gaussian distribution and the GED values as revealed by the value of the AIC and SIC (see Table 4.7). The lower the value of AIC and SIC, the better the fitness of the model. Under the Normal Gaussian distribution and the GED values, the models are serially correlated, the residuals are not normal and there is evidence of heteroskedasticity in the models. Hence, they cannot be used for policy formulation and forecasting exchange rates in Brazil.

Conversely, Student's t distribution shows no evidence of serial correlation and no ARCH effect in the residuals. Hence, it is good for forecasting and policy formulation. This is a good sign for the model. However, the large Jarque-Bera (JB) statistics for the model indicate non-normality of most of the series. This is a bad sign for the model but researchers term it a "weaker sign" as it does not constitute a threat to the model and does not affect forecasting accuracy (Bala and Asemota, 2013; Goyal and Arora, 2010).

4.5.3.2 Results of the EGARCH Model for Brazil

Table 4.8 presents the results of the EGARCH (1,1) model for Brazil. The EGARCH is an extension of the ARCH model to capture the asymmetric and leverage effects in the model as introduced by Nelson (1991). Capturing the asymmetric and leverage behaviour of Brazil's exchange rate is important for policymakers, individuals and investors in order to enable them to respond more readily to exchange rate variations.

As revealed by the Normal Gaussian distribution, Student's t distributions and the GED values in Table 4.8, the estimation results show that there is autoregressive behaviour in the exchange rates as in the mean equation. The lagged exchange rate variable is significant at 1% for all the models. This indicates that exchange rate variations in the past period significantly affect current exchange rates. The constant C is also significant in all the models. Under the variance equation, the asymmetric coefficients of the EGARCH (1) are significant at 1%, indicating that the exchange rate in Brazil is also influenced by the EGARCH factor. International interest rates also contribute to the exchange rate variations in Brazil as revealed by the other models. In addition, global oil prices are significant at 10% for the Normal Gaussian distribution and Student's t distributions. The implication of these results is that global shocks are an important determinant and may contribute to exchange rate variations in Brazil and hence, should be taken into consideration when formulating exchange rate policies.

Table 4.8: Results of the EGARCH (1,1) Model for Brazil

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.001076	0.5757	0.003256	0.0000	0.001913	0.1071
DEX(-1)	0.317411	0.0000	0.299209	0.0000	0.356979	0.0000
Variance Equation						
γ	-0.993963	0.0000	-0.374372	0.0000	-1.223841	0.0000
|RES|/SQR[GARCH](1)	0.326780	0.0002	0.276249	0.0000	0.520051	0.0003
RES/SQR[GARCH](1)	0.099804	0.1175	-0.130861	0.0052	0.014538	0.8766
EGARCH(1)	0.859773	0.0000	0.974465	0.0000	0.849921	0.0000
DFFR	-0.760530	0.0043	-0.636966	0.0000	-1.073266	0.0013
DOP	-0.012186	0.0806	-0.010168	0.0929	-0.010545	0.1859
Model Selection						
AIC	-2.797181		-3.234927		-2.996044	
SIC	-2.680466		-3.118212		-2.879329	

Table 4.9: Results of model Selection for the EGARCH (1,1): The case of Brazil

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.3051	0.9540	0.9110
ARCH Effect Test	No ARCH Effect	0.3114	0.9549	0.9125
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

The values of AIC and SIC support the Student's t distribution as the best model. Nevertheless, the other two models (Normal Gaussian distribution and the GED values) perform well in explaining the behaviour of exchange rates. Most of the coefficients of the mean and variance equations are significant. The p-values show no serial correlation and heteroskedasticity and hence, can still be recommended for policy formulation on exchange rate stability in Brazil as shown in Table 4.9.

4.5.3.3 Results of the APARCH Model for Brazil

APARCH parameters on monthly exchange rates are displayed in Table 4.10 where the output shows calculated coefficients and the p-values of the Normal Gaussian distribution, Student's t distributions and the GED values. These results show autoregressive behaviour. In the mean equation, the exchange rate at $t - 1$ is found to be significant at 1% for the three models. This implies that exchange rates in the previous period affect current exchange rates in Brazil, serving as an important factor in determining exchange rate variations. In the variance equation, the GARCH (1) term is found to be significant at 1% in all the models while the ARCH (1) terms are insignificant, indicating that the EGARCH (1,1) model is influenced by its GARCH term in determining exchange rate variations in Brazil.

Table 4.10: Result of the APARCH (1,1) Model for Brazil

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	-5.08E-05	0.4722	0.004371	0.0000	-1.17E-05	0.8386
DEX(-1)	0.317416	0.0000	0.308527	0.0000	0.420249	0.0000
Variance Equation						
γ	-0.011359	0.0000	-8.05E-05	0.4072	-0.006987	0.0000
ABS(RESID(-1)	0.288451	0.0000	0.555477	0.0000	0.406466	0.0000
RESID(-1)*ARCH (1)	-0.088600	0.5527	-0.139448	0.1512	-0.079030	0.5481
SQRT(GARCH(-1))	0.642420	0.0000	0.631602	0.0000	0.612515	0.0000
DFFR	-0.037226	0.0000	-0.000535	0.0128	-0.023006	0.0000
DOP	-0.000312	0.0963	-4.98E-05	0.0975	-0.000219	0.0655
Model Selection						
AIC	-2.836057		-3.480558		-3.054291	
SIC	-2.719342		-3.363843		-2.937576	

It follows that the GARCH term serves as an important factor in explaining exchange rates in Brazil while the ARCH does not contribute significantly to exchange rate movements in the country. The two exogenous variables that capture external shocks are found to be significant at

1% and 10% respectively for all the models. Accordingly, they also contribute significantly to exchange rate variations in Brazil. Furthermore, the leverage effect term represented by γ is significant for all the models, indicating that there is asymmetric behaviour and the presence of a leverage effect. That is, the effects of good news and bad news on exchange rate variations in Brazil are asymmetric.

Finally, while the value of AIC and SIC show the Student's t distribution as the best fitted model, Table 4.11 shows that both the Student's t distribution and the GED distribution outperform the Normal Gaussian distribution and can therefore be employed to forecast exchange rates and policy formulation in Brazil as there is no evidence of serial correlation and heteroscedasticity in the model.

Table 4.11: Results of model Selection for the APARCH (1,1): The case of Brazil

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.0730	0.9670	0.6530
ARCH Effect Test	No ARCH Effect	0.0755	0.9676	0.6573
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.3.4 Conclusion and Summary of Results

Modelling exchange rate variations has received significant attention from researchers, academics, policymakers, and investors as well as market participants in recent years as it provides a measure to avert risk in the financial market. The results obtained from various analyses refute the hypothesis that global shocks do not have an impact on exchange rate variations in Brazil. The study finds strong evidence in support of the hypothesis that global interest rates and global oil prices have a significant impact on exchange rate variations in Brazil. The GARCH (1.1) model shows that the previous period's exchange rates affect the current day's exchange rates in Brazil. The EGARCH results from the Normal Gaussian distribution, Student's t distribution and GED models show first order autoregressive behaviour in the exchange rates as revealed by the mean equations. The variance equations show asymmetric behaviour and evidence of leverage effects in which positive (good) and negative (bad) news has different effects on exchange rates in Brazil. In addition, the results of the APARCH model also show and support the presence of asymmetric behaviour and evidence of leverage effects that negative shocks imply a higher next period conditional variance than positive shocks of the same magnitude which is in line with Addalla (2012).

In the three different estimation techniques, the GARCH (1,1) model proves the best one for exchange rates and global shocks in Brazil. All the coefficients of the mean and the variance equation were found to be statistically significant and support the hypothesis that global shocks impact exchange rate variations in the Brazil. This finding is helpful and it is, therefore, recommended that it be taken into account in investor decisions and policymaking.

4.5.4 Interpretation of Results for Russia

4.5.4.1 Results of the GARCH Model for Russia

Table 4.12 presents the results of the GARCH (1,1) estimation of exchange rate variations and global shocks in Russia. All calculated coefficients are statistically significant in explaining the factors that influence exchange rates. In the mean equation, the lagged exchange rate has an unexpected positive effect on the current exchange rate. We can conclude from this finding that the lagged exchange rate (DEX(-1)) influences the current exchange rate and contributes to exchange rate variations. This is confirmed by the statistical significance of the coefficients at all levels. The parameter γ is positive and significant, confirming the symmetric GARCH (1,1) model and that global shocks may have a symmetric effect on exchange rate volatility in Russia.

The variance equation also reveals that the coefficients of ARCH and GARCH are both positive and statistically significant at 1% for all the models. This shows that exchange rates in Russia have been influenced by ARCH and GARCH factors as revealed by normal (Normal Gaussian distribution) and non-normal (Student's t distribution and the Generalized Error) distributions in the model. The major relationship of interest is centered on the direction of behavior that exists between global shocks (oil prices and domestic interest rates) and exchange rate variations in Russia. The table further shows, that, global shocks play an important role in explaining variations in exchange rates in Russia. A global shock, especially from crude oil prices, can push the economy into recession and lead to devaluation of the currency (Bykau *et al.,* 2016) given the Russian economy's dependence on oil. These results are consistent with Kutan and Wyzan (2005), Ozsoz and Akinkunmi (2011), Kutan and Wyzan (2005) and Ogundipe *et al*. (2014). The negative coefficients of the global shocks and their corresponding p-values show that the exchange rate in Russia is significantly susceptible to external shocks.

Finally, the results of the model selection between the normal and non-normal distributions show that the Normal Gaussian distribution has the best fit. This is shown by the value of AIC and SIC in Table 4.12. However, the results show that there is serial correlation and heteroscedasticity, and the residuals are not normally distributed as revealed in Table 4.13. Accordingly, these results cannot be relied upon for policy formulation. This led to a further exploration of the non-normal distributions, whose results do not show any evidence of serial correlation and heteroscedasticity. Overall, our GARCH model (non-normal) using the Student's t distribution shows that it is most suitable and best fitted for explaining Russian exchange rate volatility and global shocks as compared to the GED approach.

Table 4.12: Results of the GARCH (1,1) Model for Russia

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.007771	0.2648	-0.015225	0.6354	-0.009056	0.8520
DEX(-1)	0.484174	0.0000	0.391195	0.0000	0.415094	0.0001
Variance Equation						
γ	0.006848	0.0000	0.216779	0.0000	0.263256	0.0000
ARCH(-1)	3.058196	0.0000	0.464026	0.0036	0.678113	0.0007
GARCH(-1)	0.182581	0.0000	0.176615	0.0054	0.238773	0.0000
DFFR	-0.019412	0.0000	-0.456483	0.0000	-0.576232	0.0000
DOP	0.001402	0.0006	-0.010069	0.0126	-0.015928	0.0000
Model Selection						
AIC	1.078861		1.459750		1.607398	
SIC	1.180987		1.561875		1.709524	

Table 4.13: Results of model Selection for the GARCH (1,1)

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.0000	0.9850	0.9750
ARCH Effect Test	No ARCH Effect	0.0000	0.9855	0.9756
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.4.2 Results of the EGARCH Model for Russia

In time-series analyses, it has been proven that shocks may behave differently depending on whether they are negative or positive. This asymmetric relationship is called the leverage effect, and it describes how a negative shock causes exchange rates to rise more than if a positive shock with the same magnitude had occurred. In this regard, the GARCH model performs poorly and cannot be used to determine the leverage effect. The asymmetric EGARCH (1,1) results in Table 4.14 indicate that all the estimated coefficients are statistically significant at the 5% confidence level except for the international interest rate (FFR) under the Student's t distribution and the GED models. The parameter for the asymmetric response, γ, is negative and significant for all models, indicating an asymmetric response where it is more likely that bad news about exchange rate variations will cause investors to shift their funds to a less risky area rather than good news of the same magnitude attracting investors. This result reveals the existence of leverage effects in the returns series during the study period. In addition, global oil prices influence exchange rates as shown in the model except the international interest rate that remains insignificant under the Student's t distribution and GED models. These two results are contrary to the Normal Gaussian distributions.

However, the results of the model selection criteria show that the Student's t distribution is the best fitted model. Likewise, Table 4.15 confirms that the three models perform well and are hence good for policy formulation and forecasting, especially as there is no evidence of serial correlation and heteroscedasticity.

Table 4.14: Results of the EGARCH (1,1) Model for Russia

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.005152	0.0011	0.015006	0.0000	0.006521	0.0001
DEX(-1)	0.625726	0.0000	0.580096	0.0000	0.628006	0.0000
Variance Equation						
γ	-0.963806	0.0000	-0.604359	0.0000	-0.874047	0.0000
|RES|/SQR[GARCH](1)	1.011179	0.0000	0.632938	0.0000	0.889746	0.0000
RES/SQR[GARCH](1)	0.182065	0.0063	-0.056589	0.2799	0.114221	0.1164
EGARCH(1)	0.845519	0.0000	0.953804	0.0000	0.877861	0.0000
DFFR	-0.408697	0.0285	-0.077427	0.5953	-0.214841	0.2875
DOP	-0.033057	0.0000	-0.025342	0.0000	-0.028964	0.0000
Model Selection						
AIC	0.596001		0.274627		0.393326	
SIC	0.712716		0.391342		0.510041	

Table 4.15: Results of model Selection for the EGARCH (1,1) for Russia

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.3910	0.9600	0.6730
ARCH Effect Test	No ARCH Effect	0.3970	0.9607	0.6769
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.4.3 Results of the APARCH Model for Russia

Table 4.16 presents parameter estimation results of the APARCH model with the Normal Gaussian Distribution, Student's t distribution and GED values and their corresponding p-values. The results show that the parameters estimated under the three models are all significant, indicating that the lagged exchange rates, the ARCH and the GARCH as well as global shocks contribute to exchange rate variations in Russia. This finding supports El Abed *et al.*'s (2016) conclusion that global shocks, particularly oil prices are a key variable in determining the strength of a currency and its volatility. For instance, in the case of an oil-exporting country like Russia, oil price increases may be associated with an exchange rate appreciation, while in the case of oil-importing countries, decreases in oil prices may lead to currency appreciation. Contrary to *a priori* theoretical expectations, the results do not show an asymmetric effect, which is inconsistent with the spirit of the APARCH model. These results imply that the news impact curve may be symmetric. That is, good news and bad news may have the same effect on exchange rate variations in Russia. The results, nonetheless, suggest that there is a dynamic relationship between oil prices and exchange rate variations. Variations in oil prices have a negative impact on exchange rates. These findings are similar to those of Olomola and Adejumo (2006), who showed that oil price shocks significantly affect real exchange rates.

Table 4.17 further shows that the Student's t distribution outperforms the Normal Gaussian and GED distribution. The Normal Gaussian and GED distributions show a wrong sign of the presence of serial correlation, heteroscedasticity and non-normality of the residuals. This is in line with the results of the GARCH (1,1) model that confirms the Student's t distribution as a model that performs best given the alternatives.

Table 4.16: Results of the APARCH (1,1) Model for Russia

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	2.71E-06	0.9987	-8.26E-07	0.9999	-0.000101	0.3701
DEX(-1)	0.576751	0.0000	0.425319	0.0000	0.622498	0.0000
Variance Equation						
γ	0.021588	0.0000	0.014849	0.0000	0.018113	0.0000
ABS(RESID(-1)	1.143751	0.0000	0.222492	0.0000	0.999889	0.0000
RESID(-1)*ARCH (1)	-0.448630	0.0000	0.321671	0.0000	-0.386047	0.0000
SQRT(GARCH(-1))	0.412849	0.0000	0.833941	0.0000	0.434022	0.0000
DFFR	-0.059900	0.0000	-0.021685	0.0007	-0.044027	0.0003
DOP	-0.005968	0.0000	-0.009039	0.0000	-0.004064	0.0002
Model Selection						
AIC	2.118079		0.972306		0.602937	
SIC	2.249383		1.103610		1.734241	

Table 4.17: Results of model Selection for the APARCH (1,1) for Russia

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.0000	0.9630	0.0000
ARCH Effect Test	No ARCH Effect	0.0000	0.9632	0.0000
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.4.4 Conclusion and Summary Results

The GARCH (1,1) result shows that all the calculated coefficients and the estimated p-values are significant in explaining the factors that influence exchange rates in Russia. The mean equation shows that the previous period's exchange rate (DEX(-1)) influences the current exchange rate. The variance equation also reveals that the coefficients of ARCH and GARCH are both positive and statistically significant at 1% for all the models. This implies that conditional exchange rate variations in Russian are influenced by their ARCH and GARCH factors. Global shocks also play an important role in explaining exchange rate variations in Russia as shown by the significant values of the FFR and OP. Overall, our GARCH findings have shown the coefficients to be statistically significant and that they contribute to exchange rates movements in Russia. While the Student's t distribution model selections are found to outperform the Normal Gaussian distribution and the GED model, there is no evidence of serial correlation and heteroscedasticity in the GED model. Accordingly, they may be used for forecasting and policy formulation.

The analysis of the asymmetric EGARCH (1,1) indicates that all the estimated coefficients are statistically significant at the 5% confidence level except for the international interest rate (FFR) under the Student's t distribution and the GED models. Evidence was also found of an asymmetric response for exchange rates in the conditional variance equation, which reveals the existence of leverage effects. In addition, global shocks were found to influence exchange rate variations but international interest rates remain insignificant as revealed in the Student's t distribution and GED models.

The APARCH model, on the other hand, does not show asymmetric effects despite the fact that the parameters estimated under the three models were all statistically significant under the given conditional distributions, indicating that the ARCH and GARCH as well as global factors contribute to exchange rate variations in Russia. These results are contrary to expectations and do not support the asymmetric response hypothesis of exchange rate volatility.

Overall, it can be concluded that the GARCH approach can adequately model exchange rates in Russia. That is, the results of the GARCH (1,1) model prove to better estimate exchange rate variations and global shocks in Russia. This finding is similar to those of Abdalla (2012), who modelled exchange rate volatility in the Arab countries.

4.5.5 Interpretation of Results for India

4.5.5.1 Results of the GARCH Model for India

Using the GARCH (1,1) model, analysis of the Indian exchange rates is carried out. The parameter estimates for the exchange rate variations presented in Table 4.18 derive from the results of our analyses using the three models. It can be seen from Table 4.18 that all parameter estimates are statistically significant at 1%, 5% and 10%, respectively.

Table 4.18: Results of the GARCH (1,1) Model for India

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.023247	0.4336	0.032107	0.2629	0.001370	0.9763
DEX(-1)	0.400441	0.0000	0.361397	0.0000	0.317752	0.0000
Variance Equation						
γ	0.027281	0.0000	0.033201	0.0002	0.212122	0.0000
ARCH(-1)	0.445597	0.0000	0.447835	0.0000	0.409467	0.0012
GARCH(-1)	0.641143	0.0000	0.536408	0.0000	0.338975	0.0000
DFFR	-0.097433	0.0000	-0.107762	0.0000	-0.534167	0.0000
DOP	0.000562	0.0925	0.000734	0.0305	-0.006966	0.0623
Model Selection						
AIC	1.817098		1.672830		1.866989	
SIC	1.919223		1.774956		1.969115	

Table 4.19: Results of model Selection for the GARCH (1,1) for India

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.8670	0.7370	0.8320
ARCH Effect Test	No ARCH Effect	0.8690	0.7404	0.8342
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

The table shows that all the estimates in the GARCH model perform well in explaining exchange rates in India but the AIC and SIC reveal that the Student's t distribution is the best fitted model. This finding is consistent with Choo *et al.* (2002). The results of the diagnostic test in Table 4.19 show that the three models perform well and can be used by policymakers, investors and market participants to forecast exchange rates in India.

4.5.5.2 Result of the EGARCH Model for India

This study further presents the analytical estimates derived from the EGARCH (1,1) model for modelling exchange rates in India. According to Ishimwe and Ngalawa (2015), one of the advantages of the EGARCH specification is that even though the parameters are negative, σ_t^2 would be positive. Accordingly, there would be no violation of the positive variance conditions.

Table 4.20 shows that the parameters for the asymmetric response (γ) are negative and significant for all models, indicating an asymmetric response for exchange rate variations in the conditional variance equation. In addition, all the parameter estimates for the mean and variance equations are statistically significant except the conditional standard deviation RES/SQR[GARCH](1) and global oil prices.

The insignificant value of RES/SQR[GARCH](1) suggests that the effect of the shocks on exchange rates cannot be captured by this standard deviation method. The insignificant value of global oil prices, on the other hand, indicates that an oil price shock does not contribute to exchange rate variations in India. This result negates the result obtained from the GARCH model analysis.

The results of the model selection as revealed by the AIC and SIC indicate that the Student's t distribution is the best fitted model. Nonetheless, in Table 4.21, all three models selected for estimation perform fairly well based on the diagnostic tests. There is no evidence of serial correlation and heteroscedasticity in the models. Therefore, they can all be used for forecasting and policy formulation.

Table 4.20: Results of the EGARCH (1,1) Model for India

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.000893	0.9696	-0.000299	0.9870	-0.000849	0.9659
DEX(-1)	0.350613	0.0000	0.360495	0.0000	0.351075	0.0000
Variance Equation						
γ	-0.669909	0.0000	-0.690253	0.0000	-0.687948	0.0000
|RES|/SQR[GARCH](1)	0.823853	0.0000	0.757927	0.0000	0.794591	0.0000
RES/SQR[GARCH](1)	0.060481	0.4687	0.025057	0.7335	0.037988	0.6555
EGARCH(1)	0.856321	0.0000	0.897672	0.0000	0.877963	0.0000
DFFR	-0.449581	0.0462	-0.258298	0.2059	-0.335104	0.1578
DOP	-0.000626	0.8796	-0.001589	0.7477	-0.000571	0.9106
Model Selection						
AIC	1.797375		1.604149		1.612322	
SIC	1.914090		1.720864		1.729037	

Table 4.21: Results of model Selection for the EGARCH (1,1) Model for India

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.7090	0.7160	0.7130
ARCH Effect Test	No ARCH Effect	0.7128	0.7195	0.7167
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.5.3 Results of the APARCH Model for India

The results for the APARCH model are presented in Table 4.22, which shows that all parameter estimates are statistically significant except for the results of the ARCH term. The corresponding p-values for the Normal Gaussian Distribution, Student's t distribution and the GED values are significant for the GARCH term, global oil prices, international interest rates and the previous lagged value of exchange rates. Surprisingly, the model does not reveal asymmetric effects and leverage effects. Although the model selection criteria found no serial correlation and heteroscedasticity, it does not significantly improve on the fitness of the APARCH (1,1) model and so provides no evidence of the leverage effect for exchange rate variations. This result also implies that the news impact of the shock may likely be symmetric.

Table 4.22: Results of the APARCH (1,1) Model for India

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.018874	0.0000	0.004860	0.5150	0.005614	0.4722
DEX(-1)	0.351558	0.0000	0.393366	0.0000	0.347539	0.0000
Variance Equation						
γ	0.078546	0.0000	0.041729	0.0000	0.054251	0.0000
ABS(RESID(-1)	0.553545	0.0000	0.664663	0.0000	0.681060	0.0000
RESID(-1)*ARCH (1)	-0.142673	0.1318	-0.001358	0.9885	-0.046205	0.6536
SQRT(GARCH(-1))	0.545233	0.0000	0.492719	0.0000	0.490432	0.0000
DFFR	-0.278075	0.0000	-0.116358	0.0037	-0.156597	0.0006
DOP	0.000663	0.0022	0.000840	0.0720	0.000766	0.0717
Model Selection						
AIC	1.731686		1.545759		1.561191	
SIC	1.848401		1.662474		1.677906	

On model selection criteria, the values of the AIC and SIC are in favour of the Student's t distribution as the best fitted model. Nonetheless, in Table 4.23, the three models selected for estimations are devoid of serial correlation and heteroscedasticity. Therefore, they can be relied upon for forecasting and policy formulation to stabilize exchange rates in India.

Table 4.23: Results of model Selection for the APARCH (1,1) for India

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.8740	0.6960	0.7020
ARCH Effect Test	No ARCH Effect	0.8761	0.7002	0.7057
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.5.4 Conclusion and Summary Results

The GARCH (1,1) results shows that all parameter estimates are statistically significant at conventional levels, indicating that all the estimates in the family of GARCH models perform well in modelling exchange rates for India, which is consistent with Choo *et al.* (2002). All the results of the model selections reveal no evidence of serial correlation and heteroscedasticity. Thus, the models perform well and can all be used for forecasting exchange rates and policy formulation in India.

In addition, the asymmetric EGARCH (1,1) indicates that the parameter estimates for the mean and variance equations are statistically significant except the conditional standard deviation and global oil prices. This suggests that exchange rate variations in India are influenced by the previous period's exchange rate shocks, global interest rates and the ARCH and GARCH term. All three models selected for estimation are of good fit and can therefore be used for forecasting and policy formulation in India.

Furthermore, the results of the APARCH model show that all the parameter estimates are statistically significant at 1% except for the results of the ARCH term for all the models. However, the model does not reveal asymmetric effect and leverage effects.

Overall, it can be concluded that exchange rates in India can be well modelled by the GARCH and EGARCH models although the results of the GARCH (1,1) model prove to perform better while the APARCH model does not reveal asymmetric and leverage effects. It can be further concluded that global oil prices have an impact on exchange rates in India as revealed in the models. This finding is in line with Hridhayathulla and Mohammed Rafee (2012) and is also consistent with the results derived for the Brazilian and Russian exchange rate analyses.

4.5.6 Interpretation of Results for China

4.5.6.1 Results of the GARCH Model for China

The results displayed in Table 4.24 for the mean and variance equations show that the parameter estimates of the first four coefficients are statistically significant at 1% level. The statistical significance of the coefficient shows the presence of clustering changes in the GARCH (1,1) model for all cases.

Table 4.24: Results of the GARCH (1,1) Model for China

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	-0.000135	0.8304	4.99E-05	0.9740	-0.000387	0.5711
DEX(-1)	0.614889	0.0000	0.540112	0.0000	0.539269	0.0000
Variance Equation						
γ	1.11E-05	0.0000	3.76E-05	0.0000	8.22E-05	0.0002
ARCH(-1)	0.272537	0.0000	0.231942	0.0001	0.201638	0.0003
GARCH(-1)	0.728681	0.0000	0.562415	0.0000	0.548042	0.0000
DFFR	2.71E-05	0.0001	8.07E-05	0.0000	0.000174	0.0000
DOP	4.79E-08	0.9288	2.06E-08	0.8188	8.17E-08	0.9634
Model Selection						
AIC	-5.827827		-5.888535		-5.675561	
SIC	-5.725702		-5.786409		-5.573436	

Table 4.25: Results of model Selection for the GARCH (1,1) for China

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.0320	0.5250	0.4640
ARCH Effect Test	No ARCH Effect	0.0015	0.5306	0.4699
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

In addition, the significance of DEX(-1) indicates that, lagged conditional variance and lagged squared disturbance have an impact on the conditional variance. In other words, news about variations in exchange rates from previous periods have explanatory power for current variations. However, global oil prices do not contribute to exchange rate variations in China. This might be as a result of the diversified nature of the Chinese economy. This finding is similar to the results of Huang and Feng (2007) that suggest that real oil price shocks would lead to a minor appreciation of the long-term real exchange rate in China due to the country's lesser dependence on imported oil. However, global interest rates have a significant impact on exchange rate variations in China. Over the years, the US has been regarded as a major competitor and threat to the Chinese economy; this could account for these results. Cheung *et al.* (2008) examined the effects of US interest rates on China's exchange rates and refuted the argument that a floating exchange rate would insulate the country's monetary policy from the US.

On model selection, the AIC and SIC results select the Student's t distribution as the best fitted model. In the diagnostic test results in Table 4.25, the Normal Gaussian distribution shows evidence of serial correlation, heteroscedasticity and non-normality in the residuals. However, the Student t distribution and the GED values provide a better forecast of conditional variance and are good for policy formulation as no evidence of serial correlations and heteroscedasticity is detected in the models.

4.5.6.2 Result of the EGARCH Model for China

Applying the EGARCH (1,1) model to capture global facts about exchange rates in China, all the estimated parameters including the constant C are statistically significant (see Table 4.26). This implies that exchange rates lagged by one period affect current exchange rates in China and contribute to current exchange rate variations as shown in the mean equation. The variance equation also reveals that the asymmetric response (γ) is negative and significant for all models, indicating an asymmetric response for exchange rate variations. This finding reveals that in China, exchange rates tend to rise in response to positive shocks and fall by a larger margin in response to negative shocks of the same magnitude. This means that there are leverage effects in the series during the study period. The statistically significant coefficients of γ further suggest that news has a significant effect on exchange rate variations in China while the negative sign implies that the bad news (negative shocks) affect exchange rates more than good news (positive shocks).

The GARCH and EGARCH terms are also statistically significant at 1% level, meaning that exchange rates in China are also influenced by the GARCH and EGARCH terms. Furthermore, global oil prices and global interest rates are found to significantly explain exchange rate variations. The significant impact of oil price shocks on exchange rate variations in the asymmetric EGARCH model is not consistent with the estimation results of the symmetric GARCH model. However, while Huang and Feng (2007) found a that oil prices have a minor impact on the exchange rate in China, while Zhang (2011) concluded that the impact of oil price volatility on exchange rate fluctuations has a short-term delay.

Ma (2015) and Wu (2015) found that lower oil prices affect macroeconomic activities in China. For instance, lower imports of oil in dollar amounts were observed to increase China's current account surplus. Lower oil prices are also expected to stimulate GDP in China. A negative implication, however, is that low oil prices may create the fear of deflation. If deflation indeed occurs, the consequences could be grave, considering that China has surplus capacity in energy-related industrial sectors. The opposite of this effect is the impact of high oil prices on the Chinese economy as revealed by Zaouali (2007).

In addition, global interest rates have a significant impact on exchange rate variations in China. This is consistent with Cheung *et al.*'s (2008) study that failed to substantiate the argument that a flexible Renminbi will insulate China's monetary policy from the US. China has always been conscious of its policy decisions and guards against volatility spill over from the US.

On the model selection, the Student t distribution is selected based on the results of the AIC and SIC as the best fitted model to model exchange rates in China. On the other hand, the results of the diagnostic test in table 4.27 reveal that the three models selected for estimation are without serial correlation and heteroscedasticity. Therefore, they are all good for forecasting and policy formulation in the country.

Table 4.26: Result of the EGARCH (1,1) Model for China

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	-0.001096	0.0000	-0.000168	0.0000	-0.000282	0.0000
DEX(-1)	0.421543	0.0000	0.145430	0.0027	0.329489	0.0000
Variance Equation						
γ	-1.465802	0.0000	-0.034190	0.0000	-1.064534	0.0000
|RES|/SQR[GARCH](1)	0.147263	0.0000	0.231990	0.0000	-0.011589	0.0030
RES/SQR[GARCH](1)	-0.573881	0.0000	0.151960	0.0000	-0.596449	0.0000
EGARCH(1)	0.851587	0.0000	1.014962	0.0000	0.901986	0.0000
DFFR	1.287770	0.0000	0.179666	0.0093	1.481490	0.0000
DOP	-0.009606	0.0000	-0.026261	0.0000	-0.014202	0.0000
Model Selection						
AIC	-6.131855		-6.891553		-6.565378	
SIC	-6.015140		-6.774838		-6.448663	

Table 4.27: Result of model Selection for the EGARCH (1,1) for China

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.9060	0.9470	0.9020
ARCH Effect Test	No ARCH Effect	0.9074	0.9480	0.9035
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.6.3 Results of the APARCH Model for China

Table 4.28 presents the parameter estimation results of the APARCH (1,1) model with the Normal Gaussian, Student's t and the GED distributions as well as their corresponding p-values. The results show that the parameters estimated in these three models are all statistically significant under the given conditional distributions. This implies that all the given factors in the model contribute to the factors affecting exchange rate variations in China. The GARCH and EGARCH term as well as global shocks significantly explain exchange rate variations. The leverage and asymmetric effect term (γ) in the Normal Gaussian, Student's t distributions and the GED distributions model are statistically significant and negative. This implies that negative shocks are more likely to result in a higher next period conditional variance than positive shocks of the same magnitude. It indicates that bad news (negative shocks) exchange rates more than good news (positive shocks). This finding is consistent with Ding's (2011) study that investigated the forecast performance of the APARCH model using the Europe index. It is further consistent with the results derived from the EGARCH (1,1) model.

Table 4.28: Results of the APARCH (1,1) Model for China

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	-0.000390	0.0139	8.82E-07	0.9865	-9.97E-05	0.0000
DEX(-1)	0.525757	0.0000	0.288261	0.0001	0.479420	0.0000
Variance Equation						
γ	-0.001050	0.0000	-3.47E-05	0.1179	-0.000585	0.0000
ABS(RESID(-1)	0.312205	0.0000	0.580391	0.0000	0.617948	0.0000
RESID(-1)*ARCH (1)	0.919282	0.0000	0.173218	0.1463	0.363157	0.0135
SQRT(GARCH(-1))	0.691462	0.0000	0.567898	0.0000	0.551165	0.0000
DFFR	0.003683	0.0000	-0.000146	0.2282	0.001695	0.0000
DOP	9.76E-05	0.0022	2.75E-05	0.0000	0.000184	0.0000
Model Selection						
AIC	-6.134432		-7.120182		-6.582960	
SIC	-6.017717		-7.003467		-6.466245	

Further analyses conducted on the model for model selection confirm that the Student's t distribution is the best fitted model. Table 4.29 presents the diagnostic test results. These show that all three model distributions have good estimated parameters, as they are free from serial correlations, heteroscedasticity (ARCH effects) and are normally distributed and can hence, be recommended for policy formulation in China. However, the student t distribution is better fitted among the alternatives.

Table 4.29: Results of model Selection for the APARCH (1,1) for China

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.2450	0.9510	0.7630
ARCH Effect Test	No ARCH Effect	0.2508	0.9520	0.7661
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.6.4 Conclusion and Summary Results

The GARCH (1,1) parameter estimates show that the first four coefficients are statistically significant at 1% level. The statistical significance of the coefficient shows the presence of clustering changes in the GARCH (1,1) model for all cases. The lagged conditional variance and lagged squared disturbance are also found to have an impact on the conditional variance. In other words, news about shocks from the previous periods has explanatory power for current exchange rates. Conversely, global oil prices do not contribute to exchange rate variations in China. However, these results may contain flaws since China is the second biggest economy, the largest oil importer and biggest energy consumer in the world. Nonetheless, the EGARCH and APARCH models revealed that global oil prices influence exchange rates in China. The results of the model selection criteria show that the Student’s t distribution gives better estimates and a better fitted model as revealed by the results of the AIC, and SIC as well as the model selection, and is, therefore, good for policy formulation.

Secondly, the EGARCH (1,1) model reveals that all the estimated parameters including the coefficient of the lagged exchange rate are statistically significant. This implies that exchange rates in the previous period contribute to current exchange rate variations in China. The variance equation further reveals that the asymmetric shock response (γ) is negative and significant for all models, indicating an asymmetric response for exchange rates during the study period and serves as an important factor influencing exchange rate variations in China. The GARCH and EGARCH terms and the global shocks are also statistically significant at 1% level, meaning that exchange rates in China are also influenced by the GARCH and EGARCH terms together with global shocks as shown in the models. Moreover, the results of model selection revealed that the Student's t distribution is best fitted among the three models. There is no evidence of serial correlation and heteroscedasticity in the models. Hence, they are also good for forecasting and policy formulation.

Finally, the results of the APARCH model show that all the parameter estimates are statistically significant under the given conditional distributions. This implies that all the given factors in the model contribute to exchange rate behaviour in China. The model also reveals the presence of leverage and asymmetric effect.

On a whole, it can be concluded that exchange rates in China can be well modelled by the GARCH, EGARCH and the APARCH models. The results of the three models perform well and do not show evidence of serial correlation and heteroscedasticity. The results of the asymmetric EGARCH (1,1) and APARCH (1,1) models are consistent, and hence, outperformed the symmetric GARCH (1,1) model as further confirmed by the results of the model selection. In addition, the two asymmetric EGARCH (1,1) and APARCH (1,1) results show evidence of leverage effects through which global shocks impact exchange rate variations, indicating that negative shocks imply a higher next period conditional variance than positive shocks of the same magnitude in China. This finding is similar to those of Zhu *et al*. (2016) who established an asymmetric effect of oil price shocks on Chinese stock markets. In addition, Caselli (2014) found that the relationship between trade shocks and exchange rates in China is asymmetric. Finally, the study concludes that global interest rates and oil price shocks contribute to exchange rate variations and that these can be adequately modelled by the class of the asymmetric EGARCH (1,1) and APARCH (1,1) models.

4.5.7 Interpretation of Results for South Africa

4.5.7.1 Results of the GARCH Model for South Africa

The results for the GARCH (1,1) estimation for South Africa are reported in Table 4.30. At 1%, the model reveals that all coefficients are statistically significant in determining exchange rate variations except the ARCH term. The results further show that the lagged exchange rate, the GARCH term, global oil price and international interest rates are important factors affecting exchange rates in South Africa. The significant impact of global oil prices revealed in this study is in line with Kin and Courage (2014).

Table 4.30: Results of the GARCH (1,1) Model for South Africa

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.005620	0.7269	0.002577	0.8672	0.002252	0.8726
DEX(-1)	0.319298	0.0000	0.294534	0.0000	0.287747	0.0000
Variance Equation						
γ	0.036772	0.0001	0.035270	0.0003	0.034335	0.0004
ARCH(-1)	0.069399	0.2972	0.056837	0.4156	0.051763	0.4132
GARCH(-1)	0.439452	0.0000	0.381051	0.0043	0.432927	0.0001
DFFR	-0.103331	0.0000	-0.094475	0.0000	-0.096191	0.0000
DOP	-0.000886	0.0072	-0.000546	0.0190	-0.000784	0.0022
Model Selection						
AIC	0.034847		-0.151104		-0.101181	
SIC	0.136973		0.051022		0.100944	

Table 4.31: Results of model Selection for the GARCH (1,1) for South Africa

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.7650	0.7980	0.7310
ARCH Effect Test	No ARCH Effect	0.7682	0.8006	0.7347
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

In addition, the statistical tests conducted to select the appropriate model reveals that the Student's t distribution is of good fit and performs better in modelling exchange rates in South Africa. The results of the diagnostic tests (see Table 4.31) conducted on the model reveal that all models can also be used to model exchange rates and for policy formulation.

4.5.7.2 Results of the EGARCH Model for South Africa

As shown in Table 4.32, the EGARCH (1,1) model shows that the parameter estimation results of the Normal Gaussian, Student's t distribution and the GED values are statistically significant for all variables. This is in line with the results derived from the GARCH (1,1) model. Furthermore, the asymmetric term (γ) is significant and negative except for the Student's t distribution that is insignificant. The significant values suggest that news has a significant effect on exchange rates in South Africa while the negative sign implies that bad news (negative shocks) affects exchange rate variations more than good news. The significance of EGARCH using lagged values of the exchange rate suggests that negative news leads to a higher subsequent increase in exchange rate variations compared to positive news.

Table 4.32: Results of the EGARCH (1,1) Model for South Africa

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.027577	0.0015	0.021328	0.0294	0.022690	0.0053
DEX(-1)	0.329200	0.0000	0.313726	0.0000	0.330872	0.0000
Variance Equation						
γ	-0.606996	0.0000	-0.090047	0.1311	-0.566223	0.0000
|RES|/SQR[GARCH](1)	0.515309	0.0000	0.052368	0.0027	0.473191	0.0000
RES/SQR[GARCH](1)	0.274595	0.0000	0.110872	0.0055	0.236661	0.0005
EGARCH(1)	0.929947	0.0000	0.983424	0.0000	0.935444	0.0000
DFFR	-0.598359	0.0049	-0.191482	0.0564	-0.571723	0.0208
DOP	-0.008618	0.0069	0.002460	0.0157	-0.006453	0.0420
Model Selection						
AIC	-0.268726		-0.306771		-0.294199	
SIC	-0.152011		-0.190056		-0.177484	

On model selection, the best model is selected based on the AIC and SIC values. The results reveal that the Student's t distribution outperformed the Normal Gaussian and GED distribution as it recorded the lowest AIC and SIC values. On the other hand, the results of the diagnostic tests based on the standardized residuals show the absence of serial correlation and heteroscedasticity in the model. Therefore, all the models can perform well in modelling exchange rates and for policy formulation.

Table 4.33: Results of model Selection for the EGARCH (1,1) for South Africa

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.3550	0.3090	0.1980
ARCH Effect Test	No ARCH Effect	0.3602	0.3153	0.2025
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.7.3 Results of the APARCH Model for South Africa

The estimates for the APARCH model are presented in Table 4.34. The first four estimates (EX(-1), ARCH term, GARCH term and FFR) are statistically significant. It is observed that the lagged conditional variance of exchange rate from the mean equation has an impact on exchange rates in South Africa. This indicates that exchange rate behaviour in the previous period affects the exchange rate in the current period.

Table 4.34: Results of the APARCH (1,1) Model for South Africa

Variable	Normal Gaussian distribution		Student's t with Fixed df distribution		GED with Fixed parameter distribution	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Mean Equation						
C	0.025259	0.0054	0.017477	0.0227	0.017741	0.0231
DEX(-1)	0.362259	0.0000	0.311610	0.0000	0.326463	0.0000
Variance Equation						
γ	0.009238	0.0781	0.003931	0.1685	0.005870	0.1802
ABS(RESID(-1)	0.116873	0.0001	0.065704	0.0061	0.090386	0.0044
RESID(-1)*ARCH (1)	-0.941834	0.0000	-0.999999	0.0000	-0.947494	0.0001
SQRT(GARCH(-1))	0.906301	0.0000	0.943092	0.0000	0.926365	0.0000
DFFR	-0.035851	0.0177	-0.027089	0.0370	-0.031968	0.0321
DOP	-0.000865	0.0238	0.000261	0.0148	-0.000233	0.0096
Model Selection						
AIC	-0.261223		-0.323464		-0.304816	
SIC	-0.129918		-0.192159		-0.173512	

The significance of the ARCH and GARCH terms as well as international interest rates also suggest that the clustering changes in exchange rates are greatly influenced by these three factors. However, the results of the positive asymmetry coefficient imply that there is no presence of leverage effects conflicts with our findings from the EGARCH model. Nonetheless, the results from the diagnostic tests suggest the absence of serial correlation and no remaining ARCH effects as revealed in Table 4.35 while the Student's t distribution is selected by the values of the AIC and SIC as the best fitted model as compared to the Normal Gaussian and GED values.

Table 4.35: Results of model Selection for the APARCH (1,1)

Model Type		Normal Gaussian distribution	Student's t with Fixed df distribution	GED with Fixed parameter distribution
Test	Null Hypothesis	P Value	P Value	P Value
Serial Correlation Test	No Serial Correlation	0.2530	0.257	0.2460
ARCH Effect Test	No ARCH Effect	0.2581	0.2629	0.2519
Normality Test	Residuals are Normal	0.0000	0.0000	0.0000

4.5.7.4 Conclusion and Summary Results

The GARCH (1,1) model reveals that the previous period's exchange rates affect the current period's exchange rates in South Africa. The results further show that exchange rate variations in South Africa are influenced by the GARCH term, global oil prices and international interest rates. The statistical tests conducted reveal that the Student's t distribution is better fitted while the diagnostic tests on all the models show that the three models can perform well in modelling exchange rates and are all good for forecasting/policy formulation in South Africa.

The second step was to evaluate the performance of the EGARCH (1,1) in modelling exchange rates in South Africa. The results show the parameter estimation of the Normal Gaussian, Student's t and the GED distributions to be statistically significant for all the variables that affect exchange rate variations in this country. There is also evidence of asymmetric and leverage effects in the model. The results of the diagnostic tests further show no evidence of serial correlation and heteroscedasticity in the model while the Student's t distribution is the best fit among the alternatives.

The APARCH (1,1) estimates show the EX(-1), ARCH term, GARCH term, global oil prices and international interest rates to be highly significant. These indicate that news about exchange rates from the previous period has explanatory power for current exchange rate variations. The significance of the ARCH and GARCH terms, global oil prices and international interest rates also suggests that they contribute significantly to variations of exchange rates in South Africa.

Finally, the overall results from the GARCH (1,1), EGARCH (1,1) and APARCH (1,1) models indicate that all the variables have a significant impact on exchange rates in South Africa while the results from the EGARCH (1,1) model show that it is the best model for policy formulation.

4.5.6 Brief Overall Conclusions and Implications of the Study for the BRICS Countries

This chapter employed the GARCH (1,1), EGARCH (1,1) and APARCH (1,1) models to model exchange rates in the BRICS countries. The study's overall findings show that exchange rates in Brazil, Russia and India can well be modelled by the GARCH (1,1) model while in China, the three models perform equally well. In South Africa, the three models also perform well but the EGARCH (1,1) model is found to be the best. Further analyses of the models reveal that the Student's t distribution has the best fit for all the BRICS countries compared to the Normal Gaussian and GED values.

It can therefore be concluded that shifting to a common exchange rate policy (floating exchange rates) will contribute to the BRICS countries' agenda of industrialization as it will enable the markets to direct economic resources to optimal use (remove restrictions and allow market forces to determine the value of the currency). Similar monetary policy regime shifts and further attempts to move towards inflation targeting in the BRICS countries will no doubt accelerate their growth pattern and moderate price instability in their economies.

Finally, by employing these rigorous processes (methodologies), the study's contribution to knowledge is that econometricians and policymakers will be able to generate forecasts that are more accurate and policies and programs to stabilize exchange rates in the BRICS countries.

This would promote certainty with regard to foreign payments in their trade relationships and inspire confidence among importers and exporters.

CHAPTER FIVE

MONETARY POLICY AND INDUSTRIAL OUTPUT IN THE BRICS COUNTRIES: A MARKOV-SWITCHING MODEL

5.1 Introduction

As noted in Chapter Three, variations in exchange rates have a very large impact through which shocks transmit to other macroeconomic variables and impact industrial output in the BRICS countries. Chapter Four modelled exchange rate variations in these countries in order to identify the best model that characterises exchange rate variations. The purpose is to recommend the identified model for policy formulation and forecasting of exchange rate variations since BRICS currencies have confronted serious challenges brought about by a number of factors in international markets such as the effects of the global financial crisis (Kobersy *et al.*, 2016). The current chapter investigates whether the BRICS countries share the same business cycles and determines the probability of moving from one regime to the other (recession to expansion). The study thus examines the extent to which the effects of changes in monetary policy in terms of expansion versus contraction affect industrial output. In contrast to the $P - SVAR$ in Chapter Three, where the study employed domestic monetary policy impulses to determine the process of monetary policy transmission and the effects of exogenous/monetary policy shocks, this chapter analyses the effects of BRICS countries' changes in monetary policy in booms (expansion) versus recessions (contraction) on industrial output as they move towards an inflation targeting/floating exchange rate system; the adoption of countercyclical monetary and fiscal policies against the previous procyclical or acyclical policies; and the establishment of the BRICS' Development Bank as an alternative source of funds to the IMF and World Bank. The analysis in this chapter focuses on monetary policy regime shifts in expansions or booms versus recessions, which are known as business cycles.

5.2 Conceptual Background

One of the characteristics of any economy is the recurrence of business cycles. This term refers to the pattern of expansion and contraction in economic activity along the path of trend growth in the economy (Harding and Pagan, 2002). Long periods of expansion may create the impression that business cycles are a phenomenon of the past, but experience teaches us that recessions are inevitable. According to Caraiani (2010), recessions are most likely necessary periods of restructuring and reform, when boom misallocations are corrected. However, the way monetary policy affects economic activities (especially in the correctional process) has received increased attention in the literature through the analysis of business cycles (see Casares, 2001; Kim, 2003; Korenok and Radchenko, 2004). Policymakers and academics alike have sought to understand the fundamental causal relationships between monetary policy actions and business cycles. For example, several studies have argued that monetary policy has more significant effects on output in a recession than in a boom (see Peersman and Smets, 2001; Peersman and Smets, 2005) and can foster economic growth in the short run (see Adejare, 2014). Huber and Fischer (2015) concur and state that the effects of monetary policy are stronger in recessions, whereas the responses are more muted in the medium and long-term expansionary phases of the business cycles due to the price effect.

In contrast, Tenreyro and Thwaites (2015) found strong evidence that the effects of monetary policy on real and nominal variables are more powerful in expansions than in recessions. However, Garcia and Schaller (2002) have shown that an expansionary monetary policy (reduction in interest rates) will lower output in both a recession and an expansion. In view of these divergent views, this study seeks to examine the effects of changes in monetary policy in booms versus recessions on industrial output in Brazil, Russia, India, China and South Africa, a group of emerging market economies (EMEs), generally referred to as the BRICS.

To the best of the researchers' knowledge, this is the first study to jointly estimate and compare the effects of changes in monetary policy in booms versus recessions on industrial output in the BRICS countries. In addition, no study has jointly determined the probability of moving from one regime (recession) to the other (expansion/boom) as well as establishing how long, on average, a particular regime will last. Therefore, this study provides an up-to-date analysis of the nexus between the effects of monetary policy and industrial output in booms versus recessions in the BRICS economies.

Various shifts in the conduct of monetary policy have occurred in the BRICS countries over the past four decades. Although these have taken diverse forms, the shifts have been towards more systematic rules and less discretion in the conduct and implementation of monetary policy. Some countries, including Brazil, India and South Africa, have officially adopted inflation targeting.

Hutchison *et al*. (2013) have shown that other EMEs (including Russia and China) have adopted systematic rules that de facto define the conduct of the central bank's operating instrument using interbank interest rates. They have also highlighted official commitment to complete the shift towards a floating exchange rate system and inflation-targeting regime. Rose (2007) contends that the adoption of systemic rules focusing on inflation or the shift towards inflation targeting regimes, either implicitly or explicitly, has generated a new monetary system that is more stable than previously adopted systems, such as the fixed exchange rates system and exchange rate targeting.

For a central bank to direct the economy towards a more sustainable growth path, it is important to understand the fundamental behaviour of business cycles assuming that policymakers will discern where the economy is located and, more importantly, where it is heading in order to deal with possibly adverse future economic events. When the economy has reached or is heading in an undesirable direction, economists or policymakers may apply monetary policy tools to redirect its course. Economic indicators such as Gross Domestic Product (in particular, industrial output) and the inflation rate are indicators of business cycles.

Theoretical studies have developed optimal monetary policy rules, and empirical studies have investigated uncertainty as a potential driver of business cycles (see Taylor, 1993; Faia, 2008; Binici *et al*., 2013; Fendoğlu, 2014; Grimme, 2015; Chuliá *et al*., 2015). Taylor's (1993) optimum monetary policy rule was formulated on the premise that the United States (US) Federal Reserve Bank adjusts the policy rate in response to past inflation and the output gap (actual minus potential output). He showed that this rule described the Bank's policy and how it performed from 1987 to 1992. Using a sticky price Dynamic Stochastic General Equilibrium (DSGE) model, Faia (2008) provided formal justification for following a Taylor-type rule in which the optimal monetary policy design is based on both constrained and global Ramsey policies. Many studies have subsequently applied the Taylor-type optimal monetary policy rule to study business cycles and examine the behaviour of central banks in industrialized countries (see Clarida *et al*., 2001; Lin and Ye, 2007), while several others have applied the same approach to EMEs (see Gonçalves and Salles, 2008; Lin and Ye, 2009). Gonçalves and Salles (2008) survey of 36 EMEs found that the 13 countries that have adopted inflation targeting experienced low inflation and a greater decline in growth volatility, which helped to smoothen and stabilize their business cycles.

5.3 Objectives of the Study

Given the foregoing context, the aim of this study is to investigate whether the BRICS countries share similar business cycles. The study encompasses the following four broad objectives:

- To investigate monetary policy regime changes in the BRICS countries.
- To determine the effects of changes in monetary policy during booms versus recessions on industrial output in the BRICS countries.
- To determine the probability of moving from one monetary policy regime to the other.
- To determine how long, on average, a regime will last given that an economy of any of the BRICS countries is in regime 1 (recession) or regime 2 (boom).

5.4 The Theory of Business Cycles

This study is rooted in the pure monetary theory due to its optimum rule that best fits Taylor's (1993) optimum monetary policy rule, which is adopted in this study to explain the BRICS economies' business cycles. The theory takes into consideration the monetary and credit system of an economy to analyse business cycles because the literature has identified the credit channel as one of the transmission mechanisms through which monetary authorities drive economic growth (see Mishkin, 1995; Zhensheng, 2002). Hawtrey (1927) propounded this theory in 1927 where he postulated that changes in money flows in an economy cause fluctuations in the level of economic activities. Thus, the theory posits that business cycles are a consequence of fluctuations in the monetary and credit markets as credit expansion helps to expand economies. Another reason for the adoption of this theory is that Hawtrey (1927) employed trade cycles to explain that business cycles are a purely monetary phenomenon because aggregate demand is itself a monetary phenomenon and credit greases the economy to stimulate growth (Kelly and O'Malley, 2014). This explanation is in line with the BRICS countries' agenda of partnering for trade, integration and industrialization (see Chun, 2014) in order to achieve economic growth.

Fluctuations in bank credit and the supply of money are the main causes of business cycles (Schularick and Taylor, 2012). Following an increase in money supply, prices rise, total output and profits increase, and the economy enters an expansion phase, at least in the short run. On the other hand, if the supply of money falls, prices also fall, profits decline, total output falls as industrial production becomes sluggish, and the economy enters a contractionary phase.

The principle factor behind money supply is credit created by the banking system. The economy discerns the upswing with the expansion of bank credit and continues to expand as long as the banks create credit. The banks expand the credit facility because they find it profitable to offer credit at a relatively lower interest rate since the risk of default is relatively lower at such rates. This encourages entrepreneurs to undertake productive activities and enjoy the benefits of bank credit.

As the process of credit expansion continues, the general price level increases and after reaching a certain limit, the rate of increase in aggregate demand exceeds the increase in aggregate supply. Aggregate supply increases at a lower rate because of limited production capacity and the gestation period of new investments. Consequently, credit expansion helps to accelerate the economy while at the same time putting upward pressure on prices.

Finally, at some point, the banks might restrain credit expansion at the prevailing rate because their cash and reserves are depleted due to the increase in loans and advances, withdrawal of deposits for quicker returns and reduced inflow of deposits, among other factors. With the contraction of credit, businesses can no longer obtain bank credit to expand their business activities. Expansion slows, marking the beginning of a downswing. These processes of money supply and credit creation provide an understanding of the fundamental behaviour of a business cycle in the economy.

5.5 Methodology

To achieve the stated objectives, this study employs a Markov-Switching Model (MSM) for each country *i*, out of *n* countries (five BRICS countries). The MSM is a model of asset returns that incorporates stochastic volatility or variation components of heterogeneous durations. It captures the effects of switching from one regime (recession) to another (expansion) over time. The model compares favourably with standard volatility (shock) models such as GARCH (1,1), EGARCH and APARCH as well as VAR and SVAR.

The MSM is employed in this study because it has several advantages. First, the model is able to capture the effects of monetary policy on industrial output in the five BRICS countries under consideration as employed by Peersman and Smets (2001) for the seven euro area countries. Second, compared to the VAR approach used in Dedola and Lippi (2000) and Hayo and Uhlenbrock (2000), the MSM is superior because of its specification simplicity that allows for changes in mean and variance. In addition, the model is able to test the probabilities of being in a recession or an expansion, or whether monetary policy has stronger effects on industrial output in recessions than in expansions (see Garcia and Schaller, 2002). This means that the MSM approach makes it easy to distinguish between business cycle phases (Medhioub, 2015). Furthermore, the MSM can allow for multiple breaks and can detect outliers in time series data (Hamilton, 1989).

The MSM also allows us to analyse the effects of BRICS countries' changes in monetary policy in booms versus recessions on industrial output. This study considers this approach to be suitable not only because it resembles the various policy regime shifts in the BRICS countries' fiscal and monetary policies, but also because fiscal and monetary policies in these countries are well coordinated through participation and consultations in various annual summits. Such meetings may be attended by heads of state, finance ministers, national security advisers, agricultural, trade and industry, foreign affairs and health ministers, science and technology senior officials, BRICS competition experts, and businessmen generally, among others.

Suppose that the MSM for the BRICS countries is given as:

$$\Delta y_{i,t} - \mu_{i,s_t} = \emptyset_1\left(\Delta y_{i,t-1} - \mu_{i,s_{t-1}}\right) + \emptyset_2\left(\Delta y_{i,t-2} - \mu_{i,s_{t-2}}\right) + \varepsilon_{i,t} \tag{5.1}$$

where

$$\begin{bmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{n,t} \end{bmatrix} \sim i.id.N\left(\begin{bmatrix} 0 \\ \vdots \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1n} \\ \vdots & \ddots & \vdots \\ \sigma_{1n} & \cdots & \sigma_{nn} \end{bmatrix}\right) = N(0, \Omega) \tag{5.2}$$

$\Delta y_{i,t}$ is the monthly industrial output in each country i; μ_{i,s_t} is the mean growth rate conditional on country i being in state s_t. In this model, we assume that the state of the economy is identical in each of the n countries. Following Hamilton (1989), we assume that the autoregressive parameters ($\emptyset_1, \emptyset_2$) are independent of the state or regime and the country. s_t is assumed to follow a two-state Markov chain with the following transition probability matrix:

$$P = \begin{bmatrix} P_{00} & P_{01} \\ P_{10} & P_{11} \end{bmatrix} \tag{5.3}$$

where P_{00} is the probability that the series is at state 0 (recession) at time t and remains at state 0 at time t+1; P_{01} is the probability that the series is at state 0 at time t and transitions to state 1 (expansion or boom) at time t+1; P_{10} is the probability that the series is at state 1 at time t and transitions to state 0 at time t+1; and P_{11} is the probability that the series is at state 1 at time t and remains in state 1 at time t+1. Formula 5.3 can further be described by:

$$P_{ij} = Pr[s_{t+1} = \quad j \mid \quad s_t = i], \text{ with } \sum_{j=0}^{1} P_{ij} = 1 \text{ for all } i \tag{5.4}$$

Formula 5.4 shows the probability of transitioning (moving) from state j to state i. Following Peersman and Smets (2001), we assume that these transition probabilities are constant over time and take the following logistic form:

$$P_{00} = Pr[s_{t+1} = \quad 0 \mid \quad s_t = 0] = \frac{\exp(\emptyset_0)}{1+\exp(\emptyset_0)} \tag{5.5}$$

$$P_{11} = Pr[s_{t+1} = \quad 1 \mid \quad s_t = 1] = \frac{\exp(\emptyset_1)}{1+\exp(\emptyset_1)} \tag{5.6}$$

Formula 5.5 is the probability that the series is at state 0 (recession) at time s_t and remains at state 0 at time s_{t+1} while formula 5.6 is the probability that the series is at state 1 (expansion or boom) at time s_t and remains in state 1 at time s_{t+1}. We define $Y_t = [\Delta y_{1,t}\ ,\ \Delta y_{2,t}, \dots, \Delta y_{n,t}]$, as a vector of observations on output growth (see Peersman and Smets, 2001). This model implies that the conditional density function takes the form:

$$f(Y_t|Y_{t-1}, \dots, Y_1, s_t) = (2\pi)^{-1}|\Omega|^{-\frac{1}{2}} exp\left[-\frac{1}{2}(Y_t - h_{t,s_t})'\Omega^{-1}(Y_t - h_{t,s_t})\right] \tag{5.7}$$

where

$$h_{t,s_t} = \begin{bmatrix} \mu_{1,s_t} - \emptyset_1\mu_{1,s_{t-1}} - \emptyset_2\mu_{1,s_{t-2}} + \emptyset_1\Delta y_{1,t-1} + \emptyset_2\Delta y_{1,t-2} \\ \mu_{n,s_t} - \emptyset_1\mu_{n,s_{t-1}} - \emptyset_2\mu_{n,s_{t-2}} + \emptyset_1\Delta y_{n,t-1} + \emptyset_2\Delta y_{n,t-2} \end{bmatrix} \tag{5.8}$$

Formulas 5.7 and 5.8 are transitional matrices ($\emptyset_1$ and $\emptyset_2$ are parameters) as given in the conditional density function (see Peersman and Smets, 2001, 2005) where we also obtain a sequence of conditional probabilities $\Pr(s_t = i \ldots s_{t+r} = j|\emptyset_t)$, which are the probabilities that the series is in state i or j at times t, $t+1$, until $t+r$, respectively, conditional upon the information available at time t. Ω denotes series capturing the denominators for formulas 5.5 and 5.6 in state i or j at times t, $t+1$. By summing these joint probabilities, we can obtain the filtered probabilities, which are the probabilities of being in state 0 or 1 at time t, given the information available at time t as:

$$\Pr(s_t = j|\emptyset_t) = \sum_{i=0}^{1} \ldots \ldots \sum_{k=0}^{1} Pr\,(s_t = j, s_{t+1} = i, \ldots s_{t+r} = k|\emptyset_t)\; j, i, \ldots \ldots k = 0{,}1 \qquad (5.9)$$

These probabilities in formula 5.9 provide information about the regime in which the series is most likely to have been at every point in the sample (constant expected duration).

5.5.1 Does monetary policy change the likelihood of an expansion during a recession?

Following Garcia and Schaller (1995, 2002) and Dolado and Maria-Dolores (1999), this study assesses the transition probabilities of moving from one state to the other (from recession to expansion). The transition probabilities are given as follows:

$$P_{00} = Pr[s_{t+1} = \quad 0 \mid \quad s_t = 0] = \frac{\exp(\emptyset_{00}+\emptyset_{01}MP_t)}{1+\exp(\emptyset_{00}+\emptyset_{01}MP_t)} \qquad (5.10)$$

$$P_{11} = Pr[s_{t+1} = \quad 1 \mid \quad s_t = 1] = \frac{\exp(\emptyset_{10}+\emptyset_{11}MP_t)}{1+\exp(\emptyset_{10}+\emptyset_{11}MP_t)} \qquad (5.11)$$

In order to isolate the effect of monetary policy on the transition probabilities from the linear effect examined above, we constrain the coefficients to be equal to zero as in formula 1. Based on formulas 5.10 and 5.11, we would expect $\emptyset_{00}$ to be the probability of staying in a recession, and $\emptyset_{01}$ to explain the probability of moving from recession to boom. In contrast, $\emptyset_{10}$ shows the probability of moving from a boom to a recession, and $\emptyset_{11}$ is the probability of staying in an expansion (boom). MP_t is the monetary policy indicator in recession or an expansion.

5.5.2 How long on average will this regime last?

In order to develop the industrial output effects of monetary policy in the BRICS countries in booms (expansions) versus recessions, this study follows Peersman and Smets (2005) to estimate for each country *i* using the linear MSM regression equation given as:

$$\Delta y_{it} = (\alpha_{i,o}p_{o,t} + \alpha_{i,1}p_{1,t}) + \emptyset_{i,1}\Delta y_{i,t-1} + \emptyset_{i,2}\Delta y_{i,t-2} + (1 - \emptyset_{i,1} - \emptyset_{i,2})(\beta_{i,o}p_{o,t-1}MP_{t-1} + \beta_{i,1}p_{1,t-1}MP_{t-1}) + \varepsilon_{i,t} \tag{5.12}$$

where $\boldsymbol{\Delta y_{i,t}}$ is the monthly growth rate of industrial output of BRICS member country $\boldsymbol{i}$; $\boldsymbol{MP_t}$ represents monetary policy indicators (interest rates and money supply) and $\boldsymbol{p_{o,t}}$; and $\boldsymbol{p_{1,t}}$ are probabilities of being in a recession or an expansion at a given time $\boldsymbol{t}$ ($\boldsymbol{p_{o,t}}+ \boldsymbol{p_{1,t}} =\boldsymbol{1}$). Formula 5.12 is a reduced-form Markov-Switching output formulation that is estimated in this study in line with Peersman and Smets (2001).

5.6 Estimation Results

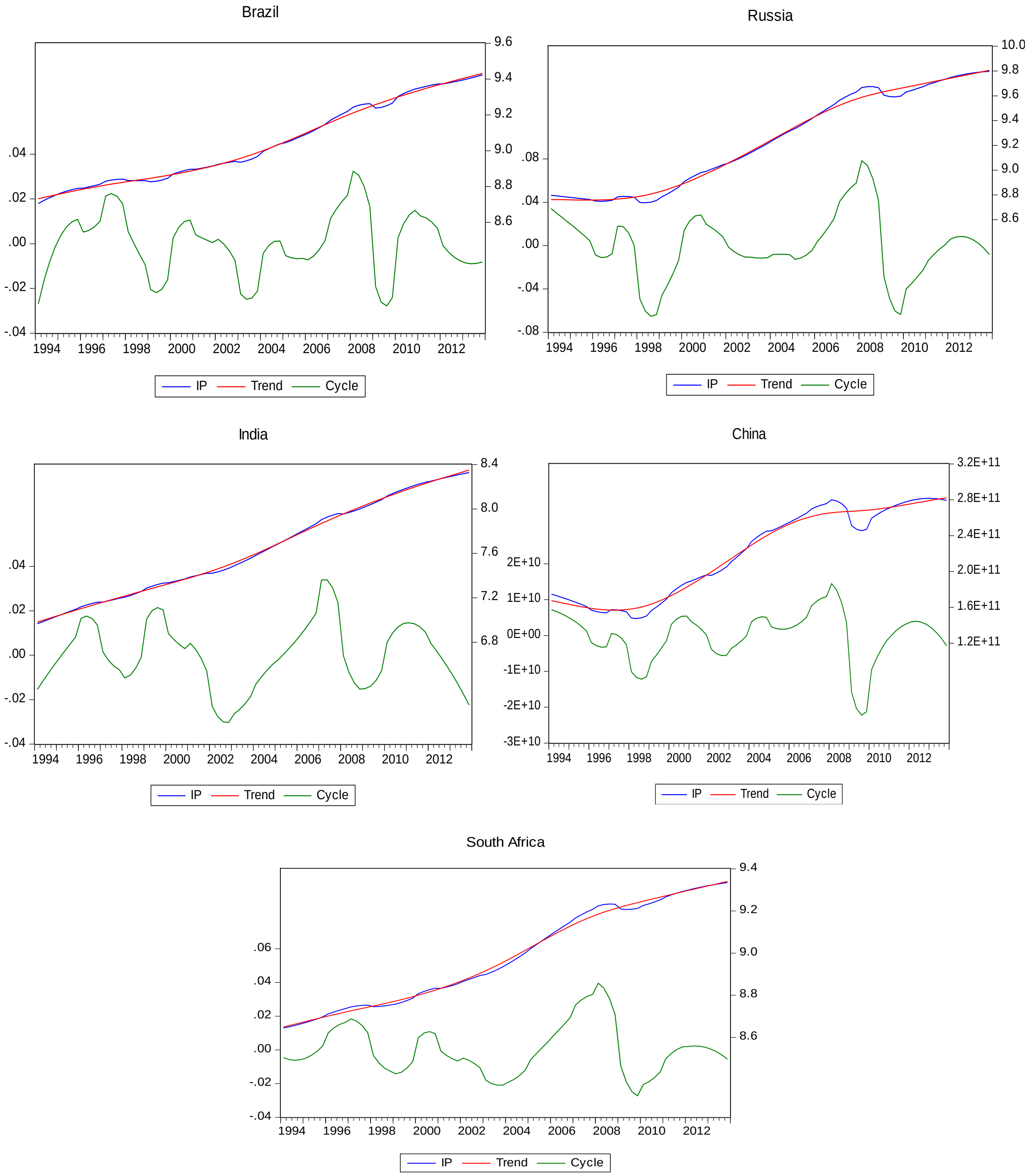
Following Schaller and Norden (1997), Hardy (2001), Alvarez-Plata and Schrooten, (2006) and Sims and Zha (2006), we estimate monetary policy shocks in a multivariate MSM using monthly data from 1994 to 2013 for each of the BRICS countries, in order to determine whether the BRICS countries share the same business cycles. The use of monthly frequency data for the estimation has the advantage of allowing for higher degrees of freedom that enables better estimates for each country.

As shown in Figure 5.1, the MSM reveals that the BRICS countries have similar business cycles. The results demonstrate that these countries' business cycles are characterized by two distinct growth rate phases: a recession regime and an expansion growth rate regime as opposed to some countries with three growth rate phases: a recession regime, a moderate growth regime and a high growth regime (see Medhioub, 2015).

It is observed that economic activity, which shifts from one process to another, is governed by a latent state of two regimes. The trends in Figure 1 show that the business cycles in BRICS countries are common and similar. They can be traced from a recession to a trough before the economy picks up in an expansionary phase (and vice versa). These results are similar to Hutchison *et al.*'s (2013) finding that the conduct of monetary policy over business cycles can be characterized by two regimes.

Based on the second objective of this paper, the study further employs the MSM to determine the probability of moving from one regime to the other and how long, on average, each regime will last.

Figure 5.1: Cycles in BRICS Countries



Source: Author's computations using data from each country's Central Bank's statistical bulletins and Statistics Offices

5.6.1 Results for Brazil

Table 5.1 provides estimates for the Brazilian economy. This study reports the probabilities of being in regime 1 (recession) or shifting to regime 2 (expansion or boom). A change in monetary policy using interest rates and money supply significantly affects industrial output as shown by the statistically significant coefficients. This indicates that the countrywide monetary policy has effects on industrial output both in a recession and in a boom. Using the log (sigma), the value of 22.0675 shows that the economy is less likely to be in regime 1 (recession) than regime 2 (expansion/boom) as shown by the coefficient value of 22.5168. This result indicates that the likelihood of being in a boom or expansion is higher than the likelihood of being in a recession. In addition, Table 5.2 shows the transition probabilities of staying in a recession or an expansion. Based on these results, the probability value of 0.9158 is less than 0.9806, indicating that the probability of an economy staying in a recession is less than that of being in an expansion. The results, therefore, reveal that the economy stays more in a boom than it does in a recession in Brazil. This result is further confirmed by the constant expected duration given in Table 5.3. The table reveals that the total expected duration of staying in a recession is 11 months while that of staying in an expansion is 51 months. There is a high probability of transitioning from a recession to an expansion as shown by the probability value of 0.0194 in Regime $2_{(t)}$ and the probability value of 0.0842 in Regime $2_{(t+2)}$ (see Table 5.2).

Table 5.1: Regime Shifts in Brazil

Variable	Coefficient	Std. Error	Z-Statistic	Prob.
Regime 1				
IN	9.2813	3.5321	2.4987	0.0125
MS	0.0477	0.0006	78.6374	0.0000
C	1.78E+	7.82E+	227.2339	0.0000
LOG(SIGMA)	22.0675	0.0651	339.1598	0.0000
Regime 2				
IN	4.74E+	1.51E+08	3.145076	0.0017
MS	0.0526	0.001989	26.45551	0.0000
C	1.88E+	2.60E+09	72.35967	0.0000
LOG(SIGMA)	22.5168	0.0814	276.5452	0.0000
Transition Matrix Parameters				
P11-C	3.9255	0.5948	6.5998	0.0000
P21-C	-3.0754	0.5055	-6.0840	0.0000

Table 5.2: Transition probabilities

	Regime $1_{(t+1)}$	Regime $2_{(t+2)}$
Regime $1_{(t)}$	0.9158	0.0842
Regime $2_{(t)}$	0.0194	0.9806

Table 5.3: Constant expected durations

Regime 1	Regime 2
11.8746	51.5396

5.6.2 Results for Russia

Parameter estimates for the Russian economy are presented in Table 5.4. The results reveal the effects of a Russian monetary policy shock on industrial output in the country. There is a high possibility of being in regime 2 given the value of 22.8175 as against the possibility of being in regime 1 with the value of 22.0856. This result is similar to that of Brazil where it was found that the likelihood of being in a boom or an expansion is higher than the likelihood of being in a recession. The high likelihood of transitioning from a recession to an expansion is shown by the probability value of 0.0068 in regime $2_{(t)}$ and the probability value of 0.0554 in regime $2_{(t+2)}$. Further justification for this is the result derived in Table 5.5 where the transition probability of staying in a recession is less than that of staying in an expansion. Given these results, the probability value of 0.9446 of staying in a recession is less than the probability value of 0.9932 of staying in an expansion. This result reveals that the Russian economy is more likely to be in a boom than in a recession. The expected duration is shown in Table 5.6. The table reveals that the total expected duration of staying in a recession is 18 months while that of staying in an expansion is 146 months.

Table 5.4: Regime Shifts in Russia

Variable	Coefficient	Std. Error	Z-Statistic	Prob.
Regime 1				
IN	-4.52E+	2.90E+	-15.6104	0.0000
MS	0.0045	0.0001	36.2767	0.0000
C	2.47E+	2.05E+	120.6685	0.0000
LOG(SIGMA)	22.0856	0.0987	223.8047	0.0000
Regime 2				
IN	-5.77E+	2.62E+	-22.0377	0.0000
MS	0.0033	8.86E-	37.1597	0.0000
C	2.16E+	2.28E+	94.9886	0.0000
LOG(SIGMA)	22.8175	0.0580	393.3038	0.0000
Transition Matrix Parameters				
P11-C	2.8368	0.5205	5.4504	0.0000
P21-C	-4.9777	0.9216	-5.4011	0.0000

Table 5.5: Transition probabilities in Russia

	Regime $1_{(t+1)}$	Regime $2_{(t+2)}$
Regime $1_{(t)}$	0.9446	0.0554
Regime $2_{(t)}$	0.0068	0.9932

Table 5.6: Constant expected durations

Regime 1	Regime 2
18.0613	146.1374

As an oil producing country, Russia is prone to global shocks and may stay more in a recession than Brazil. Oil prices are determined by the global market. On the other hand, the country may stay more in an expansion because it is more developed than Brazil and the economy is also well diversified. Russia is one of the largest manufacturers of military hardware (weapons of war) in the world.

5.6.3 Results for India

The results show that monetary policy in India has a significant impact on industrial production as revealed by the statistical significance of the parameter estimates shown in Table 5.7. The table shows that the economy is likely to be in regime 2 given the regime value of 21.7339 as against the value of 20.7977 in regime 1. The likelihood of being in a recession is lower than the likelihood of being in a boom. Thus, there is a high possibility of switching from regime 1 to regime 2. This probability is further confirmed by the result derived from the transition probabilities where the economy is less likely to stay in regime 1.

In Table 5.8, the probability value of 0.8902 is less than the probability value of 0.9916, indicating that the probability of staying in a recession is less than that of staying in an expansion. This result shows that the economy stays more in an expansion than in a recession in India. It is further observed that there is a high probability of transitioning from a recession to an expansion as shown by the probability value of 0.0084 in regime $2_{(t)}$ and that of 0.1098 in regime $2_{(t+2)}$. Table 5.9 shows the expected duration. The total expected duration of staying in a recession is 9 months while that of staying in an expansion or boom is 119 months. As a member of BRICS and as the second largest telecom producer in the world, India stays less in a recession than Brazil and Russia. The country also stays more in a boom than Brazil but slightly less than Russia. This finding is similar to Aradhna (2014) who confirmed the possibility of an increase in the industrial (manufacturing) share of GDP in India. Naudé *et al.* (2013) also confirmed that the manufacturing or industrial sector's share of employment in India and China had expanded and accounted for a significant part of aggregate growth (boom).

Table 5.7: Regime Shifts in India

Variable	Coefficient	Std. Error	Z-Statistic	Prob.
		Regime 1		
IN	-3.28E+	3.49E+	-9.3785	0.0000
MS	2.6939	2539.897	10.6066	0.0000
C	3.60E	2.36E+	15.2366	0.0000
LOG(SIGMA)	20.7977	0.0611	406.2089	0.0000
		Regime 2		
IN	-3.14E+	1.36E+	-230.4090	0.0000
MS	3.0275	317.3451	95.4017	0.0000
C	3.56E+	1.72E+	207.0262	0.0000
LOG(SIGMA)	21.7339	0.0948	229.1759	0.0000
		Transition Matrix Parameters		
P11-C	3.9576	0.5995	6.6012	0.0000
P21-C	-3.7573	0.6825	-5.5050	0.0000

Table 5.8: Transition probabilities in India

	Regime $1_{(t+1)}$	Regime $2_{(t+2)}$
Regime $1_{(t)}$	0.8902	0.1098
Regime $2_{(t)}$	0.0084	0.9916

Table 5.9: Constant expected durations

Regime 1	Regime 2
9.1095	119.4080

5.6.4 Results for China

China is the most populous country in the world with a population of 1.36 billion and is the second largest manufacturer of goods in the world after the US. Its vast resources and geographical location create a strong market advantage. As shown in Table 5.10, monetary policy in China has a significant impact on industrial production both in a recession and in a boom and there is high possibility of staying in regime 2 with a value of 24.8687 against that of 24.2218 in regime 1. The likelihood of transitioning to and staying in regime 2 is higher than the likelihood of staying in regime 1. This likelihood is confirmed by the result derived from the transition probabilities where it is observed that China is less likely to stay in regime 1 (see Table 5.11). There is a high probability of transitioning from a recession to an expansion as shown by the probability value of 0.0125 in regime $2_{(t)}$ and that of 0.2882 in regime $2_{(t+2)}$. The transition matrix also reveals the probability value of 0.9875 of staying in regime 2 as compared to that of 0.7118 of staying in regime 1. This points to the fact that the probability of staying in a recession is less than the probability of staying in an expansion or boom in China. The total expected duration of staying in a recession in China is 3 months while the likely expected duration of staying in an expansion or boom is 80 months (see Table 5.12).

China has the second largest economy in the world after the US; the country is well diversified; and it remains the most industrialized among the BRICS members. Naudé *et al.* (2013) also confirm that the manufacturing or industrial share of employment in China has expanded and accounts for a significant part of the country's aggregate growth (boom).

Table 5.10: Regime Shifts in China

Variable	Coefficient	Std. Error	Z-Statistic	Prob.
		Regime 1		
IN	1.39E+	5.76E+	24.2034	0.0000
MS	0.0152	0.0003	47.8048	0.0000
C	3.83E+	1.56E+	24.5413	0.0000
LOG(SIGMA)	24.2218	0.4563	53.0854	0.0000
		Regime 2		
IN	-6.12E+	5.36E+	-11.4282	0.0000
MS	0.0202	0.0004	57.0248	0.0000
C	5.86E+	2.98E+	19.6730	0.0000
LOG(SIGMA)	24.8687	0.1446	172.0394	0.0000
		Transition Matrix Parameters		
P11-C	0.9041	0.2797	3.2324	0.0012
P21-C	-4.3706	0.7778	-5.6190	0.0000

Table 5.11: Transition probabilities

	Regime $1_{(t+1)}$	Regime $2_{(t+2)}$
Regime $1_{(t)}$	0.7118	0.2882
Regime $2_{(t)}$	0.0125	0.9875

Table 5.12: Constant expected durations in China

Regime 1	Regime 2
3.4697	80.0911

5.6.5 Results for South Africa

In South Africa, the findings of the MSM show that monetary policy has a significant impact on industrial production both in a recession and in a boom. The results of the analysis in Table 5.13 show that monetary policy instruments significantly impact on industrial output in the country. As shown in Table 5.14, the possibility of staying in regime 2 (expansion or boom) is higher than that of staying in regime 1 (recession).

Table 5.13: Regime Shifts in South Africa

Variable	Coefficient	Std. Error	Z-Statistic	Prob.
Regime 1				
IN	-2.45E+	27.7589	-8.8147	0.0000
MS	0.0174	0.0003	57.2865	0.0000
C	5.48E+	5.10E+	107.5020	0.0000
LOG(SIGMA)	20.3196	0.0869	233.9690	0.0000
Regime 2				
IN	-2.40E+	1.21E+	-1.9801	0.0477
MS	0.0127	0.0006	20.6195	0.0000
C	5.50E+	1.73E+	31.8856	0.0000
LOG(SIGMA)	21.0641	0.0822	256.1212	0.0000
Transition Matrix Parameters				
P11-C	3.6312	0.5389	6.7388	0.0000
P21-C	-3.6651	0.6257	-5.8576	0.0000

The likelihood of transitioning from a recession to an expansion is shown by the probability value of 0.0250 in regime $2_{(t)}$ as against that of 0.0258 in regime $2_{(t+2)}$. The economy is less likely to stay in regime 1 given that the probability value of 0.9750 in regime 2 is higher than that of 0.9742 in regime 1. This finding is in line with studies by Baxter (2009) and Padayachee (2010) that revealed that South Africa weathered the 2008 global recession despite being a small, open economy.

Table 5.14: Transition probabilities in South Africa

	Regime $1_{(t+1)}$	Regime $2_{(t+2)}$
Regime $1_{(t)}$	0.9742	0.0258
Regime $2_{(t)}$	0.0250	0.9750

Table 5.15: Constant expected durations

Regime 1	Regime 2
10.7568	92.0587

Overall, the results show that the probability of staying in regime 2 (boom) is higher than that of staying in regime 1 (recession). In addition, the probability of shifting from regime 1 to regime 2 is high and the economy also remains longer in a boom than in a recession as shown in Table 5.15.

5.7 Conclusion

This chapter analysed the effects of changes in monetary policy in booms versus recessions on industrial output in each of the BRICS countries, determined the probability of moving from one regime to the other and estimated how long, on average, each regime will last.

The findings reveal that the BRICS countries have similar business cycles. This finding is of interest because it suggests that in a large open economy such as in the BRICS group of countries, cyclical differences have not been an important factor in the quest to develop the bloc along areas of common interest. The study also finds evidence that monetary policy has significantly larger effects on industrial output both in recessions as well as in booms. In addition, it is found that there is a high probability of moving from state 1 (recession) to state 2 (expansion) but a relatively low probability of moving from state 2 (expansion) to state 1 (recession) for all the countries. Finally, the study estimates how long, on average, each regime will last. It is found that, on average, the probabilities of staying in state 2 (boom) are higher than those of staying in a recession for all the five countries. Therefore, it can safely be recommended from the findings that the BRICS countries should sustain uniform policy consistency (monetary policy), especially as they formulate and implement economic policies to stimulate industrial output.

CHAPTER SIX

DYNAMICS OF INDUSTRIAL PRODUCTION IN BRICS COUNTRIES

6.1 Introduction

Despite the alarming levels of unemployment and sluggish output growth in the developing world, most developing countries confront challenges in diversifying their economies and achieving their potential through industrialization. In many cases, government policies are tailored to fulfil a political agenda rather than stimulate industrial production (Nkurayija, 2011; Akinmulegun, S2014; Olotu *et al*., 2015). The political economy of public policy maintains that monetary policy is limited to keeping the rate of inflation low (preferably within single digits) as an election campaign strategy while fiscal policy is centred on government subsidies and price controls, which has led to inefficiencies.

As stated by Chun (2014, 2016), the BRICS countries have formed a partnership for development, integration and industrialization with consistent monetary and fiscal policies. They aim to achieve output growth through industrialization; creating room for development via trade liberalization; and developing both domestic and international markets. To achieve this, policies and development institutions were established and strengthened in order to mobilize funds (e.g., the establishment of the BRICS New Development Bank, the BRICS Think Tank group, Annual BRICS Summit, BRICS Competition Conference and BRICS Business Forum, among others) for infrastructural development and economic growth via industrialization (Di Maio, 2015).

With all the effort exerted to achieve industrialization and sustainable output growth, it is puzzling that the BRICS countries industrial share of global GDP is still declining (Dietzenbacher *et al.*, 2013). Naudé *et al.* (2013), Aradhna (2014) and Naudé *et al*. (2015) confirm the declining trend of the manufacturing/industrial contribution to GDP and the fall in the industrial share of employment in BRICS countries. This development has been blamed on differentiated growth dynamics and changes in global demand patterns.

The focus of this study is thus industrialization (as proxied by the manufacturing sector's contribution to GDP) in the BRICS countries, which is rooted in growth theory, evolutionary economics and institutional economics that maintain that manufacturing is important for economic development. The study therefore investigates the determinants of industrial output in

BRICS countries; the long run and short run relationship between industrial output and the factors affecting production in these countries; whether the impact of long run factors of production can foster industrial output; and the factors affecting production in BRICS countries.

A few studies have empirically analysed the nature of industrialization in the BRICS countries (see for, example, Naudé *et al*., 2013; Aradhna, 2014; Aldrighi and Colistete, 2015). This chapter complements these studies by providing a more detailed analysis of the determinants of industrial production in these countries using a panel ARDL. To the best of our knowledge, no study has analysed industrial production in the BRICS countries using this technique.

According to Aradhna (2014), the BRICS countries are focusing on structural changes to shift production from low productivity labour-intensive sectors towards high productivity skilled- and capital-intensive activities that can foster output growth through increases in productivity and technological development. Industrial production perfectly fits this profile. The industrial sector is defined as a branch of economic activities concerned with the processing of raw materials and manufacture of goods and services, and may also involve commercial activities that stimulate the economy. At micro level, the sector is proxied by the manufacturing sector's contribution to GDP (Naudé *et al*., 2013; Aradhna, 2014; Aldrighi and Colistete, 2015).

An economy's stock of capital, labour, knowledge and the way in which these factors are structured and allocated across industries for productive activities determine overall industrial production. For instance, optimal allocation during diversification will maximize welfare and boost production in the long run while other allocations (misallocations) result in lower levels of output and therefore show up in the aggregate as a lower level of total output which affects the economy (Jones, 2011).

The composition of manufacturing value added and its contribution to GDP and employment by major sectors in BRICS countries during the periods 2000 to 2014 and 1980 to 2008 are shown in Tables 6.1 and 6.2. Structural changes during these periods reveal that India is the only country where the share of manufacturing value added in GDP increased considerably. In the other countries in the bloc, there are marginal declines, and evidence of a declining trend in the manufacturing sector's contribution to GDP (dis-industrialization). Furthermore, Table 6.2

shows a decline in the share of the primary sector's employment in all the BRICS countries. India and China are the only countries that recorded an increase in manufacturing sector employment while in the other countries, it declined.

Table 6.1: Share of manufacturing Value Added as % of GDP (2000 - 2014) in the BRICS countries

Sectors	Brazil		Russia		India		China		South Africa	
	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
Agriculture	5.5	5.5	6.4	3.9	23.0	16.9	14.7	9.2	3.2	2.5
Mining	26.0	23.0	38.0	36.0	26.0	30.0	45.0	43.0	32.0	29.0
Manufacturing	**15.1**	**11.0**	**17.0**	**14.0**	**15.0**	**17.0**	**32.0**	**30.0**	**19.0**	**13.0**
Utilities	3.0	13.0	4.4	2.6	1.9	3.0	2.7	2.9	1.9	2.8
Construction	7.2	3.7	6.6	4.0	6.3	7.1	5.6	8.9	2.5	2.0
Services	67.9	71.0	55.6	60.0	50.9	53.0	39.8	48.2	64.8	68.0

Source: *World Databank (World Development Indicators); Author's calculations*

Table 6.2: % Shares of Sectorial Employment (1980 - 2008) in the BRICS countries

Sectors	Brazil		Russia		India		China		South Africa	
	1980	2008	1995	2008	1980	2008	1987	2008	1980	2008
Agriculture	38.4	17.8	27.7	21.5	69.9	54.0	59.2	40.2	12.6	5.7
Mining	0.5	0.3	1.4	1.2	0.5	0.6	1.8	1.3	11.1	2.4
Manufacturing	**12.8**	**12.0**	**17.3**	**13.7**	**10.3**	**12.3**	**16.0**	**18.5**	**15.0**	**14.3**
Utilities	0.8	0.4	1.9	2.3	0.3	0.3	0.3	0.5	1.6	0.7
Construction	8.9	7.2	7.7%	7.3	1.9	6.7	4.5	6.7	7.8	8.3
Services	38.6	61.3	44.0	54.0	17.1	26.0	18.3	32.8	51.8	68.6

Source: Naudé *et al* (2013) & *author's calculations*

6.2 Industrial Production and Factors Affecting Production in BRICS Countries

In order to effectively model industrial production and factors affecting production in the BRICS countries, we employ the Aggregate Production Function (APF) in the Neo-Classical framework of the Cobb-Douglas production function. One of the main reasons why this study is interested in the APF is because of the empirical puzzle (as predicted by the neoclassical model) that countries with low per-capita incomes grow faster than those with high per-capita incomes, so that over time, per-capita incomes converge. According to Calderón and Yeyati (2009), all BRICS member countries are EMEs with a per-capita income lower than the average per-capita income in the G7 countries. This satisfies the puzzle that the BRICS countries are expected to grow faster than the G7 countries. However, there is no evidence that the low- and middle-income countries are catching up with the developed countries (Acemoglu and Robinson, 2012; Arias and Wen, 2015). Secondly, the APF explains long run growth as emanating from economic activities that create new technological knowledge and relationships between two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by these inputs. This is in line with the aim of this study, which is to investigate the long run and short run relationships between industrial output and factors affecting production in BRICS countries. In addition, the APF is interesting because it often leaves a role for policymakers. The model holds that the long run growth rate of output in an economy is explained by policy measures (Felipe, 2001; Frimpong and Oteng-Abayie, 2006).

The point of departure for the Cobb-Douglas production function is an economy in which there are two types of factors of production (Rebelo, 1990). These are the reproductive economy, which can accumulate over time (e.g., physical and human capital) and the non-reproductive economy, which is available in the same quantity in every period of time (e.g., land). In this economy (reproductive and non-reproductive), it is assumed that industrial production is given by a production function of the following form:

$$Y_t = A_t L_t^{\beta} K_t^{\alpha} \tag{6.1}$$

$$0 < a < 1,\ 0 < b < 1$$

where Y_t is total output (real value of all goods produced in a year) at time t; A_t is total factor productivity over time; L_t is labour input (total number of man-hours over a given period); K_t is capital input (real value of all machinery, equipment, and buildings at a given time); and β and α are the output elasticity of capital and labour, respectively. These values are constantly determined by available technology.

On the condition that (β + α) = 1, the Cobb-Douglas model shows constant returns to scale. This means that doubling the usage of capital K_t and labour L_t will also double output Y_t. Conversely, if $(\beta + \alpha) > 1$, it shows increasing returns to scale, and if $(\beta + \alpha) < 1$, it shows diminishing returns to scale. An equivalent of equation (6.1) is a linear function of the logarithms of the three variables given as:

$$log(Y_t) = c_o + log(A_t) + \beta\, log(L_t) + \alpha\, log(K_t) \tag{6.2}$$

where Y_t, L_t and K_t denote output, labour and capital, respectively, c_o is a constant parameter and A_t is Total Factor Productivity (TFP) or other factors not captured by labour and capital (also considered as unconventional inputs). For the purposes of this study, these factors or inputs include: per-capita income, exchange rates, imports and exports. We assume that TFP is a function of per-capita income (KY), imports (IMP), exports (EXP) and exchange rates (EX) over a particular period of time t which is given by:

$$A_t = f(KY_t, IMP_t, EXP_t, EX_t) \tag{6.3}$$

Therefore, substituting A_t in equation (6.3) into equation (6.1), we get a new extended Cobb-Douglass production function given by:

$$Y_t = KY_t^{\beta 1} IMP_t^{\beta 2} EXP_t^{\beta 3} EX_t^{\beta 4} L_t^{\beta} K_t^{a}, \tag{6.4}$$

Equation (6.4) represents our industrial production model for the BRICS countries where Y_t is viewed as industrial production that captures the industrial sector's contribution to GDP. Following Omar and Hussin (2015:102), we take logs of the equation (6.4) and simplify it to capture our industrial production (IP) in a panel form as:

$$logIP_{i,t} = c_i + \beta_1 logKY_{i,t} + \beta_2 logIMP_{i,t} + \beta_3 logEXP_{i,t} + \beta_4 logEX_{i,t} + \beta logL_{i,t} + alogK_{i,t} + \varepsilon_{i,t} \tag{6.5}$$

where $IP_{i,t}$ is industrial production (replacing $Y_{i,t}$); c_i is a constant term; $\beta_1 logIMP_{i,t} + \beta_2 logEXP_{i,t} + \beta_3 logEX_{i,t} + \beta_4 logKY_{i,t}$ capture TFP or $logA_t$; $L_{i,t}$ and $K_{i,t}$ are labour and capital respectively; i is a country index; t is a time counter; and $\varepsilon_{i,t}$ is an error term.

6.3 Methodology

6.3.1 Aim and Objectives

This study aims to investigate how fast the BRICS countries have diversified the structure of their economies over the years. Other specific objectives include: investigating the determinants of industrial production in the BRICS countries; analysing the long run and short run relationship between industrial production and the factors affecting production in the BRICS countries; investigating whether the impact of long run factors of production can foster industrial production; and examining the steady-state relationship between industrial production and factors affecting production in the BRICS countries.

To model the data appropriately and establish both the long run and short run relationships between industrial output and selected variables, this study takes into account the existence of unit roots and/or cointegration associated with the data to determine the appropriate methodology. To achieve this, Giles (2013) enumerates four situations that normally confront data and subsequently determine the choice of method used:

- when all of the series are I(0), and hence stationary: In this case, the appropriate methodology is Ordinary Least Square (OLS) estimation of the data in levels.
- when all the series are integrated of the same order (*e.g.* I(1)), but they are not cointegrated: In this case, the correct model is an estimation in first differences involving no long run elements.
- when all of the series are integrated of the same order, and are also cointegrated: In this case, two types of regression models can be estimated: (i) An OLS regression model using the levels of the data. This will provide long run equilibrium relationships between the variables. (ii) An Error Correction Model (ECM) or a Vector Error Correction Model (VECM), estimated by OLS. This model will represent the short-run dynamics of the relationship between the variables.
- a more complicated situation is where some of the variables in question are stationary in levels i.e. I(0), and some are I(1) or even fractionally integrated, leading to no clear cut order such as in the three situations noted above: This is the case for the series employed in this study and forms the basis for the adoption of the advanced methodology of Chudik

and Pesaran (2013), which is the P-ARDL model. Many recent studies have followed this same procedure and employed the P-ARDL model (Mercan *et al.*, (2013); Bakar *et al.*, (2013); Al Mamun *et al.*, (2013); Gerni *et al.*, (2013)).

6.3.2 Brief Definition of Variables

In line with Sari *et al.* (2008), we employ monthly data for the BRICS countries over the period 1994:1 to 2013:12. The variables are drawn from the literature and rooted in the Cobb-Douglass growth theory (the APF). The dependent variable is industrial production (IP) proxied by the manufacturing sector's contribution to GDP while other variables are production variables, trade variables and some control variables as explained below:

- Production variables are capital (K) and labour (L) (Jajri and Ismail, 2010; Ayres and Voudouris, 2014). Capital is measured by gross capital formation. It consists of added outlays to the fixed assets of the economy plus net changes in the level of inventories while labour (L) is the labour force participation rate (% of total population aged between 15 and 64) as compiled by the International Labour Organization (ILO).
- In line with Sebri and Ben-Salha (2014), trade variables are the total volume of imports (IMP) and exports (EXP). These variables capture the open economy status of the BRICS countries.
- Control variables are per-capita income (KY) and real exchange rate (EX) as posited in Omolade and Ngalawa (2014). Per-capita income is captured by GDP per capita based on purchasing power parity while the real exchange rate is the local currency per US dollar.

6.3.3 Data Sources

The data for this study are obtained from the individual countries' central banks' statistical bulletins, the World Bank's WDI, the OECD, the IMF's International Financial Statistics (IFS), the Quantec Database and the statistics offices of each country. All data are in 2005 base year and are expressed in natural logarithms except labour that is already in percentage.

6.3.4 Estimation Technique

Following Rafindadi and Yosuf (2013), Gerni *et al.* (2013), Mohaddes and Raissi (2014) and Al Mamun *et al*. (2013), we adopt the P-ARDL model of Chudik and Pesaran (2013) to test for the existence of long run and short run relationships between industrial production and the factors affecting production in the BRICS countries. The choice of the ARDL methodology for this study is based on a number of features that give it some advantages over conventional short run and long run estimates. For example, the ARDL model:

- is a contemporary technique to investigate long run and short run dynamics (Giles, 2013);
- can be used with a mixture of I(0) and I(1) variables. This means that this approach can be applied to data, whether they are purely I(0), I(1), a mixture of I(0) and I(1), mutually co-integrated, or irrespective of their order of integration but not I(2) (Sari *et al*., 2008; Katircioglu, 2009);
- allows different variables to be assigned different lags in the model (Giles, 2013);
- can accommodate more than two lags and up to seven variables (Giles, 2013);
- simultaneously estimates the short run and long run parameters of the model (Dritsakis, 2011; Shin *et al*., 2014);
- is good for both small and large sample sizes (Narayan, 2005; Rafindadi and Yosuf, 2013); and
- involves a single-equation set-up, making it simple to implement and interpret (Giles, 2013).

On the whole, the Chudik and Pesaran (2013) model is suitable for panel analysis as it accounts for cross-sectional dependence and can allow for one or two structural breaks when carrying out the unit root testing.

Suppose the P-ARDL regression model for the BRICS countries is given by:

$$\Delta Y_{it} = \beta_{i0} + \beta_1 \Delta X_{it-1} + \beta_2 \Delta X_{it-2} + \beta_3 \Delta X_{it-3} \ldots\ldots.. + \beta_P \Delta X_{it-p} + \alpha_1 y_{it-1} + \alpha_2 y_{it-2} + \alpha_3 y_{it-3} + \cdots \ldots + \alpha_Q y_{it-q} + \varepsilon_{it} \quad (6.6)$$

where Y_{it} is a $(k \times 1)$ vector of endogenous variables capturing industrial production; β_{io} is a $(k \times 1)$ vector of intercept/drift components of the constant term; i is a country index; Δ denotes the first difference operator; X_i and y_i are lagged explanatory variables in the short run and in the long run respectively; $\beta_1 - \beta_p$ represent short run dynamics of the model; $\alpha_1 - \alpha_q$ represent the long run relationships; and ε_{it} is a vector of disturbance terms.

6.3.5 Why Panel Data Analysis?

Following Mahembe (2014:95), Hasio (2014), Gujarati (2004) and Baltagi (2008), we consider pooling cross-sectional time series data because panel data:

- offers more explanatory power, more variability, less collinearity among the variables, additional degrees of freedom and it is more efficient when compared to time-series or cross-sectional data (Baltagi, 2008:7);
- can control for heterogeneity in individual data (Baltagi, 2008:6);
- is suitable for the study of dynamic adjustments (Baltagi, 2008:7);
- is able to ascertain and measure effects that are not detectable in pure cross-section or time-series data (Baltagi, 2008:8);
- allows for the creation and analysis of more complex behavioral models (Baltagi, 2008:8), such as economies of scale and technological change (Gujarati, 2004:639); and removes the problem of non-standard distributions that is emblematic of unit root tests in time series analysis (Baltagi, 2008).

6.4 Estimation Results

We begin by testing for stationarity (testing for unit roots). In addition, the tests for cross-sectional dependence and determination of P-ARDL lag selection criteria are done. A test is also conducted to determine the strength of the model selection before embarking on the P-ARDL regression. The study also carries out a cointegration test that leads to the estimation of a P-ARDL Error Correction Model (ECM).

6.4.1 Panel ARDL Unit Root Results

We test the data for the presence of unit roots (stationarity) using the Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS) and Augmented Dickey-Fuller (ADF) Tests. Different approaches are used in order to compare and validate the results and to further ensure consistency (Moon and Perron, 2004; Demetriades and Fielding, 2012; Ishibashi, 2012; Frimpong, 2012). The results show that only exchange rates are stationary in levels i.e. I(0), while all other variables are integrated of order one i.e. I(1). None of the variables is I(2). As shown in Table 6.3, the dependent variable is I(1), which satisfies the Pesaran *et al.* (2001) condition for testing and running an ARDL model.

Table 6.3: Levin et al., IPS and Augmented ADF unit root tests

Variable	Levin, Lin, Chu (individual intercept)			Levin, Lin, Chu (individual intercept & trend)		
	Order of integration	t* Statistics	P-Value	Order of integration	t* Statistics	P- Value
Industrial production	I(1)	-7.06046	0.0000***	I(1)	-7.78681	0.0000***
Imports	I(1)	-70.9336	0.0000***	I(1)	-86.2116	0.0000***
Exports	I(1)	-41.9356	0.0007***	I(1)	- 54.6091	0.0010***
Exchange rates	I(0)	-27.3567	0.0000***	I(0)	-33.4942	0.0000***
Labour	I(1)	-4.44365	0.0034***	I(1)	-4.65629	0.0000***
Capital	I(1)	-1.63839	0.0507**	I(1)	-1.83571	0.0332**
Per capita income	I(1)	-1.75217	0.0339**	I(1)	-1.82306	0.0341**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variables	IPS Unit-root test (individual intercept)			IPS Unit-root test (individual intercept & trend)		
	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
Industrial production	I(1)	-11.3642	0.0000***	I(1)	-10.7897	0.0000***
Imports	I(1)	-62.8885	0.0000***	I(1)	-67.7558	0.0000***
Exports	I(1)	-6.00020	0.0000***	I(1)	-4.88129	0.0000***
Exchange rates	I(0)	-21.7836	0.0000***	I(0)	-22.4592	0.0000***
Labour	I(1)	-10.0301	0.0000***	I(1)	-9.57040	0.0000***
Capital	I(1)	-6.55210	0.0000***	I(1)	-6.47163	0.0000***
Per capita income	I(1)	-6.92596	0.0000***	I(1)	-6.36449	0.0000***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

Variables	ADF-Fisher Chi Square Unit root-test (individual intercept)			ADF-Fisher Chi Square Unit root-test (individual intercept and trend)		
	Order of integration	t* Statistics	P- Value	Order of integration	t* Statistics	P- Value
Industrial production	I(1)	151.640	0.0000***	I(1)	127.601	0.0000***
Imports	I(1)	453.826	0.0000***	I(1)	528.863	0.0000***
Exports	I(1)	59.7182	0.0000***	I(1)	42.2605	0.0000***
Exchange rates	I(0)	361.007	0.0000***	I(0)	346.251	0.0000***
Labour	I(1)	125.952	0.0000***	I(1)	106.980	0.0000***
Capital	I(1)	67.5535	0.0000***	I(1)	61.2786	0.0000***
Per capita income	I(1)	73.1296	0.0000***	I(1)	59.8966	0.0000***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10%, respectively.

6.4.2 Cross-Sectional Dependency

Despite the fact that Chudik and Pesaran (2013) account for cross-sectional dependence, and with the standard ADF test suggested by Pesaran (2007) to remove the influence of cross-sectional dependence employed in this study, a chow test is first conducted to determine whether data for the BRICS countries can be pooled. Subsequently, the Pesaran CD (cross-sectional dependence) test is employed to test whether the residuals are correlated across entities. The benchmark hypotheses that are tested for cross-sectional dependence are:

- $H0: \alpha = 1$, there is no correlation of the residuals (error term).
- $H1: \alpha \neq 1$, there is correlation of the residuals (error term).

The Pesaran's test of cross-sectional dependence conducted on the regression does not indicate the presence of common factors affecting the cross-sectional units (no cross-sectional dependence). Since the p-value of $0.0333 < 5\%$, the study fails to reject the null hypothesis of no correlation of the residuals and rejects the alternative hypothesis that correlation of the residuals exists in the model.

6.4.3 The Panel ARDL Lag Determination

For the P-ARDL model, we estimate the regressions separately to obtain the optimal lag length for each variable. The orders of lags are selected using the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC), which are mainly used in panel estimation (Ali and Ali, 2008; Raza *et al.*, 2015). The results are presented in Table 6.4.

Table 6.4: Panel ARDL Lag Selection Criteria

Serial No	Variables Name	Lags Selection
1	Industrial production (IP)	3
2	Imports (IMP)	2
3	Exports (EXP)	2
4	Exchange rates (EX)	2
5	Labour (L)	4
6	Capital (K)	3
7	Per-Capita Income (KY)	3

Since different variables can be assigned different lags as they enter the model, we tested for the optimal lag length of each variable. The results show 3 lags for Industrial Production (IP), 2 lags for Imports (IMP), 2 lags for Exports (EXP), 2 lags for Exchange Rates (EX), 4 lags for Labour (L), 3 lags for Capital (K), and 3 lags for Per-Capita Income (KY). The lag length is obtained on each first difference variable in line with Dritsakis (2011). We further employed the unrestricted likelihood ratio test for the optimum lag lengths and found the most appropriate lag length for the entire model to be 3 as shown in Table 6.5. Lag 3 gives the minimum criteria for the value of AIC and SIC, hence making it the optimal lag length for the variables in the system. The 3-lags for the P-ARDL model is consistent with Nowak-Lehmann *et al.* (2011).

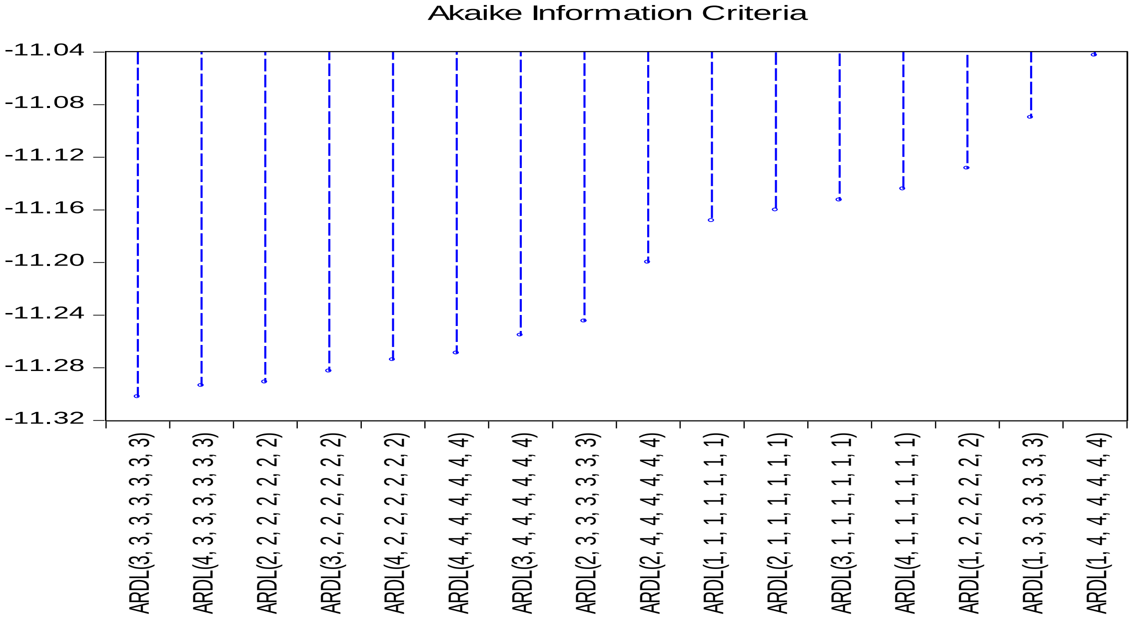
Table 6.5: The Panel ARDL Optimum Lag Selection Criteria

Lag Lengths	AIC	SIC
2	-7.569456	-7.475190
3	-7.685606*	-7.550924*
4	-7.671150	-7.525843
5	-7.675214	-7.489073
6	-7.676548	-7.459361

6.4.4 Measuring the Strength of the Model Selection Criteria

In order to determine the strength of the Akaike Information Criterion (AIC) over other criteria (the Schwarz Information Criterion and Hannan-Quinn criterion) for model selection in the regression as well as the long run and short run relationships in this study, we employ the criteria graph to determine the top 16 different P-ARDL models based on the bench mark analysis, "the lower the value of the AIC, the better the model". As shown in Figure 6.1, the first ARDL (3, 3, 3, 3, 3, 3, 3) model appears to be strongly preferred over the others as it gives the lowest (most negative) value of the Akaike Information Criterion. In addition, the ARDL (4, 3, 3, 3, 3, 3, 3) model appears to be the second most preferred one.

Figure 6.1: The Strength of the Model Selection Summary



Source: *Author's computations using data released by BRICS countries statistics offices*

6.5 Interpretation of Results

6.5.1 The Panel ARDL Regression Model

The estimation results of the P-ARDL are presented in Table 6.6. They show that in the long run, all the variables in the model (except for imports) are statistically significant in explaining industrial production. It is observed that capital (K), labour (L), per capita income (KY) and exports (EXP) have a positive long run impact on industrial production in the BRICS countries. This relationship is consistent with economic theory and empirical evidence (Jajri and Ismail, 2010; Ayres and Voudouris, 2014; Sebri and Ben-Salha, 2014; Omolade and Ngalawa, 2014) that an increase in these variables will lead to an increase in industrial production. A currency appreciation (an increase in the exchange rate), however, has a negative impact on industrial production. This relationship is also in line with expectations, economic theory and empirical evidence (Omolade and Ngalawa, 2014) that currency appreciation adversely affects industrial production due to lower exports (i.e., causes a trade deficit, which can exert a contractionary effect on the economy).

In the short run, it is found that the coefficients of all explanatory variables are statistically significant. The results throw more light on which variables are the major drivers of industrial production in the BRICS countries.

Table 6.6: Panel ARDL Dynamic Regression for Short run and Long run Estimates

Dependent Variable: D(LOGIP)				
Method: ARDL				
Sample: 1994M01-2013M12				
Model selection method: Akaike info criterion (AIC)				
Selected Model: ARDL (3, 3, 3, 3, 3, 3, 3)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
LOGIMP	-0.010522	0.009773	-1.076571	0.2819
LOGEXP	0.024340	0.008252	2.949505	0.0033
LOGEX	-0.079702	0.012747	-6.252870	0.0000
L	0.008635	0.004219	2.046799	0.0409
LOGK	0.004534	0.001935	2.343612	0.0193
LOGKY	0.000102	4.26E-05	2.399555	0.0166
Short Run Equation				
COINTEQ01	-0.584465	1.33E-16	-4.39E+15	0.0000
D(LOGIP(-1))	-0.196344	9.37E-17	-2.10E+15	0.0000
D(LOGIP(-2))	-0.099535	4.66E-17	-2.14E+15	0.0000
D(LOGIMP)	-0.002395	2.18E-18	-1.10E+15	0.0000
D(LOGIMP(-1))	-0.003731	5.76E-18	-6.48E+14	0.0000
D(LOGIMP(-2))	-0.001430	2.72E-18	-5.26E+14	0.0000
D(LOGEXP)	-0.007125	4.25E-19	-1.68E+16	0.0000
D(LOGEXP(-1))	-0.002690	4.14E-18	-6.50E+14	0.0000
D(LOGEXP(-2))	-0.003627	8.82E-19	-4.11E+15	0.0000
LOGEX	0.046119	1.07E-17	4.29E+15	0.0000
LOGEX(-1)	0.022678	5.42E-18	4.18E+15	0.0000
LOGEX(-2)	0.048387	6.80E-18	7.12E+15	0.0000
D(L)	0.042119	7.16E-17	5.88E+14	0.0000
D(L(-1))	-0.016019	1.59E-16	-1.01E+14	0.0000
D(L(-2))	0.007014	5.02E-17	1.40E+14	0.0000
D(LOGK)	-0.033031	2.77E-17	-1.19E+15	0.0000
D(LOGK(-1))	0.010320	1.46E-16	7.06E+13	0.0000
D(LOGK(-2))	-0.001812	2.51E-17	-7.21E+13	0.0000
D(LOGKY)	-3.73E-08	3.59E-20	-1.04E+12	0.0000
D(LOGKY(-1))	-0.000280	8.47E-20	-3.30E+15	0.0000
D(LOGKY(-2))	0.000115	3.22E-20	3.58E+15	0.0000
C	0.051971	8.33E-18	6.24E+15	0.0000

The estimates show that all the variables in the model are statistically significant, hence affecting industrial production in the BRICS countries. The overall results for the panel analysis allow for heterogeneous short run dynamics and a common long run cointegrating vector in stimulating industrial output. Further confirming the existence of the appropriate model and cointegration, is the default parameter estimate of the short run coefficient (COINTEQO1), which is found to be both negative and statistically significant as expected (otherwise, there would be no cointegration).

As shown in Table 6.6, a large number of variables with a negative impact on industrial production appear in the short run equation. All the short run coefficients show the dynamic adjustment of all the variables (Dritsakis, 2011). According to Engle and Granger (1987), an error correction mechanism exists for a cointegrated relationship. Therefore, a negative and significant coefficient of the error correction term is an indication of cointegration.

6.5.2 The Panel ARDL Cointegration Results

The F-statistics in Table 6.7 show a p-value of less than 0.05. Accordingly, the study rejects the null hypothesis of no cointegration and fails to reject the alternative hypothesis that there is a long run cointegration relationship among the variables in the model. The F-statistic value of 11.998 is larger than the upper band of the Pesaran critical value of 4.09 at 5% level (Pesaran and Pesaran, 1997:478). This again shows evidence of cointegration. The F-statistics has a significant and positive value, indicating a long run cointegration relationship between industrial production and the other variables in the model.

Table 6.7: Panel ARDL Cointegration Testing

Wald Test			
Equation: ARDL			
Test Statistic	Value	Df	Probability
F-statistic	11.99780	(7, 1151)	0.0000
Chi-square	83.98461	7	0.0000

6.5.3 The P-ARDL Error Correction Model (ECM)

Using the ECM, the study investigates the short run and long run dynamics of the present model. The ECM coefficient shows how quickly or slowly (speed of adjustment) the variables return to equilibrium. As shown in Table 6.8, the negative sign of the ECM coefficient shows the existence of disequilibrium in the short run and convergence in the long run. The ECM value of -0.240003 suggests a relatively low speed of adjustment from the short run deviation to the long run equilibrium of industrial production. More precisely, it indicates that about 24% deviation from the long run industrial production in the EMEs is corrected in each period. In addition, the error correction term is statistically significant at 5% level, indicating that long run equilibrium is attainable. These results are consistent with Waliullah and Rabbi (2011) and Bannerjee *et al*. (2008) who argued that a highly significant error correction term is further proof of the existence of a stable long run relationship.

Table 6.8: Error Correction Coefficient

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECT(-1)	-0.240003	0.088888	-2.700062	0.0070

6.6 Conclusion

This chapter examined the dynamics of industrial production in the BRICS countries using a panel data analysis method and monthly data covering the period 1994 to 2013. The estimation results reveal the existence of a long run relationship between industrial production and a number of selected variables in the BRICS countries during the period under review. This relationship is consistent with economic theory and empirical evidence in other countries (see, for example, Gerni *et al*., 2013). It is observed that capital (K), labour (L), per capita income (KY) and exports (EXP) have a positive long run impact on industrial production in the BRICS countries. However, a currency appreciation (an increase in the exchange rate), has a negative impact on industrial production. This relationship is also in line with theoretical expectations and empirical evidence, similar to Omolade and Ngalawa (2014), that a direct relationship exists between exchange rates and manufacturing sector growth. A similar result was obtained by Égert and Leonard (2008) in their study of the Republic of Kazakhstan.

The results also show that there is a stable and balanced relationship in the establishment of the long run analysis as revealed by the negative sign and significant value of the ECM. The ECM integrates the short run dynamics with the long run equilibrium without losing either the short run or long run information. Thus, the result shows that there is a relationship between industrial production and the selected variables in the BRICS countries and that long run equilibrium can be achieved (Waliullah and Rabbi, 2011).

Finally, all the variables employed in the model, except imports, significantly determine industrial production and a stable relationship between industrial production and the factors that explain industrial production in BRICS countries has been established. The policy implication stemming from this analysis is that sound economic policy is important for industrial production and industrialization in the BRICS countries while poor policy will result in a nexus of constraints from which escape may be difficult (or impossible). Therefore, there should be policy consistency in curtailing the declining trend in industrial production.

CHAPTER SEVEN

SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

7.1 Summary and Conclusions

There is growing consensus that monetary policy has contributed significantly to the stabilization of EMEs, especially since the adoption of inflation targeting (Amato and Gerlach, 2002; Fraga *et al.*, 2004; Mohanty and Rishabh, 2016). Thirteen of Gonçalves and Salles' (2008) sample of 36 EMEs implemented inflation targeting and experienced lower rates of inflation and larger decline in economic growth volatility than those that did not adopt this strategy. The growth of the industrial sector is important, especially given its contribution to real GDP. Empirical findings from various studies are consistent with the hypothesis that both output and inflation increase in response to a positive demand shock while output increases and inflation decreases in response to positive supply shocks (Arora and Bhundia, 2003).

The $P-SVAR$ analysis of the impact of monetary policy shocks on industrial output in the BRICS countries revealed that a positive inflation shock significantly increases industrial output, peaking after about 11 months and declining thereafter. The initial increase in industrial output caused by an inflation shock may be the result of information asymmetry in the economy. If producers observe only their prices and not the general price level, they will not know whether a change in the price of their goods reflects a change in the goods' relative price or a change in the aggregate price level (Aoki, 2001). Therefore, the rational response on their part is to increase output on the basis that it is likely that, the general price increase reflects an increase in the relative prices of goods. The impulse response functions revealed that industrial output responds significantly to a positive interest rate shock (representing monetary tightening) after about two years, when it starts increasing, albeit marginally and that such response remains persistent after eight years. A possible explanation is that following a rise in the expected rate of return (reflected by the increase in real interest rates), the BRICS countries start attracting capital inflows that trickle to the industrial sector, the impact of which becomes apparent after two years. In addition, a monetary policy shock characterised by an unexpected increase in money supply, causes industrial output to initially decrease, bottoming out after seven months. Thereafter, industrial output remains generally constant. It is further observed that, the spill over effect of a 1% increase in world interest rates is reflected in a positive, significant reaction on the part of industrial output.

Other results that are noteworthy are those derived from Chapter Four that examined how global shocks impact on exchange rate variations in the BRICS countries. The results obtained from various analyses refute the hypothesis that global shocks do not have an impact on exchange rate variations in these countries. The study found strong evidence to support the hypothesis that global interest rates and global oil prices have a significant impact on exchange rate variations in BRICS countries. The results of the GARCH (1.1) model show that the previous period's exchange rates affect the current period's exchange rates in BRICS countries. Variables that capture global shocks had the same effect. The EGARCH results from the Normal Gaussian distribution, Student's t distribution and the GED models showed first order autoregressive behaviour in exchange rates as revealed by the mean equations. The variance equations showed asymmetric behaviour and evidence of leverage effects in which positive (good) and negative (bad) news has different impacts on exchange rates in the BRICS countries. In addition, the results of the APARCH model supported asymmetric behaviour and provided evidence of leverage effects (only in Brazil and China); negative shocks imply a higher next period conditional variance than positive shocks of the same magnitude but do not show asymmetric effects in Russia, India and South Africa despite the fact that the parameters estimated under the three models were all statistically significant under the given conditional distributions. This indicates that the ARCH and GARCH as well as global factors contribute to exchange rate variation in all these countries. In the three different estimation techniques, the results of the GARCH (1,1) model prove that this is the best model (except for South Africa where the EGARCH is found to be the best) for modelling exchange rates and global shocks in BRICS countries since all the coefficients of the mean and variance equation are found to be statistically significant. This supports the hypothesis that global shocks impact exchange rate variations in the BRICS countries. Therefore, the study's results shed light on the importance of global shocks in relation to exchange rate behaviour in the BRICS countries. It can safely be recommended from the results of this study that the monetary authorities should consider the impact of global shocks (especially oil prices and global interest rates) when formulating and implementing economic policies, especially as they relate to the exchange rate.

Furthermore, this study examined whether the five BRICS countries share similar business cycles and determines the probability of any of the countries moving from a contractionary regime to an expansionary regime. The study further examines the extent to which changes in monetary policy affect industrial output in expansions relative to contractions. It could not reject the hypothesis that the BRICS countries indeed share similar business cycle. Strong evidence was found in support of the hypothesis that changes in monetary policies have significant effects on industrial output in recessions as well as in booms in these countries. It is also established that there is a high probability of moving from state 1 (recession) to state 2 (expansion) and that on average, the probabilities of staying in state 2 (expansion) are high for each of the five countries. It is, therefore, recommended that the BRICS countries should sustain uniform policy consistency (monetary policy), especially as they formulate and implement economic policies to stimulate industrial output.

In addition, the study examined the dynamics of industrial production in the BRICS countries using a panel data analysis method and monthly data covering the period 1994 to 2013. The estimation results revealed the existence of a long run relationship between industrial production and a number of selected variables in the BRICS countries during the period under review. This relationship is consistent with economic theory and empirical evidence in other countries (see, for example, Gerni *et al*., 2013). It was observed that capital (K), labour (L), per capita income (KY) and exports (EXP) have a positive long run impact on industrial production in the BRICS countries. However, a currency appreciation (an increase in the exchange rate), has a negative impact. This relationship is also in line with theoretical expectations and empirical evidence, similar to Omolade and Ngalawa (2014), that a direct relationship exists between exchange rates and manufacturing sector growth. A similar result was obtained by Égert and Leonard (2008) in their study of the Republic of Kazakhstan.

The study results also showed that there is a stable and balanced relationship in the establishment of long run analysis in the economy as revealed by the negative sign and significant value of the ECM. The ECM integrates the short run dynamics with the long run without losing either the short run or long run information. Thus, the result showed that there is a relationship between industrial production and the selected variables in the BRICS countries.

Finally, all the variables employed in the model, except imports, significantly determined industrial production and a stable relationship was established between industrial production and factors that explain output production in the BRICS countries.

7.2 Policy Implications and Recommendations arising from the findings

An investigation of the potential growth of industrial output in the BRICS countries is beneficial for policy purposes. It is expected to strengthen the basis on which to measure the strength of resource utilization, the impact of external shocks and the effect of monetary policy in order to manage real output and prices. A number of policy implications emerge from the study's results.

Firstly, it can be inferred from the $P - SVAR$ analysis that the adoption and shift towards inflation targeting and freely floating exchange rates is justified (Levy-Yeyati and Sturzenegger, 2003). However, the floating exchange rate is not insulated from external shocks (Carlin and Soskice, 1990).

Secondly, the GARCH, EGARCH and APACH estimation results could assist the monetary authorities in their attempts to cope with exchange rate uncertainties. The study showed that the GARCH (1,1) model had more robust results than the EGARCH and APARCH models especially in Brazil, Russia and India. It also performed fairly well in China and South Africa. Therefore, the monetary authorities and investors in the BRICS countries could employ this framework to model and forecast exchange rates and formulate related policies. The behaviour of exchange rates is one of the least understood topics in economics. Following this study, economic agents in the BRICS countries would be well advised to employ the GARCH (1,1) framework to model and predict exchange rate variations. However, it should be noted that the challenge of using the GARCH (1,1) model is the associated risk and uncertainty in the global market where the effects of global shocks on exchange rates are asymmetric. This implies that bad news (negative shocks) affect the exchange rates more than good news (positive shocks). If this is well understood, the model could significantly improve policy formulation in relation to exchange rates.

In addition, in assessing monetary policy regime shifts from recession to expansion or vice versa, and the impact of monetary policy shocks in the BRICS countries, the impact of monetary policy on the economy became evident, especially the significant impacts of monetary policy instruments on industrial output. The policy implication is that when the economy heads into a tailspin (recession), job losses, a collapse in the financial sector and shrinking economic output are the results. This is indeed bad news for the BRICS economies since it was found that they share the same business cycle and that this affects investors' decision.

7.3 Limitations of the Study

The main aims of this study were threefold: (i) to investigate how monetary policy shocks affect the growth of industrial output in the BRICS countries, (ii) to investigate the effects of monetary policy in booms and in contractions on industrial output, and, (iii) to investigate the short run and long run dynamics of industrial production in the BRICS countries. While these aims were achieved, this study suffered some limitations. One was its inability, due to lack of data, to capture all the monetary policy variables suggested by the theoretical models. This problem has also confronted previous researchers (Tovar, 2009; Pescatori and Zaman, 2011). The data problem was further experienced in inadequate observations. The problem with inadequate observation is that one runs the risk of running out of degrees of freedom, especially in data-intensive frameworks such as the $P-SVAR$ that was employed in this study. In many cases, data was only available in quarterly or annual frequency and not in the higher frequency required. This was overcome by interpolating some low frequency data to obtain high frequency data, an approach that has been widely adopted in the literature (Ngalawa and Viegi, 2011; Cheng, 2006). In addition, the study faced software limitations in running a panel MSM that is also known as standard Markov-Switching VAR.

7.4 Areas for Further Research

The debate on what monetary policy can and cannot achieve in stabilizing prices and stimulating output growth is becoming increasing complicated due to global events and unstable financial structures in the BRICS and other economies. This calls for further research. The ensuing debate around the "dual mandate" of central banks worldwide is also an area for future research. Another area could be to capture important monetary variables that are not included in the $P-SVAR$ model in this study. Furthermore, a study can be conducted using the Factor-Augmented Vector Autoregressive (FAVAR) methodology proposed by Bernanke *et al.* (2005), which improves the traditional Structural Vector Autoregressive ($SVAR$) method by including more variables without the risk of running out of degrees of freedom. Future researchers could develop panel GARCH, EGARCH and APARCH models by pooling cross-section time series to estimate exchange rate variations for the BRICS countries. This suggestion is vital as these countries share some distinctive characteristics in their monetary and fiscal policies. Finally, the Chudik and Pesaran (2013) P-ARDL model employed in this study could be improved by using the cross-section augmented distributed lag (CS-DL) approach developed by Chudik *et al.* (2015) to model cross-section correlated errors.

7.5 Conclusion

Debate on how monetary policy can achieve price stability and industrial output growth in an economy has increased in recent times due to divergent opinions (Fry et *al.*, 2000; Meyer, 2001). This study investigated monetary policy shocks and industrial output in the BRICS countries using the $P-SVAR$ estimated with nine variables spanning the period January 1994 to December 2013 (1994:01 to 2013:12). The estimated $P-SVAR$ is thus structural in the sense that shocks are identified by imposing structural factorization (restrictions) on the impact of these shocks on output and prices. The $P-SVAR$ is appropriately designed for the interaction matrix of the variables to account for contemporaneous and sluggish relationships among the domestic variables and foreign variables. It is notable that the domestic variables are likely to have minor or no effects on the external variables, while the external variables are more disposed to strongly impact on domestic variables as shown through the impulse response functions. The study also revealed that external shocks are easily transmitted to the domestic economy through the exchange rates channel.

In light of this finding, this study modelled exchange rate variations using the GARCH (1,1), EGARCH (1,1) and APARCH (1,1) models in order to understand exchange rate behaviour and establish if global oil prices and international interest rates (global shocks) have any impact on exchange rate variations in the BRICS countries. The findings showed that in Brazil, Russia and India, exchange rates are best modelled by the GARCH (1,1) model while in China, the three models perform equally well. In South Africa, it was observed that exchange rates are best modelled using the EGARCH (1,1) model. Further analyses of the models revealed that the Student's t distribution had the best fit for all the BRICS countries as compared to the Normal Gaussian and GED values. This further supported the justification for employing the Panel data estimation ($P-SVAR$) owing to the distinctive characteristics of the BRICS economies.

The study also investigated whether the BRICS countries share the same business cycles. In particular, it examined the effects of area-wide changes in monetary policy in booms and contractions on industrial output in these countries and analysed the probability of moving from one regime (expansion or contraction) to the other (expansion or contraction). The study also examined how long, on average, each regime will last. The findings revealed that the BRICS countries share the same business cycles. It also found evidence that area-wide monetary policies have significant effects on industrial output in recessions as well as in booms. In addition, evidence was found of a high probability of moving from state 1 (recession) to state 2 (expansion), and that the probabilities of staying in state 2 (boom) are higher for all the BRICS countries. The results for all the countries pointed to the fact that the probability of staying in a recession is less than the probability of staying in an expansion or boom. This finding provides the motivation for estimating the dynamics of industrial production using the P-ARDL approach.

In line with the findings in Chapters Four and Five, the dynamics of industrial production in the BRICS countries were estimated using a panel data analysis method. The results revealed the existence of a long run relationship between industrial production and a number of selected variables in the BRICS countries during the period under review. The results also showed that there is a well-defined short run relationship between the selected variables. The ECM integrates the short run dynamics with the long run equilibrium without losing either the short run or long run information. Thus, the results showed that there is a relationship between industrial production and the selected variables in the BRICS countries and that long run equilibrium can be achieved.

Finally, all the variables employed in the model, except imports, significantly determined industrial production and a stable relationship was established between industrial production and the factors that explain output production in the BRICS countries. This confirms the possibility of an equilibrium relationship between industrial production and the factors affecting production in the BRICS countries. The policy implication is that sound economic policy is important for production and industrialization in the BRICS countries. The industrial sector should thus, be acknowledged as a sector that can actualize diversification and boost economic performance in the BRICS countries in order to achieve industrialization.

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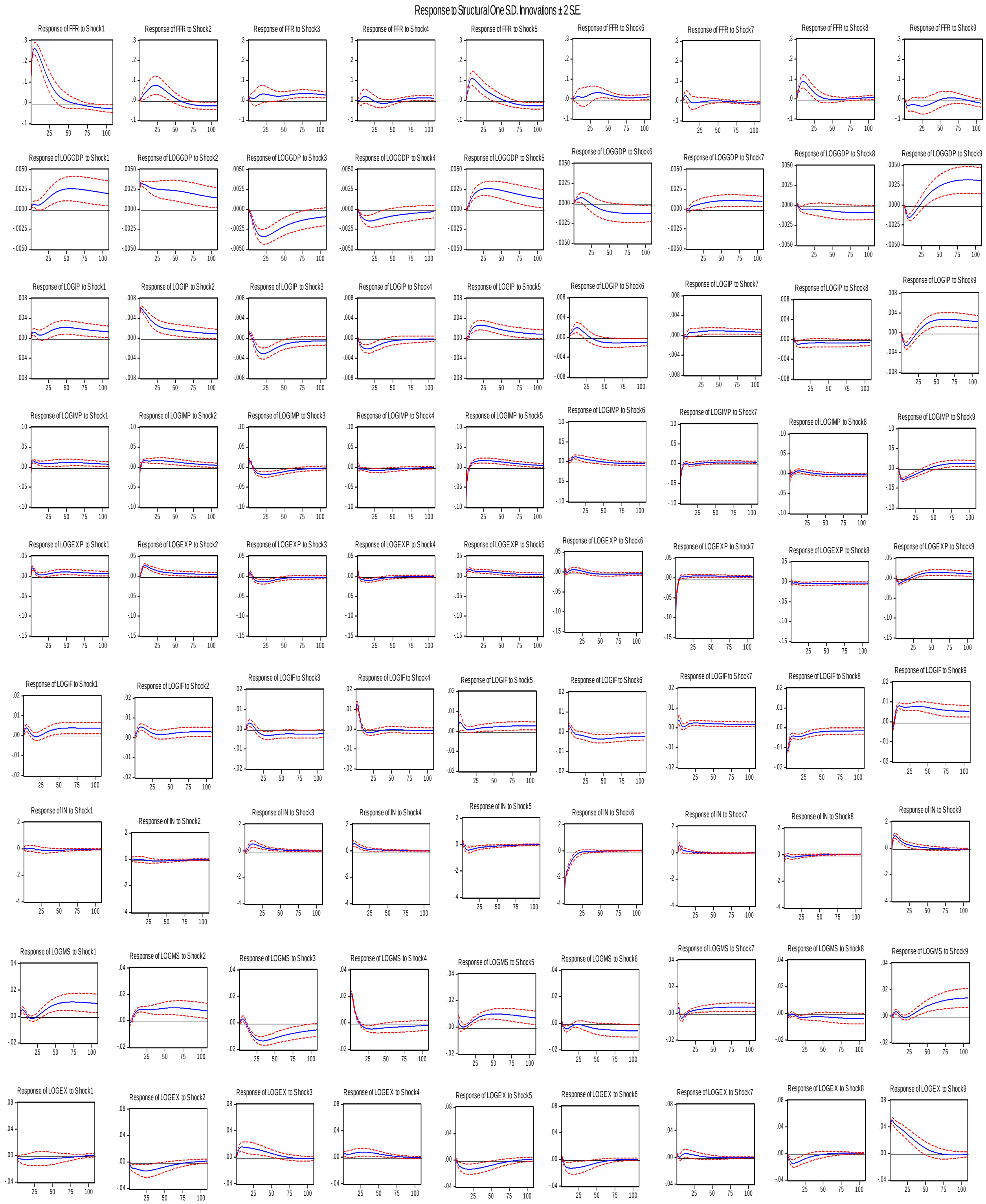
9 APPENDICES

Appendix 1: The Generalized Impulse Response Function (Full Sample) of all the Variables



Appendix 2: Detail Results of Variance Decomposition of all the Variables

VARIANCE DECOMPOSITION OF FFR

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	0.131328	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.243646	98.03406	0.012459	0.099111	0.001325	0.714112	0.003788	0.196629	0.738469	0.200043
3	0.348064	95.09469	0.075267	0.171064	0.007881	2.037343	0.005222	0.465444	1.611130	0.531963
4	0.442401	92.18203	0.183863	0.184972	0.005614	3.524487	0.011080	0.636028	2.455832	0.816093
5	0.527171	89.50606	0.319764	0.171479	0.006472	4.993698	0.024667	0.713941	3.265119	0.998798
6	0.603140	87.16899	0.467374	0.151773	0.019533	6.316310	0.043180	0.715204	4.022366	1.095266
7	0.671238	85.16593	0.620743	0.135059	0.045720	7.455965	0.061847	0.667642	4.714068	1.133022
8	0.732304	83.46617	0.779248	0.124043	0.080920	8.408131	0.077254	0.599201	5.327776	1.137257
9	0.787107	82.02239	0.945723	0.119630	0.119602	9.191919	0.088030	0.529906	5.856791	1.126008
10	0.836312	80.78859	1.123936	0.122634	0.157120	9.831901	0.094483	0.470596	6.299980	1.110756
11	0.880504	79.72255	1.317548	0.133930	0.190367	10.35363	0.097716	0.424880	6.661243	1.098133
12	0.920192	78.78870	1.529352	0.154094	0.217713	10.77956	0.098993	0.392085	6.947808	1.091695
13	0.955832	77.95780	1.761006	0.183152	0.238625	11.12850	0.099398	0.369679	7.168695	1.093151
14	0.987829	77.20666	2.012921	0.220531	0.253287	11.41550	0.099763	0.354785	7.333404	1.103152
15	1.016550	76.51726	2.284335	0.265183	0.262305	11.65249	0.100721	0.344917	7.451064	1.121726
16	1.042324	75.87592	2.573465	0.315768	0.266510	11.84885	0.102799	0.338205	7.529952	1.148533
17	1.065453	75.27250	2.877726	0.370825	0.266831	12.01196	0.106496	0.333368	7.577298	1.183001
18	1.086210	74.69961	3.193955	0.428909	0.264221	12.14771	0.112324	0.329581	7.599274	1.224412
19	1.104840	74.15206	3.518641	0.488680	0.259604	12.26083	0.120811	0.326348	7.601073	1.271953
20	1.121566	73.62626	3.848124	0.548954	0.253850	12.35515	0.132486	0.323386	7.587038	1.324752
21	1.136588	73.11991	4.178758	0.608723	0.247745	12.43379	0.147848	0.320545	7.560787	1.381897
22	1.150086	72.63159	4.507052	0.667164	0.241983	12.49933	0.167334	0.317753	7.525331	1.442458
23	1.162221	72.16062	4.829763	0.723631	0.237149	12.55389	0.191288	0.314986	7.483179	1.505497
24	1.173135	71.70679	5.143970	0.777644	0.233712	12.59921	0.219937	0.312244	7.436412	1.570085
25	1.182955	71.27023	5.447120	0.828876	0.232029	12.63675	0.253381	0.309542	7.386756	1.635317
26	1.191794	70.85132	5.737055	0.877136	0.232343	12.66771	0.291581	0.306899	7.335631	1.700324
27	1.199752	70.45057	6.012017	0.922349	0.234787	12.69308	0.334367	0.304336	7.284193	1.764296
28	1.206915	70.06853	6.270648	0.964539	0.239400	12.71371	0.381444	0.301871	7.233376	1.826490
29	1.213361	69.70572	6.511970	1.003810	0.246132	12.73027	0.432410	0.299524	7.183918	1.886244
30	1.219159	69.36263	6.735365	1.040327	0.254858	12.74336	0.486775	0.297306	7.136388	1.942990
31	1.224370	69.03963	6.940543	1.074305	0.265396	12.75345	0.543978	0.295229	7.091215	1.996260
32	1.229048	68.73693	7.127506	1.105988	0.277516	12.76095	0.603414	0.293300	7.048702	2.045689
33	1.233242	68.45463	7.296516	1.135641	0.290954	12.76621	0.664456	0.291521	7.009051	2.091015
34	1.236994	68.19264	7.448053	1.163535	0.305430	12.76953	0.726469	0.289894	6.972375	2.132076
35	1.240345	67.95071	7.582779	1.189946	0.320651	12.77114	0.788836	0.288417	6.938715	2.168809
36	1.243330	67.72842	7.701503	1.215144	0.336330	12.77126	0.850969	0.287084	6.908052	2.201236
37	1.245982	67.52521	7.805146	1.239387	0.352186	12.77008	0.912322	0.285890	6.880319	2.229459
38	1.248331	67.34038	7.894712	1.262925	0.367959	12.76774	0.972401	0.284828	6.855410	2.253648
39	1.250406	67.17308	7.971257	1.285993	0.383411	12.76439	1.030771	0.283888	6.833189	2.274027
40	1.252233	67.02236	8.035871	1.308813	0.398331	12.76014	1.087058	0.283061	6.813496	2.290870
41	1.253836	66.88719	8.089647	1.331594	0.412538	12.75511	1.140954	0.282338	6.796154	2.304481
42	1.255239	66.76644	8.133672	1.354531	0.425884	12.74939	1.192213	0.281707	6.780976	2.315187
43	1.256464	66.65894	8.169008	1.377810	0.438252	12.74308	1.240652	0.281160	6.767769	2.323329
44	1.257531	66.56349	8.196681	1.401605	0.449557	12.73626	1.286143	0.280685	6.756334	2.329249
45	1.258459	66.47885	8.217671	1.426079	0.459744	12.72901	1.328614	0.280273	6.746475	2.333284
46	1.259267	66.40379	8.232905	1.451388	0.468786	12.72142	1.368039	0.279916	6.737998	2.335758
47	1.259972	66.33709	8.243254	1.477677	0.476685	12.71356	1.404435	0.279604	6.730715	2.336978
48	1.260590	66.27756	8.249527	1.505083	0.483462	12.70551	1.437855	0.279331	6.724446	2.337224
49	1.261136	66.22402	8.252470	1.533734	0.489163	12.69737	1.468383	0.279089	6.719017	2.336751
50	1.261623	66.17539	8.252768	1.563749	0.493848	12.68920	1.496127	0.278874	6.714267	2.335783
51	1.262066	66.13059	8.251040	1.595235	0.497592	12.68109	1.521215	0.278680	6.710044	2.334513

52	1.262475	66.08865	8.247846	1.628290	0.500483	12.67313	1.543788	0.278504	6.706208	2.333101
53	1.262861	66.04866	8.243687	1.663000	0.502615	12.66539	1.563999	0.278343	6.702631	2.331677
54	1.263234	66.00976	8.239007	1.699438	0.504089	12.65797	1.582006	0.278197	6.699195	2.330338
55	1.263603	65.97121	8.234195	1.737663	0.505007	12.65094	1.597969	0.278065	6.695798	2.329156
56	1.263976	65.93231	8.229592	1.777720	0.505473	12.64439	1.612048	0.277949	6.692346	2.328173
57	1.264360	65.89247	8.225489	1.819640	0.505590	12.63840	1.624399	0.277850	6.688758	2.327409
58	1.264760	65.85116	8.222137	1.863439	0.505457	12.63304	1.635174	0.277771	6.684963	2.326862
59	1.265182	65.80794	8.219741	1.909115	0.505167	12.62839	1.644517	0.277717	6.680903	2.326515
60	1.265631	65.76243	8.218476	1.956653	0.504809	12.62451	1.652567	0.277692	6.676528	2.326334

VARIANCE DECOMPOSITION OF LOGGDP

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	0.002814	0.225294	99.77471	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.004375	0.919585	97.98469	0.165565	0.023801	0.002562	0.616810	0.062292	0.022868	0.201826
3	0.005579	1.604612	95.17853	0.575791	0.351618	0.054236	0.901107	0.123613	0.023178	1.187317
4	0.006624	2.037896	91.23775	1.362907	0.935108	0.288716	1.054384	0.143931	0.122179	2.817127
5	0.007612	2.238725	86.47129	2.571138	1.654700	0.833436	1.190493	0.115649	0.293338	4.631234
6	0.008583	2.266454	81.34774	4.187641	2.378250	1.639613	1.332093	0.096372	0.479039	6.272798
7	0.009550	2.194738	76.24943	6.125584	3.037827	2.630578	1.473908	0.113538	0.634085	7.540308
8	0.010513	2.079572	71.43552	8.274786	3.610550	3.700585	1.605607	0.161921	0.744856	8.386598
9	0.011465	1.956328	67.03184	10.52284	4.100353	4.780816	1.715319	0.225310	0.814227	8.852964
10	0.012402	1.844021	63.07730	12.77779	4.519278	5.825715	1.795452	0.290678	0.852475	9.017287
11	0.013318	1.751725	59.55923	14.97075	4.879897	6.815035	1.842659	0.351248	0.869854	8.959609
12	0.014210	1.683146	56.44187	17.05596	5.192120	7.741133	1.857666	0.405152	0.874579	8.748369
13	0.015078	1.639453	53.68137	19.00577	5.463096	8.604511	1.843845	0.453113	0.872307	8.436532
14	0.015921	1.620731	51.23389	20.80617	5.697793	9.408745	1.806081	0.496834	0.866668	8.063095
15	0.016739	1.626679	49.05894	22.45233	5.899786	10.15863	1.749750	0.538100	0.859826	7.655949
16	0.017533	1.656895	47.12062	23.94546	6.071846	10.85885	1.680084	0.578400	0.852988	7.234849
17	0.018304	1.710959	45.38765	25.29029	6.216328	11.51360	1.601794	0.618817	0.846770	6.813789
18	0.019052	1.788448	43.83304	26.49353	6.335394	12.12642	1.518910	0.660053	0.841443	6.402767
19	0.019780	1.888904	42.43361	27.56279	6.431110	12.70026	1.434747	0.702495	0.837089	6.009000
20	0.020487	2.011809	41.16943	28.50602	6.505476	13.23757	1.351955	0.746299	0.833697	5.637743
21	0.021175	2.156548	40.02340	29.33112	6.560421	13.74043	1.272594	0.791457	0.831216	5.292817
22	0.021845	2.322393	38.98078	30.04582	6.597795	14.21058	1.198222	0.837863	0.829585	4.976963
23	0.022498	2.508486	38.02890	30.65756	6.619349	14.64956	1.129976	0.885350	0.828746	4.692076
24	0.023136	2.713831	37.15682	31.17349	6.626725	15.05874	1.068651	0.933723	0.828651	4.439367
25	0.023759	2.937297	36.35509	31.60051	6.621457	15.43936	1.014756	0.982784	0.829262	4.219489
26	0.024369	3.177628	35.61553	31.94521	6.604963	15.79258	0.968571	1.032334	0.830547	4.032632
27	0.024965	3.433455	34.93109	32.21396	6.578556	16.11949	0.930191	1.082189	0.832485	3.878596
28	0.025550	3.703317	34.29562	32.41284	6.543443	16.42113	0.899560	1.132175	0.835059	3.756862
29	0.026124	3.985684	33.70381	32.54770	6.500734	16.69854	0.876502	1.182136	0.838257	3.666648
30	0.026687	4.278977	33.15102	32.62414	6.451446	16.95271	0.860751	1.231931	0.842069	3.606958
31	0.027241	4.581597	32.63324	32.64749	6.396513	17.18464	0.851968	1.281432	0.846490	3.576628
32	0.027786	4.891943	32.14695	32.62284	6.336782	17.39531	0.849766	1.330526	0.851516	3.574365
33	0.028322	5.208436	31.68906	32.55500	6.273029	17.58572	0.853719	1.379116	0.857143	3.598779
34	0.028850	5.529541	31.25688	32.44849	6.205955	17.75685	0.863384	1.427115	0.863369	3.648413
35	0.029371	5.853779	30.84805	32.30760	6.136193	17.90966	0.878303	1.474450	0.870192	3.721773
36	0.029885	6.179743	30.46047	32.13631	6.064315	18.04512	0.898022	1.521059	0.877611	3.817345
37	0.030391	6.506110	30.09229	31.93835	5.990832	18.16420	0.922089	1.566892	0.885623	3.933620
38	0.030891	6.831651	29.74187	31.71715	5.916199	18.26782	0.950070	1.611908	0.894225	4.069104
39	0.031385	7.155231	29.40775	31.47591	5.840821	18.35692	0.981544	1.656074	0.903414	4.222337
40	0.031872	7.475820	29.08862	31.21756	5.765052	18.43239	1.016114	1.699368	0.913185	4.391901

41	0.032354	7.792489	28.78330	30.94477	5.689207	18.49509	1.053406	1.741772	0.923531	4.576430
42	0.032829	8.104410	28.49075	30.65998	5.613555	18.54589	1.093070	1.783278	0.934444	4.774615
43	0.033299	8.410859	28.21001	30.36542	5.538333	18.58559	1.134784	1.823880	0.945916	4.985211
44	0.033763	8.711205	27.94022	30.06307	5.463741	18.61496	1.178250	1.863578	0.957935	5.207036
45	0.034222	9.004914	27.68058	29.75475	5.389949	18.63477	1.223197	1.902378	0.970488	5.438979
46	0.034675	9.291535	27.43039	29.44205	5.317101	18.64571	1.269380	1.940287	0.983562	5.679994
47	0.035123	9.570702	27.18898	29.12641	5.245316	18.64845	1.316577	1.977315	0.997140	5.929102
48	0.035565	9.842126	26.95577	28.80911	5.174690	18.64365	1.364590	2.013476	1.011206	6.185393
49	0.036003	10.10558	26.73020	28.49125	5.105302	18.63188	1.413241	2.048783	1.025741	6.448017
50	0.036434	10.36092	26.51176	28.17384	5.037210	18.61374	1.462375	2.083252	1.040724	6.716188
51	0.036861	10.60803	26.29999	27.85772	4.970461	18.58973	1.511853	2.116901	1.056136	6.989178
52	0.037282	10.84688	26.09446	27.54365	4.905086	18.56036	1.561557	2.149746	1.071954	7.266314
53	0.037698	11.07745	25.89478	27.23225	4.841107	18.52610	1.611380	2.181806	1.088156	7.546976
54	0.038109	11.29978	25.70059	26.92409	4.778533	18.48737	1.661232	2.213098	1.104717	7.830591
55	0.038515	11.51396	25.51155	26.61962	4.717368	18.44458	1.711037	2.243640	1.121613	8.116635
56	0.038916	11.72007	25.32735	26.31924	4.657608	18.39811	1.760727	2.273451	1.138820	8.404624
57	0.039312	11.91826	25.14772	26.02326	4.599241	18.34830	1.810246	2.302548	1.156313	8.694113
58	0.039702	12.10867	24.97238	25.73196	4.542252	18.29547	1.859549	2.330949	1.174067	8.984695
59	0.040088	12.29147	24.80111	25.44555	4.486621	18.23994	1.908595	2.358670	1.192056	9.275995
60	0.040469	12.46685	24.63367	25.16419	4.432327	18.18197	1.957352	2.385728	1.210255	9.567668

VARIANCE DECOMPOSITION OF LOGIP

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	0.005290	0.245066	97.51382	2.241115	0.000000	0.000000	9.59E-31	1.79E-27	6.82E-29	5.04E-30
2	0.008191	1.025986	95.51923	2.407795	0.028575	0.049299	0.715249	0.058637	0.000708	0.194520
3	0.010386	1.832145	92.91100	2.426248	0.349842	0.030723	1.160756	0.116897	0.057321	1.115071
4	0.012205	2.383655	89.89512	2.190052	0.906806	0.062694	1.532919	0.131476	0.254939	2.642340
5	0.013818	2.682703	86.66731	1.827257	1.601501	0.252891	1.944093	0.105989	0.523834	4.394427
6	0.015297	2.778972	83.40786	1.492631	2.322805	0.615321	2.416425	0.095264	0.795975	6.074742
7	0.016676	2.745668	80.22621	1.309261	3.013454	1.134654	2.931378	0.121406	1.023353	7.494615
8	0.017967	2.642821	77.19675	1.340955	3.649308	1.755116	3.461784	0.176199	1.194200	8.582866
9	0.019175	2.511728	74.35469	1.597819	4.228128	2.433997	3.975553	0.242357	1.312870	9.342860
10	0.020306	2.376700	71.71383	2.056770	4.754630	3.134771	4.446887	0.306875	1.391574	9.817963
11	0.021363	2.250538	69.27288	2.678887	5.235081	3.836037	4.857374	0.363477	1.442317	10.06341
12	0.022350	2.139110	67.02389	3.422296	5.674362	4.524369	5.197282	0.410986	1.474985	10.13272
13	0.023274	2.044587	64.95543	4.248474	6.075769	5.193199	5.463819	0.450787	1.496591	10.07135
14	0.024138	1.967383	63.05491	5.125051	6.441291	5.839223	5.659481	0.485130	1.511828	9.915707
15	0.024947	1.907219	61.30938	6.026056	6.772202	6.461208	5.790086	0.516212	1.523614	9.694025
16	0.025706	1.863656	59.70605	6.931264	7.069490	7.058730	5.863281	0.545832	1.533678	9.428023
17	0.026419	1.836329	58.23247	7.825125	7.334155	7.631745	5.887388	0.575315	1.542974	9.134501
18	0.027089	1.825019	56.87671	8.695771	7.567352	8.180283	5.870673	0.605562	1.551984	8.826643
19	0.027720	1.829654	55.62743	9.534176	7.770435	8.704381	5.820900	0.637133	1.560920	8.514974
20	0.028316	1.850273	54.47392	10.33352	7.944928	9.204047	5.745114	0.670323	1.569847	8.208018
21	0.028879	1.886973	53.40622	11.08875	8.092487	9.679285	5.649550	0.705244	1.578760	7.912734
22	0.029412	1.939857	52.41507	11.79619	8.214839	10.13011	5.539636	0.741878	1.587626	7.634803
23	0.029919	2.008992	51.49196	12.45337	8.313739	10.55656	5.420032	0.780122	1.596405	7.378820
24	0.030401	2.094358	50.62915	13.05881	8.390935	10.95873	5.294698	0.819824	1.605058	7.148427
25	0.030861	2.195823	49.81964	13.61188	8.448140	11.33678	5.166952	0.860803	1.613556	6.946422
26	0.031302	2.313116	49.05715	14.11268	8.487016	11.69091	5.039546	0.902862	1.621874	6.774846
27	0.031725	2.445813	48.33611	14.56192	8.509171	12.02140	4.914724	0.945800	1.629997	6.635059
28	0.032132	2.593334	47.65160	14.96086	8.516146	12.32862	4.794282	0.989417	1.637913	6.527821
29	0.032526	2.754947	46.99933	15.31120	8.509414	12.61299	4.679622	1.033517	1.645620	6.453358

30	0.032907	2.929771	46.37559	15.61497	8.490383	12.87502	4.571800	1.077914	1.653120	6.411429
31	0.033278	3.116803	45.77718	15.87452	8.460385	13.11529	4.471570	1.122429	1.660422	6.401397
32	0.033638	3.314928	45.20140	16.09237	8.420685	13.33447	4.379430	1.166895	1.667538	6.422283
33	0.033991	3.522946	44.64595	16.27121	8.372471	13.53328	4.295657	1.211158	1.674488	6.472831
34	0.034335	3.739595	44.10893	16.41383	8.316859	13.71251	4.220342	1.255076	1.681295	6.551562
35	0.034673	3.963578	43.58875	16.52304	8.254887	13.87299	4.153425	1.298523	1.687984	6.656819
36	0.035005	4.193581	43.08411	16.60164	8.187519	14.01563	4.094718	1.341388	1.694586	6.786824
37	0.035331	4.428301	42.59395	16.65241	8.115645	14.14133	4.043940	1.383574	1.701133	6.939713
38	0.035652	4.666461	42.11741	16.67803	8.040078	14.25105	4.000731	1.424998	1.707657	7.113580
39	0.035968	4.906830	41.65379	16.68110	7.961560	14.34575	3.964679	1.465593	1.714193	7.306505
40	0.036279	5.148239	41.20253	16.66409	7.880761	14.42638	3.935332	1.505303	1.720773	7.516588
41	0.036587	5.389590	40.76316	16.62934	7.798286	14.49392	3.912218	1.544086	1.727430	7.741970
42	0.036890	5.629865	40.33533	16.57902	7.714672	14.54930	3.894854	1.581911	1.734195	7.980856
43	0.037189	5.868134	39.91872	16.51517	7.630396	14.59345	3.882756	1.618758	1.741096	8.231525
44	0.037484	6.103559	39.51305	16.43966	7.545879	14.62727	3.875451	1.654616	1.748159	8.492351
45	0.037775	6.335393	39.11811	16.35423	7.461487	14.65161	3.872481	1.689479	1.755409	8.761801
46	0.038062	6.562981	38.73367	16.26043	7.377538	14.66731	3.873407	1.723353	1.762865	9.038449
47	0.038346	6.785760	38.35952	16.15969	7.294302	14.67514	3.877814	1.756246	1.770544	9.320974
48	0.038625	7.003252	37.99549	16.05328	7.212011	14.67586	3.885315	1.788173	1.778460	9.608159
49	0.038901	7.215064	37.64136	15.94235	7.130859	14.67015	3.895547	1.819150	1.786624	9.898896
50	0.039172	7.420876	37.29694	15.82791	7.051006	14.65867	3.908179	1.849200	1.795042	10.19217
51	0.039440	7.620445	36.96202	15.71086	6.972581	14.64203	3.922906	1.878346	1.803719	10.48709
52	0.039704	7.813589	36.63640	15.59200	6.895689	14.62079	3.939451	1.906613	1.812657	10.78282
53	0.039963	8.000189	36.31986	15.47201	6.820410	14.59547	3.957562	1.934028	1.821852	11.07863
54	0.040219	8.180179	36.01217	15.35149	6.746803	14.56654	3.977015	1.960618	1.831302	11.37388
55	0.040471	8.353540	35.71310	15.23097	6.674910	14.53446	3.997608	1.986410	1.840999	11.66801
56	0.040719	8.520294	35.42243	15.11089	6.604758	14.49961	4.019160	2.011432	1.850935	11.96049
57	0.040962	8.680501	35.13992	14.99162	6.536360	14.46237	4.041514	2.035711	1.861098	12.25090
58	0.041202	8.834252	34.86532	14.87350	6.469717	14.42307	4.064527	2.059274	1.871477	12.53886
59	0.041438	8.981664	34.59840	14.75678	6.404822	14.38201	4.088078	2.082147	1.882057	12.82404
60	0.041670	9.122876	34.33892	14.64169	6.341659	14.33946	4.112058	2.104356	1.892823	13.10616

VARIANCE DECOMPOSITION OF LOGIMP

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	0.102969	0.640773	1.028386	0.001955	9.690188	57.08345	0.030444	30.17750	1.254493	0.092816
2	0.110194	1.905246	1.233661	2.627570	8.488955	51.24771	0.064683	33.02297	1.264905	0.144302
3	0.118372	2.856886	1.263764	3.992286	7.356504	50.65481	0.102541	30.84632	1.189166	1.737719
4	0.123564	4.298002	2.217504	5.064179	6.918638	46.75943	0.125255	28.94898	1.091416	4.576588
5	0.128614	5.308938	3.142940	5.147980	6.524895	43.43116	0.313881	26.77124	1.011988	8.346978
6	0.133822	6.072376	4.320132	4.854805	6.189119	40.14486	0.601666	24.72857	0.946886	12.14159
7	0.139016	6.529039	5.349414	4.502133	5.859888	37.28877	1.051789	22.93522	0.911254	15.57250
8	0.144289	6.793825	6.279135	4.284970	5.556848	34.90918	1.560073	21.30967	0.932910	18.37339
9	0.149458	6.923064	7.037415	4.279271	5.286624	32.92496	2.094612	19.87114	0.995092	20.58782
10	0.154546	6.971366	7.665184	4.458970	5.054238	31.30458	2.591464	18.58599	1.091118	22.27708
11	0.159493	6.970271	8.178629	4.787684	4.859795	29.96376	3.029800	17.45109	1.198721	23.56025
12	0.164310	6.940692	8.611001	5.216616	4.701303	28.86094	3.393536	16.44628	1.305842	24.52379
13	0.168983	6.895009	8.984226	5.711284	4.575221	27.94649	3.684642	15.55636	1.401647	25.24512
14	0.173519	6.840843	9.318055	6.243751	4.477600	27.18945	3.908729	14.76340	1.481863	25.77631
15	0.177915	6.782968	9.625574	6.796026	4.404350	26.56045	4.075757	14.05301	1.544767	26.15709
16	0.182175	6.724533	9.916293	7.355089	4.351713	26.03815	4.195440	13.41279	1.591164	26.41482
17	0.186299	6.667786	10.19615	7.912348	4.316328	25.60400	4.277067	12.83320	1.622728	26.57040
18	0.190286	6.614420	10.46888	8.461529	4.295328	25.24351	4.328473	12.30657	1.641608	26.63968

19	0.194138	6.565764	10.73657	8.998188	4.286284	24.94455	4.356195	11.82682	1.649911	26.63572
20	0.197854	6.522868	11.00025	9.518986	4.287158	24.69737	4.365451	11.38889	1.649585	26.56944
21	0.201437	6.486546	11.26030	10.02149	4.296229	24.49391	4.360391	10.98851	1.642322	26.45030
22	0.204887	6.457409	11.51671	10.50394	4.312029	24.32758	4.344262	10.62195	1.629569	26.28655
23	0.208207	6.435887	11.76925	10.96513	4.333298	24.19294	4.319607	10.28592	1.612545	26.08542
24	0.211401	6.422259	12.01756	11.40432	4.358939	24.08547	4.288406	9.977524	1.592271	25.85325
25	0.214471	6.416677	12.26128	11.82117	4.387995	24.00134	4.252205	9.694163	1.569604	25.59557
26	0.217422	6.419184	12.50003	12.21561	4.419623	23.93734	4.212216	9.433518	1.545255	25.31722
27	0.220258	6.429741	12.73345	12.58783	4.453089	23.89072	4.169387	9.193518	1.519815	25.02245
28	0.222984	6.448239	12.96122	12.93819	4.487747	23.85907	4.124464	8.972307	1.493772	24.71499
29	0.225603	6.474515	13.18305	13.26718	4.523034	23.84033	4.078040	8.768223	1.467526	24.39811
30	0.228121	6.508363	13.39870	13.57538	4.558463	23.83264	4.030583	8.579771	1.441400	24.07470
31	0.230542	6.549539	13.60797	13.86344	4.593614	23.83436	3.982474	8.405606	1.415656	23.74734
32	0.232870	6.597773	13.81070	14.13202	4.628127	23.84405	3.934019	8.244515	1.390499	23.41830
33	0.235110	6.652770	14.00675	14.38181	4.661695	23.86036	3.885473	8.095402	1.366092	23.08964
34	0.237267	6.714215	14.19603	14.61352	4.694062	23.88213	3.837049	7.957272	1.342559	22.76317
35	0.239343	6.781775	14.37847	14.82783	4.725014	23.90826	3.788927	7.829225	1.319992	22.44051
36	0.241343	6.855107	14.55403	15.02545	4.754377	23.93776	3.741265	7.710439	1.298461	22.12310
37	0.243272	6.933853	14.72271	15.20704	4.782009	23.96976	3.694203	7.600170	1.278014	21.81224
38	0.245134	7.017647	14.88449	15.37328	4.807801	24.00344	3.647867	7.497736	1.258682	21.50906
39	0.246930	7.106118	15.03942	15.52481	4.831671	24.03807	3.602370	7.402516	1.240483	21.21455
40	0.248667	7.198889	15.18752	15.66228	4.853560	24.07297	3.557817	7.313941	1.223425	20.92960
41	0.250346	7.295578	15.32886	15.78632	4.873431	24.10755	3.514303	7.231492	1.207507	20.65496
42	0.251971	7.395807	15.46350	15.89753	4.891268	24.14128	3.471919	7.154692	1.192722	20.39128
43	0.253546	7.499196	15.59152	15.99653	4.907067	24.17368	3.430746	7.083105	1.179056	20.13910
44	0.255072	7.605368	15.71301	16.08391	4.920844	24.20432	3.390858	7.016329	1.166494	19.89887
45	0.256553	7.713953	15.82807	16.16023	4.932623	24.23283	3.352325	6.953997	1.155015	19.67096
46	0.257992	7.824587	15.93681	16.22606	4.942441	24.25889	3.315207	6.895769	1.144596	19.45564
47	0.259391	7.936912	16.03934	16.28197	4.950345	24.28223	3.279560	6.841334	1.135212	19.25310
48	0.260753	8.050583	16.13578	16.32848	4.956387	24.30261	3.245430	6.790406	1.126837	19.06349
49	0.262079	8.165264	16.22626	16.36612	4.960630	24.31984	3.212859	6.742720	1.119445	18.88686
50	0.263371	8.280632	16.31091	16.39541	4.963139	24.33378	3.181879	6.698033	1.113005	18.72321
51	0.264632	8.396377	16.38986	16.41686	4.963984	24.34431	3.152518	6.656120	1.107490	18.57248
52	0.265864	8.512202	16.46327	16.43093	4.963238	24.35134	3.124795	6.616775	1.102869	18.43457
53	0.267067	8.627828	16.53128	16.43812	4.960979	24.35482	3.098723	6.579807	1.099114	18.30933
54	0.268244	8.742990	16.59403	16.43887	4.957282	24.35473	3.074310	6.545040	1.096192	18.19656
55	0.269396	8.857439	16.65169	16.43362	4.952228	24.35106	3.051554	6.512311	1.094075	18.09602
56	0.270524	8.970943	16.70441	16.42281	4.945896	24.34385	3.030452	6.481469	1.092731	18.00744
57	0.271629	9.083287	16.75235	16.40684	4.938363	24.33313	3.010991	6.452378	1.092130	17.93053
58	0.272713	9.194271	16.79567	16.38611	4.929709	24.31897	2.993157	6.424908	1.092242	17.86497
59	0.273777	9.303714	16.83453	16.36099	4.920010	24.30145	2.976927	6.398942	1.093035	17.81040
60	0.274821	9.411450	16.86911	16.33186	4.909342	24.28065	2.962278	6.374371	1.094480	17.76646

VARIANCE DECOMPOSITION OF LOGEXP

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	0.101176	0.101820	0.002897	2.55E-07	10.19403	0.688242	0.596597	88.41624	0.000163	1.21E-05
2	0.113979	3.037802	0.031192	0.474631	8.363182	1.406688	0.704230	85.97206	0.009735	0.000481
3	0.122010	5.450635	0.892399	0.962429	7.299509	2.377271	0.670546	81.76367	0.098231	0.485307
4	0.127891	7.158520	2.896214	1.155404	6.783684	3.699225	0.648573	76.19752	0.170763	1.290099
5	0.133124	8.052111	5.671604	1.117050	6.523465	4.985164	0.606832	70.64617	0.221005	2.176598
6	0.138122	8.353620	8.709872	1.041538	6.380598	6.127780	0.565057	65.64598	0.246748	2.928805
7	0.142851	8.314246	11.61410	1.061313	6.307214	7.037120	0.551018	61.37619	0.259715	3.479087

8	0.147286	8.111208	14.19670	1.215770	6.287096	7.742287	0.573609	57.76146	0.268078	3.843788
9	0.151406	7.846504	16.40018	1.490384	6.313492	8.280441	0.627703	54.69402	0.278109	4.069167
10	0.155235	7.570324	18.24058	1.852046	6.380368	8.700676	0.702198	52.06180	0.293729	4.198278
11	0.158807	7.304874	19.76061	2.270149	6.480530	9.039921	0.786694	49.77656	0.317771	4.262887
12	0.162160	7.058435	21.00915	2.722125	6.605948	9.327227	0.873249	47.76893	0.351615	4.283325
13	0.165325	6.833292	22.03111	3.193569	6.748459	9.582065	0.956677	45.98759	0.395273	4.271961
14	0.168327	6.629354	22.86491	3.675648	6.900533	9.817699	1.033769	44.39436	0.447470	4.236259
15	0.171184	6.445827	23.54224	4.162849	7.055721	10.04237	1.102650	42.96100	0.506139	4.181199
16	0.173908	6.281831	24.08915	4.651216	7.208862	10.26106	1.162237	41.66596	0.568904	4.110775
17	0.176506	6.136611	24.52703	5.137373	7.356047	10.47645	1.211961	40.49218	0.633523	4.028829
18	0.178986	6.009568	24.87357	5.618036	7.494458	10.68971	1.251616	39.42554	0.698129	3.939370
19	0.181353	5.900234	25.14352	6.089889	7.622156	10.90107	1.281304	38.45390	0.761330	3.846602
20	0.183613	5.808232	25.34917	6.549627	7.737878	11.11015	1.301412	37.56656	0.822185	3.754787
21	0.185771	5.733242	25.50080	6.994086	7.840869	11.31623	1.312593	36.75398	0.880130	3.668064
22	0.187833	5.674968	25.60703	7.420364	7.930746	11.51841	1.315730	36.00758	0.934884	3.590291
23	0.189808	5.633110	25.67501	7.825927	8.007412	11.71571	1.311896	35.31965	0.986360	3.524921
24	0.191701	5.607343	25.71072	8.208671	8.070988	11.90714	1.302297	34.68331	1.034597	3.474932
25	0.193520	5.597295	25.71912	8.566947	8.121769	12.09174	1.288213	34.09242	1.079709	3.442794
26	0.195273	5.602531	25.70433	8.899564	8.160189	12.26861	1.270946	33.54151	1.121850	3.430467
27	0.196966	5.622546	25.66979	9.205770	8.186796	12.43696	1.251765	33.02576	1.161194	3.439420
28	0.198606	5.656757	25.61835	9.485214	8.202224	12.59608	1.231868	32.54093	1.197922	3.470653
29	0.200199	5.704501	25.55241	9.737912	8.207176	12.74540	1.212352	32.08330	1.232214	3.524736
30	0.201750	5.765039	25.47400	9.964202	8.202402	12.88445	1.194186	31.64964	1.264246	3.601847
31	0.203265	5.837560	25.38482	10.16470	8.188683	13.01290	1.178204	31.23713	1.294188	3.701809
32	0.204748	5.921191	25.28637	10.34026	8.166814	13.13056	1.165093	30.84337	1.322205	3.824137
33	0.206203	6.015008	25.17995	10.49193	8.137592	13.23733	1.155398	30.46627	1.348452	3.968073
34	0.207633	6.118048	25.06667	10.62091	8.101800	13.33324	1.149524	30.10409	1.373078	4.132633
35	0.209041	6.229319	24.94757	10.72852	8.060202	13.41844	1.147747	29.75533	1.396223	4.316650
36	0.210430	6.347820	24.82356	10.81616	8.013532	13.49315	1.150224	29.41873	1.418021	4.518808
37	0.211801	6.472548	24.69545	10.88529	7.962486	13.55768	1.157007	29.09326	1.438599	4.737686
38	0.213156	6.602513	24.56402	10.93738	7.907724	13.61241	1.168058	28.77803	1.458074	4.971792
39	0.214496	6.736751	24.42994	10.97390	7.849857	13.65779	1.183261	28.47235	1.476557	5.219592
40	0.215821	6.874330	24.29386	10.99631	7.789454	13.69429	1.202438	28.17562	1.494151	5.479543
41	0.217133	7.014365	24.15636	11.00602	7.727036	13.72243	1.225362	27.88735	1.510954	5.750117
42	0.218431	7.156020	24.01798	11.00437	7.663077	13.74275	1.251770	27.60716	1.527054	6.029820
43	0.219715	7.298516	23.87920	10.99266	7.598007	13.75579	1.281372	27.33472	1.542532	6.317210
44	0.220986	7.441132	23.74045	10.97210	7.532209	13.76211	1.313865	27.06975	1.557466	6.610912
45	0.222243	7.583215	23.60215	10.94382	7.466025	13.76227	1.348937	26.81204	1.571923	6.909629
46	0.223486	7.724171	23.46465	10.90886	7.399756	13.75679	1.386278	26.56139	1.585966	7.212146
47	0.224715	7.863475	23.32827	10.86820	7.333666	13.74619	1.425583	26.31763	1.599651	7.517339
48	0.225929	8.000662	23.19327	10.82271	7.267983	13.73099	1.466560	26.08062	1.613029	7.824173
49	0.227127	8.135330	23.05992	10.77319	7.202904	13.71166	1.508928	25.85022	1.626146	8.131707
50	0.228310	8.267135	22.92841	10.72036	7.138595	13.68866	1.552428	25.62629	1.639039	8.439088
51	0.229476	8.395791	22.79891	10.66486	7.075196	13.66241	1.596815	25.40872	1.651745	8.745552
52	0.230626	8.521060	22.67159	10.60728	7.012822	13.63330	1.641866	25.19737	1.664293	9.050418
53	0.231760	8.642757	22.54654	10.54811	6.951569	13.60172	1.687381	24.99212	1.676709	9.353088
54	0.232876	8.760737	22.42388	10.48781	6.891510	13.56800	1.733175	24.79284	1.689014	9.653036
55	0.233975	8.874899	22.30366	10.42677	6.832704	13.53245	1.779086	24.59940	1.701227	9.949807
56	0.235056	8.985175	22.18593	10.36532	6.775193	13.49537	1.824971	24.41167	1.713360	10.24301
57	0.236119	9.091533	22.07073	10.30377	6.719007	13.45701	1.870703	24.22950	1.725426	10.53231
58	0.237165	9.193965	21.95808	10.24236	6.664165	13.41762	1.916175	24.05276	1.737432	10.81744
59	0.238193	9.292492	21.84796	10.18132	6.610675	13.37740	1.961291	23.88131	1.749386	11.09816
60	0.239202	9.387155	21.74038	10.12081	6.558539	13.33655	2.005974	23.71500	1.761289	11.37429

VARIANCE DECOMPOSITION OF LOGIF

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	0.014733	0.209345	0.297398	0.066062	40.85545	4.129470	3.216611	5.687528	42.40102	3.137109
2	0.023913	0.817754	0.414017	0.302979	42.97983	4.600324	2.953355	4.971753	40.47972	2.480268
3	0.029993	1.640018	0.797434	0.683087	43.50922	5.186987	2.743138	4.497343	39.23756	1.705212
4	0.033928	2.500679	1.496214	1.157259	43.03117	5.644621	2.558257	4.088265	38.05441	1.469124
5	0.036616	3.253857	2.498775	1.664276	41.62990	5.932659	2.372527	3.735456	36.72201	2.190544
6	0.038657	3.792726	3.704757	2.129914	39.57796	6.017514	2.183587	3.431865	35.27008	3.891597
7	0.040379	4.090273	4.987159	2.498934	37.21983	5.941040	2.007938	3.173913	33.79338	6.287533
8	0.041931	4.181673	6.236326	2.745462	34.85678	5.761395	1.863615	2.957060	32.40082	8.996871
9	0.043370	4.129468	7.384199	2.871272	32.67252	5.533449	1.759470	2.776543	31.16726	11.70583
10	0.044717	3.994498	8.397525	2.895290	30.74282	5.293307	1.694729	2.630312	30.12721	14.22431
11	0.045985	3.823044	9.265738	2.844494	29.07326	5.060727	1.662779	2.518956	29.28093	16.47007
12	0.047184	3.644944	9.990030	2.747463	27.63612	4.844159	1.655155	2.443790	28.60763	18.43071
13	0.048324	3.476597	10.57758	2.630547	26.39350	4.646061	1.664152	2.404838	28.07636	20.13037
14	0.049416	3.325007	11.03861	2.515666	25.30886	4.466145	1.683938	2.399892	27.65406	21.60783
15	0.050466	3.191340	11.38509	2.419331	24.35121	4.303175	1.710729	2.424666	27.31024	22.90422
16	0.051482	3.073619	11.62994	2.352553	23.49571	4.155744	1.742462	2.473593	27.01924	24.05714
17	0.052468	2.968576	11.78639	2.321369	22.72289	4.022569	1.778335	2.540730	26.76079	25.09835
18	0.053429	2.872815	11.86744	2.327742	22.01753	3.902547	1.818372	2.620487	26.51969	26.05338
19	0.054367	2.783480	11.88537	2.370563	21.36767	3.794738	1.863078	2.708044	26.28500	26.94205
20	0.055285	2.698543	11.85149	2.446616	20.76382	3.698320	1.913198	2.799510	26.04921	27.77929
21	0.056185	2.616875	11.77587	2.551402	20.19840	3.612547	1.969551	2.891905	25.80737	28.57607
22	0.057069	2.538162	11.66731	2.679776	19.66533	3.536720	2.032923	2.983032	25.55649	29.34025
23	0.057940	2.462757	11.53333	2.826426	19.15976	3.470162	2.104000	3.071339	25.29498	30.07724
24	0.058798	2.391505	11.38028	2.986201	18.67783	3.412211	2.183324	3.155762	25.02227	30.79062
25	0.059645	2.325562	11.21340	3.154323	18.21652	3.362212	2.271261	3.235612	24.73853	31.48258
26	0.060482	2.266244	11.03704	3.326519	17.77346	3.319522	2.367994	3.310472	24.44446	32.15428
27	0.061311	2.214895	10.85471	3.499082	17.34686	3.283510	2.473515	3.380129	24.14112	32.80618
28	0.062131	2.172785	10.66926	3.668898	16.93536	3.253568	2.587628	3.444517	23.82979	33.43819
29	0.062944	2.141033	10.48298	3.833433	16.53796	3.229115	2.709965	3.503684	23.51193	34.04990
30	0.063750	2.120560	10.29768	3.990705	16.15393	3.209606	2.839995	3.557759	23.18907	34.64069
31	0.064550	2.112060	10.11484	4.139238	15.78274	3.194536	2.977051	3.606933	22.86272	35.20988
32	0.065343	2.115988	9.935612	4.278014	15.42400	3.183442	3.120351	3.651440	22.53441	35.75674
33	0.066130	2.132562	9.760913	4.406410	15.07743	3.175908	3.269025	3.691546	22.20556	36.28065
34	0.066911	2.161777	9.591471	4.524139	14.74278	3.171565	3.422139	3.727537	21.87754	36.78105
35	0.067685	2.203428	9.427854	4.631201	14.41988	3.170088	3.578726	3.759709	21.55158	37.25754
36	0.068452	2.257130	9.270507	4.727816	14.10852	3.171194	3.737806	3.788362	21.22880	37.70986
37	0.069211	2.322350	9.119771	4.814386	13.80853	3.174642	3.898407	3.813794	20.91021	38.13791
38	0.069963	2.398435	8.975902	4.891441	13.51968	3.180225	4.059590	3.836294	20.59668	38.54175
39	0.070708	2.484638	8.839084	4.959606	13.24176	3.187770	4.220460	3.856142	20.28894	38.92160
40	0.071443	2.580147	8.709444	5.019563	12.97452	3.197134	4.380181	3.873604	19.98761	39.27779
41	0.072171	2.684108	8.587053	5.072027	12.71768	3.208196	4.537985	3.888931	19.69321	39.61081
42	0.072889	2.795647	8.471940	5.117723	12.47095	3.220858	4.693180	3.902357	19.40612	39.92122
43	0.073598	2.913887	8.364092	5.157364	12.23402	3.235039	4.845153	3.914098	19.12664	40.20971
44	0.074297	3.037964	8.263462	5.191644	12.00655	3.250672	4.993369	3.924353	18.85499	40.47700
45	0.074987	3.167043	8.169970	5.221223	11.78820	3.267704	5.137375	3.933305	18.59128	40.72390
46	0.075667	3.300321	8.083507	5.246721	11.57862	3.286088	5.276796	3.941119	18.33558	40.95125
47	0.076337	3.437041	8.003940	5.268716	11.37746	3.305786	5.411329	3.947943	18.08787	41.15992
48	0.076996	3.576493	7.931112	5.287740	11.18436	3.326765	5.540741	3.953910	17.84809	41.35079
49	0.077645	3.718022	7.864848	5.304278	10.99897	3.348994	5.664864	3.959141	17.61614	41.52474
50	0.078285	3.861024	7.804953	5.318769	10.82094	3.372447	5.783586	3.963739	17.39188	41.68267
51	0.078914	4.004949	7.751217	5.331608	10.64992	3.397095	5.896851	3.967799	17.17512	41.82544
52	0.079533	4.149304	7.703418	5.343146	10.48559	3.422913	6.004646	3.971402	16.96567	41.95391

53	0.080142	4.293646	7.661325	5.353695	10.32762	3.449874	6.107001	3.974619	16.76330	42.06892
54	0.080741	4.437581	7.624695	5.363529	10.17569	3.477949	6.203982	3.977512	16.56779	42.17127
55	0.081331	4.580767	7.593280	5.372885	10.02951	3.507110	6.295683	3.980135	16.37888	42.26175
56	0.081911	4.722902	7.566830	5.381971	9.888792	3.537325	6.382224	3.982533	16.19633	42.34110
57	0.082483	4.863729	7.545088	5.390963	9.753259	3.568562	6.463745	3.984745	16.01988	42.41003
58	0.083045	5.003029	7.527799	5.400012	9.622650	3.600784	6.540405	3.986805	15.84927	42.46924
59	0.083600	5.140617	7.514708	5.409243	9.496717	3.633954	6.612374	3.988740	15.68426	42.51938
60	0.084145	5.276340	7.505562	5.418760	9.375225	3.668034	6.679831	3.990574	15.52460	42.56108

VARIANCE DECOMPOSITION OF IN

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	2.770619	0.008418	0.011959	0.002656	1.642843	0.166051	96.10823	0.228702	1.704992	0.126147
2	3.643235	0.020895	0.008267	0.024871	3.038220	0.223157	91.10381	2.147177	1.239719	2.193879
3	4.233496	0.018296	0.007487	0.020589	3.943993	0.165967	86.26146	3.547121	0.986599	5.048485
4	4.677303	0.014994	0.007632	0.035675	4.614384	0.222800	82.48571	3.979190	0.834708	7.804910
5	5.027645	0.012981	0.006957	0.140273	5.069954	0.440047	79.34703	3.991699	0.742576	10.24848
6	5.314141	0.011830	0.006245	0.380724	5.356372	0.772987	76.66425	3.850441	0.689879	12.26727
7	5.553049	0.012049	0.005733	0.762146	5.526177	1.171924	74.32149	3.679321	0.668786	13.85238
8	5.754095	0.013854	0.005356	1.259860	5.621069	1.587664	72.25937	3.523853	0.674230	15.05474
9	5.923940	0.016712	0.005055	1.834288	5.671245	1.991628	70.43483	3.396500	0.701075	15.94867
10	6.067616	0.019754	0.004823	2.445494	5.695928	2.367262	68.81718	3.297114	0.743146	16.60930
11	6.189254	0.022209	0.004652	3.060188	5.706701	2.708922	67.38134	3.221323	0.794354	17.10031
12	6.292336	0.023674	0.004509	3.654507	5.710051	3.016060	66.10723	3.163731	0.849455	17.47079
13	6.379838	0.024135	0.004388	4.213295	5.709451	3.291118	64.97762	3.119269	0.904590	17.75613
14	6.454293	0.023891	0.004369	4.728355	5.706652	3.537406	63.97740	3.083787	0.957262	17.98088
15	6.517846	0.023428	0.004644	5.196370	5.702513	3.758390	63.09280	3.054223	1.006108	18.16152
16	6.572297	0.023310	0.005510	5.617201	5.697464	3.957211	62.31112	3.028521	1.050563	18.30910
17	6.619149	0.024098	0.007332	5.992605	5.691750	4.136622	61.62063	3.005423	1.090562	18.43098
18	6.659650	0.026305	0.010490	6.325379	5.685548	4.298979	61.01053	2.984222	1.126312	18.53224
19	6.694832	0.030360	0.015343	6.618824	5.679010	4.446306	60.47096	2.964553	1.158141	18.61650
20	6.725549	0.036603	0.022192	6.876418	5.672279	4.580351	59.99305	2.946237	1.186415	18.68646
21	6.752512	0.045278	0.031270	7.101627	5.665481	4.702639	59.56881	2.929180	1.211483	18.74424
22	6.776307	0.056537	0.042734	7.297802	5.658724	4.814510	59.19116	2.913323	1.233668	18.79154
23	6.797425	0.070441	0.056670	7.468112	5.652096	4.917142	58.85388	2.898607	1.253257	18.82979
24	6.816273	0.086975	0.073095	7.615517	5.645664	5.011574	58.55150	2.884971	1.270504	18.86020
25	6.833193	0.106052	0.091972	7.742744	5.639475	5.098719	58.27927	2.872345	1.285635	18.88379
26	6.848468	0.127525	0.113212	7.852281	5.633561	5.179378	58.03311	2.860656	1.298852	18.90143
27	6.862337	0.151202	0.136691	7.946380	5.627945	5.254251	57.80949	2.849832	1.310337	18.91387
28	6.874996	0.176852	0.162249	8.027056	5.622636	5.323949	57.60542	2.839800	1.320259	18.92177
29	6.886612	0.204224	0.189704	8.096105	5.617641	5.389002	57.41837	2.830494	1.328769	18.92569
30	6.897321	0.233049	0.218855	8.155113	5.612961	5.449872	57.24616	2.821852	1.336006	18.92613
31	6.907238	0.263057	0.249490	8.205470	5.608595	5.506958	57.08700	2.813818	1.342101	18.92351
32	6.916457	0.293978	0.281390	8.248392	5.604540	5.560608	56.93935	2.806340	1.347172	18.91823
33	6.925058	0.325556	0.314334	8.284936	5.600791	5.611123	56.80193	2.799375	1.351327	18.91063
34	6.933107	0.357547	0.348101	8.316017	5.597343	5.658767	56.67366	2.792881	1.354668	18.90101
35	6.940659	0.389728	0.382479	8.342423	5.594190	5.703768	56.55364	2.786826	1.357287	18.88966
36	6.947760	0.421895	0.417259	8.364834	5.591324	5.746325	56.44108	2.781176	1.359269	18.87684
37	6.954449	0.453868	0.452247	8.383831	5.588737	5.786614	56.33533	2.775906	1.360694	18.86277
38	6.960760	0.485490	0.487258	8.399914	5.586419	5.824789	56.23584	2.770991	1.361632	18.84766
39	6.966719	0.516626	0.522121	8.413509	5.584360	5.860985	56.14213	2.766410	1.362151	18.83171
40	6.972353	0.547162	0.556679	8.424980	5.582548	5.895322	56.05376	2.762144	1.362310	18.81509
41	6.977681	0.577005	0.590788	8.434635	5.580969	5.927908	55.97038	2.758175	1.362164	18.79798

42	6.982723	0.606082	0.624321	8.442740	5.579610	5.958835	55.89165	2.754489	1.361765	18.78050
43	6.987496	0.634335	0.657164	8.449518	5.578457	5.988192	55.81729	2.751070	1.361156	18.76282
44	6.992013	0.661723	0.689217	8.455159	5.577493	6.016054	55.74703	2.747907	1.360380	18.74504
45	6.996290	0.688216	0.720396	8.459826	5.576703	6.042491	55.68063	2.744986	1.359473	18.72728
46	7.000339	0.713800	0.750629	8.463654	5.576069	6.067567	55.61786	2.742297	1.358468	18.70966
47	7.004171	0.738466	0.779856	8.466760	5.575575	6.091341	55.55851	2.739827	1.357394	18.69227
48	7.007798	0.762216	0.808030	8.469241	5.575203	6.113867	55.50241	2.737567	1.356277	18.67519
49	7.011230	0.785060	0.835115	8.471181	5.574938	6.135195	55.44935	2.735507	1.355139	18.65851
50	7.014477	0.807011	0.861084	8.472650	5.574762	6.155374	55.39918	2.733636	1.354000	18.64230
51	7.017549	0.828088	0.885922	8.473707	5.574659	6.174447	55.35173	2.731944	1.352877	18.62663
52	7.020456	0.848313	0.909619	8.474403	5.574614	6.192456	55.30684	2.730423	1.351784	18.61155
53	7.023205	0.867711	0.932178	8.474780	5.574611	6.209444	55.26437	2.729064	1.350732	18.59712
54	7.025807	0.886307	0.953602	8.474876	5.574638	6.225447	55.22417	2.727856	1.349732	18.58337
55	7.028268	0.904130	0.973907	8.474720	5.574680	6.240504	55.18611	2.726792	1.348791	18.57036
56	7.030598	0.921208	0.993110	8.474341	5.574727	6.254650	55.15008	2.725861	1.347916	18.55811
57	7.032803	0.937568	1.011234	8.473761	5.574767	6.267922	55.11593	2.725057	1.347111	18.54665
58	7.034892	0.953239	1.028305	8.473000	5.574791	6.280353	55.08356	2.724370	1.346379	18.53600
59	7.036872	0.968249	1.044354	8.472077	5.574790	6.291976	55.05286	2.723792	1.345722	18.52618
60	7.038749	0.982623	1.059413	8.471007	5.574757	6.302825	55.02373	2.723316	1.345141	18.51719

VARIANCE DECOMPOSITION OF LOGMS

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	0.020764	0.913829	0.036913	0.000204	89.77749	5.970900	0.003184	3.156552	0.131219	0.009708
2	0.031107	1.924960	0.334001	0.040646	90.29905	3.683853	0.012238	3.323979	0.376213	0.005057
3	0.038158	2.710817	0.332407	0.209501	90.94941	2.802615	0.161703	2.211119	0.583126	0.039297
4	0.042920	3.482294	0.265614	0.505535	90.15286	2.303316	0.448127	1.976007	0.622096	0.244152
5	0.046184	4.128344	0.298231	0.862747	88.39129	2.015488	0.904675	2.204431	0.591772	0.603021
6	0.048463	4.575742	0.571910	1.174561	86.22257	1.834979	1.477933	2.566968	0.555604	1.019732
7	0.050091	4.820944	1.170193	1.372858	83.98622	1.718397	2.109574	2.894345	0.529558	1.397914
8	0.051288	4.898337	2.112864	1.441891	81.85150	1.639163	2.737549	3.121359	0.517105	1.680232
9	0.052220	4.860372	3.378227	1.419534	79.83199	1.581524	3.312849	3.241500	0.521821	1.852185
10	0.053011	4.757669	4.910986	1.379519	77.86473	1.536517	3.799947	3.272783	0.550379	1.927473
11	0.053760	4.629772	6.636548	1.411877	75.86010	1.500809	4.178903	3.240153	0.609236	1.932600
12	0.054539	4.501699	8.469165	1.604004	73.74231	1.475659	4.443190	3.166796	0.701835	1.895344
13	0.055400	4.384784	10.32277	2.025686	71.46680	1.466041	4.597501	3.071165	0.826922	1.838328
14	0.056377	4.279924	12.11935	2.720101	69.02502	1.479133	4.654340	2.966587	0.978929	1.776623
15	0.057487	4.181671	13.79588	3.700980	66.43856	1.522934	4.630671	2.861984	1.149299	1.718021
16	0.058734	4.082153	15.30778	4.955312	63.74915	1.604803	4.544849	2.762899	1.328313	1.664744
17	0.060116	3.974037	16.62927	6.449505	61.00769	1.730476	4.414349	2.672453	1.506653	1.615564
18	0.061624	3.852318	17.75125	8.136976	58.26526	1.903452	4.254377	2.592136	1.676497	1.567735
19	0.063245	3.715016	18.67772	9.965309	55.56699	2.124866	4.077273	2.522378	1.832039	1.518411
20	0.064967	3.563066	19.42179	11.88201	52.94895	2.393657	3.892508	2.462962	1.969558	1.465507
21	0.066774	3.399764	20.00203	13.83844	50.43724	2.706961	3.707011	2.413299	2.087188	1.408066
22	0.068653	3.230014	20.43952	15.79211	48.04868	3.060570	3.525653	2.372607	2.184542	1.346305
23	0.070592	3.059609	20.75568	17.70759	45.79221	3.449398	3.351733	2.340029	2.262310	1.281447
24	0.072580	2.894601	20.97086	19.55659	43.67060	3.867881	3.187408	2.314701	2.321888	1.215462
25	0.074606	2.740838	21.10356	21.31744	41.68215	4.310305	3.034031	2.295796	2.365076	1.150799
26	0.076662	2.603635	21.17000	22.97431	39.82207	4.771047	2.892410	2.282546	2.393848	1.090127
27	0.078742	2.487574	21.18413	24.51634	38.08365	5.244750	2.762973	2.274249	2.410200	1.036133
28	0.080840	2.396401	21.15764	25.93681	36.45915	5.726434	2.645891	2.270275	2.416036	0.991358
29	0.082950	2.332997	21.10027	27.23235	34.94041	6.211558	2.541149	2.270060	2.413119	0.958094
30	0.085070	2.299396	21.01995	28.40228	33.51929	6.696060	2.448590	2.273103	2.403032	0.938303

31	0.087195	2.296831	20.92312	29.44804	32.18798	7.176356	2.367949	2.278962	2.387172	0.933592
32	0.089325	2.325815	20.81496	30.37271	30.93912	7.649338	2.298863	2.287245	2.366757	0.945189
33	0.091456	2.386216	20.69957	31.18064	29.76593	8.112352	2.240890	2.297605	2.342832	0.973963
34	0.093588	2.477347	20.58020	31.87707	28.66222	8.563171	2.193520	2.309737	2.316288	1.020435
35	0.095719	2.598058	20.45938	32.46795	27.62239	8.999968	2.156183	2.323371	2.287881	1.084815
36	0.097848	2.746816	20.33906	32.95964	26.64139	9.421281	2.128260	2.338271	2.258245	1.167033
37	0.099975	2.921791	20.22071	33.35880	25.71470	9.825980	2.109098	2.354228	2.227911	1.266782
38	0.102098	3.120930	20.10545	33.67217	24.83826	10.21324	2.098020	2.371059	2.197321	1.383554
39	0.104218	3.342025	19.99406	33.90653	24.00845	10.58248	2.094335	2.388605	2.166840	1.516677
40	0.106333	3.582773	19.88710	34.06854	23.22200	10.93339	2.097352	2.406727	2.136770	1.665355
41	0.108443	3.840835	19.78493	34.16470	22.47597	11.26582	2.106387	2.425303	2.107358	1.828696
42	0.110548	4.113874	19.68774	34.20127	21.76772	11.57985	2.120775	2.444230	2.078802	2.005748
43	0.112647	4.399599	19.59559	34.18424	21.09485	11.87564	2.139877	2.463418	2.051264	2.195518
44	0.114738	4.695796	19.50847	34.11928	20.45517	12.15354	2.163084	2.482791	2.024871	2.397000
45	0.116823	5.000350	19.42625	34.01173	19.84668	12.41396	2.189827	2.502284	1.999723	2.609191
46	0.118899	5.311267	19.34878	33.86657	19.26756	12.65741	2.219573	2.521842	1.975895	2.831110
47	0.120967	5.626687	19.27584	33.68843	18.71610	12.88444	2.251836	2.541418	1.953443	3.061804
48	0.123026	5.944891	19.20717	33.48160	18.19075	13.09567	2.286170	2.560976	1.932404	3.300364
49	0.125075	6.264307	19.14250	33.25000	17.69006	13.29175	2.322174	2.580482	1.912803	3.545927
50	0.127113	6.583512	19.08154	32.99721	17.21266	13.47334	2.359492	2.599912	1.894652	3.797685
51	0.129140	6.901230	19.02399	32.72650	16.75729	13.64111	2.397806	2.619243	1.877950	4.054883
52	0.131156	7.216327	18.96953	32.44083	16.32276	13.79574	2.436840	2.638458	1.862691	4.316824
53	0.133159	7.527809	18.91786	32.14285	15.90795	13.93791	2.476353	2.657545	1.848858	4.582867
54	0.135149	7.834810	18.86868	31.83494	15.51182	14.06826	2.516142	2.676491	1.836431	4.852426
55	0.137126	8.136587	18.82169	31.51924	15.13337	14.18744	2.556031	2.695288	1.825381	5.124969
56	0.139090	8.432513	18.77661	31.19763	14.77168	14.29608	2.595877	2.713929	1.815677	5.400012
57	0.141038	8.722065	18.73317	30.87178	14.42585	14.39477	2.635561	2.732408	1.807284	5.677120
58	0.142973	9.004816	18.69110	30.54318	14.09505	14.48408	2.674986	2.750721	1.800163	5.955903
59	0.144891	9.280427	18.65016	30.21310	13.77850	14.56458	2.714079	2.768864	1.794273	6.236011
60	0.146795	9.548639	18.61013	29.88269	13.47545	14.63678	2.752781	2.786834	1.789571	6.517129

VARIANCE DECOMPOSITION OF LOGEX

Period	S.E.	ShockFFR	ShockGDP	ShockIP	ShockIMP	ShockEXP	ShockIF	ShockIN	ShockMS	ShockEX
1	0.035001	0.901178	0.010034	0.002235	1.381917	0.139677	0.108800	0.192378	1.434196	95.82958
2	0.059574	0.775968	0.364125	0.367194	1.140550	0.049266	0.213137	0.420597	1.302036	95.36713
3	0.078997	0.808636	0.854086	1.036146	1.065540	0.231109	0.135300	0.278129	1.788931	93.80212
4	0.095225	0.834319	1.309874	1.875158	0.996012	0.536895	0.307273	0.192073	2.463938	91.48446
5	0.109267	0.851156	1.687781	2.741009	0.931470	0.905647	0.668190	0.146517	3.199334	88.86890
6	0.121671	0.866495	1.976128	3.546854	0.877140	1.265596	1.126233	0.126671	3.895689	86.31919
7	0.132808	0.886680	2.197035	4.242680	0.836883	1.609510	1.606685	0.136394	4.506336	83.97779
8	0.142931	0.913307	2.373132	4.817333	0.810594	1.931313	2.067424	0.176239	5.009789	81.90087
9	0.152226	0.945848	2.524751	5.279028	0.797217	2.236513	2.487883	0.239062	5.406542	80.08316
10	0.160830	0.982367	2.665894	5.646238	0.795112	2.527910	2.862479	0.313993	5.706969	78.49904
11	0.168844	1.020630	2.805802	5.938989	0.802689	2.808562	3.192936	0.391103	5.926307	77.11298
12	0.176341	1.058546	2.949692	6.175536	0.818467	3.079504	3.484410	0.463465	6.080088	75.89029
13	0.183378	1.094509	3.100085	6.370654	0.841193	3.341114	3.742821	0.527354	6.182357	74.79991
14	0.189997	1.127464	3.257621	6.535637	0.869817	3.593075	3.973759	0.581455	6.244780	73.81639
15	0.196233	1.156871	3.421805	6.678702	0.903491	3.834989	4.181974	0.625942	6.276639	72.91959
16	0.202111	1.182594	3.591484	6.805672	0.941517	4.066498	4.371316	0.661723	6.285104	72.09409
17	0.207655	1.204784	3.765218	6.920583	0.983314	4.287464	4.544815	0.689965	6.275651	71.32821
18	0.212886	1.223764	3.941495	7.026210	1.028375	4.497965	4.704830	0.711832	6.252459	70.61307

19	0.217819	1.239949	4.118869	7.124460	1.076247	4.698289	4.853202	0.728365	6.218745	69.94187
20	0.222473	1.253779	4.296032	7.216657	1.126508	4.888874	4.991372	0.740455	6.177026	69.30930
21	0.226861	1.265688	4.471838	7.303739	1.178758	5.070258	5.120487	0.748847	6.129307	68.71108
22	0.230997	1.276082	4.645309	7.386383	1.232614	5.243026	5.241466	0.754164	6.077214	68.14374
23	0.234895	1.285326	4.815627	7.465091	1.287708	5.407774	5.355057	0.756930	6.022081	67.60440
24	0.238566	1.293741	4.982115	7.540241	1.343691	5.565079	5.461874	0.757591	5.965016	67.09065
25	0.242021	1.301607	5.144230	7.612115	1.400230	5.715482	5.562423	0.756526	5.906933	66.60045
26	0.245270	1.309165	5.301537	7.680927	1.457012	5.859482	5.657127	0.754065	5.848594	66.13209
27	0.248324	1.316619	5.453706	7.746833	1.513747	5.997525	5.746340	0.750490	5.790621	65.68412
28	0.251192	1.324142	5.600493	7.809947	1.570167	6.130007	5.830362	0.746045	5.733523	65.25531
29	0.253882	1.331877	5.741729	7.870344	1.626027	6.257276	5.909450	0.740942	5.677706	64.84465
30	0.256402	1.339943	5.877313	7.928073	1.681104	6.379636	5.983828	0.735357	5.623490	64.45126
31	0.258761	1.348438	6.007202	7.983160	1.735199	6.497348	6.053695	0.729444	5.571123	64.07439
32	0.260966	1.357438	6.131399	8.035617	1.788134	6.610636	6.119233	0.723330	5.520787	63.71343
33	0.263025	1.367002	6.249949	8.085448	1.839754	6.719692	6.180611	0.717122	5.472612	63.36781
34	0.264945	1.377177	6.362930	8.132648	1.889924	6.824678	6.237988	0.710909	5.426682	63.03706
35	0.266733	1.387991	6.470445	8.177213	1.938528	6.925732	6.291520	0.704764	5.383045	62.72076
36	0.268395	1.399466	6.572622	8.219142	1.985470	7.022970	6.341358	0.698746	5.341719	62.41851
37	0.269938	1.411607	6.669602	8.258434	2.030672	7.116491	6.387654	0.692902	5.302693	62.12994
38	0.271370	1.424415	6.761540	8.295100	2.074071	7.206377	6.430557	0.687269	5.265940	61.85473
39	0.272694	1.437878	6.848597	8.329154	2.115623	7.292699	6.470220	0.681878	5.231414	61.59254
40	0.273919	1.451978	6.930941	8.360623	2.155296	7.375521	6.506793	0.676748	5.199057	61.34304
41	0.275049	1.466689	7.008743	8.389542	2.193071	7.454895	6.540429	0.671895	5.168798	61.10594
42	0.276091	1.481981	7.082174	8.415955	2.228944	7.530873	6.571279	0.667329	5.140564	60.88090
43	0.277049	1.497814	7.151403	8.439920	2.262919	7.603500	6.599495	0.663056	5.114271	60.66762
44	0.277929	1.514146	7.216600	8.461501	2.295014	7.672822	6.625226	0.659076	5.089835	60.46578
45	0.278737	1.530931	7.277929	8.480775	2.325254	7.738884	6.648623	0.655390	5.067167	60.27505
46	0.279475	1.548116	7.335552	8.497828	2.353671	7.801732	6.669830	0.651993	5.046178	60.09510
47	0.280151	1.565648	7.389627	8.512751	2.380306	7.861413	6.688991	0.648877	5.026779	59.92561
48	0.280767	1.583469	7.440305	8.525647	2.405206	7.917980	6.706247	0.646037	5.008881	59.76623
49	0.281329	1.601520	7.487736	8.536623	2.428422	7.971485	6.721731	0.643461	4.992397	59.61662
50	0.281839	1.619742	7.532064	8.545792	2.450011	8.021988	6.735577	0.641139	4.977243	59.47644
51	0.282303	1.638071	7.573428	8.553273	2.470034	8.069550	6.747910	0.639060	4.963334	59.34534
52	0.282723	1.656448	7.611963	8.559186	2.488552	8.114238	6.758850	0.637211	4.950591	59.22296
53	0.283103	1.674809	7.647800	8.563656	2.505632	8.156123	6.768513	0.635580	4.938936	59.10895
54	0.283447	1.693094	7.681066	8.566806	2.521340	8.195280	6.777008	0.634154	4.928294	59.00296
55	0.283757	1.711245	7.711883	8.568763	2.535743	8.231790	6.784440	0.632919	4.918596	58.90462
56	0.284036	1.729203	7.740371	8.569649	2.548910	8.265735	6.790904	0.631862	4.909772	58.81359
57	0.284287	1.746912	7.766644	8.569588	2.560909	8.297203	6.796494	0.630970	4.901758	58.72952
58	0.284512	1.764321	7.790817	8.568699	2.571808	8.326285	6.801293	0.630230	4.894494	58.65205
59	0.284714	1.781378	7.812996	8.567099	2.581674	8.353072	6.805383	0.629629	4.887921	58.58085
60	0.284895	1.798039	7.833288	8.564898	2.590571	8.377662	6.808836	0.629156	4.881985	58.51556

Factorization: Structural