PUBLIC INVESTMENT, PRIVATE INVESTMENT AND ECONOMIC GROWTH IN ZAMBIA

By

BENJAMIN K. CHIBUYE

A Dissertation Submitted to the University Of Zambia in Partial Fulfilment Of The Requirements of the Degree Of Master of Arts in Economics

THE UNIVERSITY OF ZAMBIA

LUSAKA

2013

DECLARATION

I, BENJAMIN. K. CHIBUYE, declare that this dissertation:

a) Represents my own work;
b) Has not been submitted for a degree at this or any other University;
c) Does not incorporate any published work or material from another dissertation.

Signed:……..

Date :…….

APPROVAL

This dissertation of BENJAMIN K. CHIBUYE has been approved as partial fulfilment the requirements for the award of the degree of Master of Arts in Economics by the University of Zambia.

Signed: Date:

……. ……..

…… ……

…… ……..

ABSTRACT

This study investigated the impact of public investment on private investment and real output in Zambia, utilising time series data for the period 1980-2008. A Cointergrated Vector Autoregressive Model (VAR) was employed. Based on the existence of a long run Cointergrating relationship, the short run interactions were also investigated.

Public investment has been identified as an indispensable component of a developing countries strategy to achieve sustainable long term growth and economic development. The Zambian government has in turn placed an emphasis on public investment in its development agenda. However the exact impact of public investment in the context of the Zambian economy is unknown, owing to a severe lack of research in this area. This points to a critical information gap regarding the exact impact of public investment, warranting an empirical investigation.

The study reveals that public investment has a positive and significant effect on both private investment and real output in the long run. However the effects of inefficiencies and constraints inherent in the nature of public investment in Zambia would seem to be pervasive on the short run dynamics as well as the adjustment mechanism towards the long run. This is evident from the VECM, Granger causality and variance decomposition analyses, which all reveal a surprisingly weak causal effect of public investment on private investment and real output in the short run. These results imply that the beneficial effects of public on private investment and real output only accrue with a substantial time lag.

Thus public investment is encouraged as the government attempts to close the infrastructure gap, eliminate supply bottlenecks and provide an enabling environment for increased private investment and economic growth. Equally critical however are renewed attempts to improve the efficiency and management of public investment, as these will ensure that its positive benefits begin to accrue in the shortest possible time. Furthermore the finding of weak exogeneity of real output reveals that increased investments in human capital through improved education and health provision, as well as initiatives such as eliminating gender disparities and other initiatives contained in the MDG's may also be critical in the process of economic growth. The use of GDFI disaggregated by sector as it becomes available through the Economic Census may shed more light on the sector specific impacts of public investment.

DEDICATION

To my mother, Mrs. P.K. Chibuye and my father Colonel D.C. Chibuye.

ACKNOWLEDGEMENTS

Thanks go to my Lord and Saviour Jesus Christ, whose grace and faithfulness has enabled me to come this far in life. Lord, without you I am nothing. Deepest gratitude to my supervisor Dr. C. Mphuka, for his inspiration, guidance, understanding and inexhaustible patience. The following people who have inspired me immensely; Prof. V. Seshamani, Dr. F. Masiye, Dr. M. Lemba, Dr. P. Kabaso, Mr. C. Cheelo, Mr. G. Pollen, Mrs. S. Shalumba. To all my graduate and undergraduate lecturers for your input that has shaped my training as an economist.

The Bank of Zambia for the scholarship that has enabled me to pursue a Masters Degree at the University of Zambia. To all my former Masters classmates.

My mother, Mrs. P.K. Chibuye and my father Colonel D.C. Chibuye, who have given me so much more than life. My brothers Raymond, Dickson and my sisters, Phyllis, Brenda and Ngosa whose love and support has inspired me to excel in life. Lastly and certainly not the least, to so many people who I am unable to mention due to space limitations, I shall be eternally grateful

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

ADB : Africa Development Bank

GDFI : Gross Domestic Fixed Investment

GDP : Gross Domestic Product

GFCF : Gross Fixed Capital Formation

IMF : International Monetary Fund

JICA : Japan International Corporation Agency

MDGS : Millennium Development Goals

MOFNP : Ministry Of Finance and National Planning

OECD : Organization for Economic Cooperation and Development

OLS : Ordinary Least Squares

PPP : Public Private Partnerships

SNDP : Sixth National Development Plan

UNDP : United Nations Development Programme

UNECA : United Nations Economic Commission for Africa

VAR : Vector Autoregressive Model

VECM : Vector Error Correction Model

ZDA : Zambia Development Agency

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Although Public investment continues to be an integral part of the Zambian economy, its benefits cannot be automatically assumed. This is owing to the fact that in reality, public investment can either stimulate or impede an economy's growth. This is due to its two distinct and opposing effects on private investment: the crowding-in and crowding-out effects. The ultimate impact of public investment on the economy can thus vary depending on which of the two effects is dominant. The question of whether public investment crowds-in or crowds-out private investment and thus its net effect on the economy though critical, has however remained virtually unexplored in the Zambian context. The importance of studies investigating the impact of public investment on the economy cannot therefore be overemphasized. This study sought to investigate the impact of public investment on private investment and real output in Zambia.

The potential role of public investment in the growth process has been argued to be particularly significant in a landlocked developing country such as Zambia. This is because geographic disadvantages and poor infrastructure result in higher indirect costs of production, undermine Zambia's competitiveness, limit employment creation and serve as a major constraint to growth. These disadvantages can in turn be offset through public investment (Lanchovichina and Lundstrum, 2008). Under such circumstances, public investment is argued to crowd-in private investment. This is because public investment provides those goods and services essential to the efficient participation of the private sector in the economy and enhances its productivity by eliminating transportation, communication and other bottlenecks (Nasmi and Ramirez, 1997).

However public investment financed through excessive public borrowing, excessive money creation or that undertaken by inefficient state owned enterprises can act as a deterrent to private investment and long term economic growth. Under such circumstances, public investment crowds-out private investment (Ibid).

The crowding-out hypothesis has however been argued to be based on a series of assumptions that are implausible in the context of developing countries. Theoretically, the crowding-out proposition follows from the hypothesis that financial markets are in equilibrium. However if

this is not the case, then the existence of supply side bottlenecks and (or) demand constraints greatly affects the relevance of the crowding-out hypothesis. The existence of such constraints in developing countries implies that the relevance of the crowding-out hypothesis and its ensuing policy prescriptions is highly questionable in developing countries (Roy and Weeks, 2004).

Surprisingly, the empirical literature investigating the impact of public investment on private investment and real output is however inconclusive as to whether the two types of investment are complimentary or substitutable. Whether public investment leads to tangible benefits in terms of higher growth is thus also a subject of controversy.

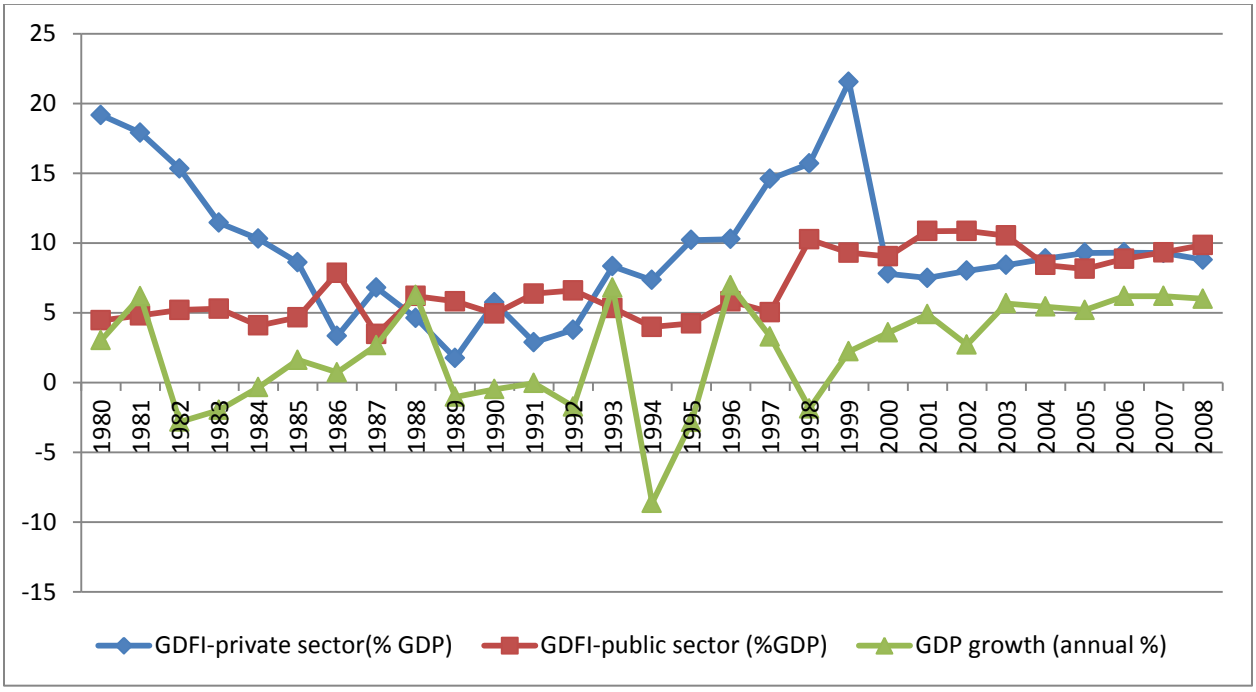
Empirical results differ depending on the methodology employed. Studies based on the production function and growth approaches have been particularly criticized in the literature due to various econometric problems which are discussed below. The VARS approach, employed in this study has been argued to overcome these problems.

Therefore before a developing country can allocate scarce public resources to investment in any sector, at the expense of other pressing developmental demands, empirical investigation of the impact of public investment on the economy is particularly critical.

This study utilised time series data covering the period 1980-2008 to investigate the impact of public investment, as this constituted the longest time period for which disaggregated data was available. Public and private sector GDFI (GFCF) were be used as measures of public and private sector investment respectively, while real GDP was used as a measure of real output. A Cointegrated Vector Autoregressive Model (VAR) was employed. Contingent on the existence of a long run Cointergrating relationship among the variables, a Vector Error Correction Model (VECM) was employed. The direction of causality was investigated through Granger causality.

To shed light on the impact of public investment in Zambia, figure 1 below present's an overview of trends in public and private investment measured by public and private sector GDFI respectively and GDP growth over the period 1980-2008.

Figure 1: Overview of Trends In Public, Private GDFI (%GDP) and GDP Growth in Zambia: 1980-2008



Source: Own calculations based on World Bank Africa Development Indicators (2011)

In analysing the relationship between public and private investment shown in figure 1, it is evident that in the period between 1980 and 1985, while public investment remains rather stable around the 5% level, private investment falls consistently throughout this period. However for the period 1986 to 1992, high levels of public investment appear to correspond with low levels of private investment and vice versa. In the period 1993 to 1998, increases in public investment, though less pronounced, seem to correspond to increases in private investment. For the period 2000 to 2008, public and private investment again seem to be inversely related, with high levels of public investment corresponding to low levels of private investment and vice versa.

The relationship between public investment and the growth rate of real GDP for the period 1980 to 2000 seems rather complex based on figure 1, due to the volatility of the growth rate during the period. However between 1982 and 1985, the stability in public investment corresponds to a growth in GDP. Between 1986 and 1998, fluctuations in public investment would seem to correspond to fluctuations in the growth rate of GDP. After 1998, the increased levels of public investment would seem to correspond with the strong growth in GDP.

1.2 Statement of the Problem

Analysis of the above trends in public, private investment and real output growth in the Zambian economy is inconclusive as to the exact impact of public investment. The impact of public investment on private investment and real output growth would seem to vary from positive in some periods, to negative, while the two would also seem to be unresponsive in other periods.

What we would expect is for the impact of public investment to be very definite and precise-for periods of increasing public investment to correspond to increased private investment and real output growth and vice versa. This is because Zambia, like other developing countries is characterized by low levels of public investment which constitute a significant bottleneck to private investment and economic growth. Development experts including the IMF (2004), World Bank (1994), UNECA (2011) and the Commission on Growth and Development (2008) thus hold that increased public sector investment should have an unambiguous positive effect on both private investment and real output through the alleviation of the above constraint, while declining public investment should have the opposite effects.

This reveals the existence of a clear discrepancy, on one hand the expectation of a definite and precise impact of public investment on private investment and real output. On the other, evidence based on analysis of the trends pointing to an inconclusive impact of public investment on private investment and the real output of the Zambian economy.

This implies a critical information gap as regards the exact impact of public investment on private investment and real output of the Zambian economy. Thus an investigation into the exact nature of the impact of public investment in the Zambian context was necessitated to fill this information gap.

1.3 General Objective

The aim of this study was to investigate the impact of public GDFI on both private GDFI and real output of the Zambian economy over the period 1980-2008.

1.3.1 Specific Objectives

1. To determine the impact of public GDFI on private GDFI.
2. To determine the impact of public GDFI on real output.

1.4 Hypotheses

1. Public GDFI has a positive effect on private GDFI.
2. Public GDFI has a positive effect on real output.

1.5 Significance of Study

This study constitutes an important contribution to the empirical literature investigating the impact of public investment. This is because it fills an information gap as regards the impact of public investment on the Zambian economy. Furthermore, the study goes a long way towards settling the controversy existent in the empirical literature as regards the impact of public investment on private investment and real output.

Also, with a premium having been placed on public investment as an integral part of Zambia's national development agenda, the results of this study have significant practical policy applicability and relevance. For instance, to achieve the objectives of the SNDP, including the acceleration of: infrastructure development, economic growth and diversification, rural investment and poverty reduction, the government committed to undertaking public investments in key economic infrastructure such as feeder roads, water canals, tourist access roads and electricity generation and access (MOFNP, 2011). As such critical public investments are undertaken, it is important for policymakers to be well informed as to their exact impact on the economy. This can only occur by undertaking empirical investigation.

At the heart of Zambia's investment promotion and economic diversification strategy involves the encouragement of Public-Private Partnerships (PPP's) in the development of key socio-economic infrastructure and the delivery of social services. The role of the public sector in this regard involves the provision of an enabling environment for private investment (ZDA, 2011). A critical determinant of the success of this investment strategy involves public policy makers having accurate knowledge as regards the impact of public investment, which this study provides.

1.6 Scope of the study

This study utilised time series data covering the period 1980-2008. This represented the longest time period for which data on GDFI, disaggregated by the public and private sector was available.

1.7 Organisation of the Study

The study is divided into six chapters. Chapter one introduces the study, chapter two presents a brief analysis of trends in the two types of investment and real output overtime, chapter three reviews the relevant theoretical and empirical literature, chapter four outlines the methodology and estimation techniques, chapter five presents an analysis of the results, while chapter six presents the main findings, gives recommendations for policy makers and concludes the study.

CHAPTER TWO

2.1 TRENDS IN PUBLIC INVESTMENT, PRIVATE INVESTMENT AND REAL OUTPUT IN ZAMBIA

This chapter analyses trends in public investment, private investment and the growth rate of real output over the period 1980-2008. The importance of undertaking this process is to gain a better understanding of the nature of public investment and its potential impact on private investment and real output over the relevant period. Insights gained from this process will provide very valuable information for the empirical analysis to follow, which is based on the identified problem above.

For the purposes of shedding light on the impact of public investment on private investment and the rate of GDP growth, table 2.1 shows trends in public investment, private investment and the growth rate of real GDP in five year averages over the period 1980-2008.

Table 1: Trends In Public and Private GDFI (% GDP) and GDP Growth: 1980-2008

	1980-84	1985-89	1990-94	1995-99	2000-04	2005-08*
GDFI-public sector (%)	4.8	6.4	5.4	6.9	9.9	9.0
GDFI-private sector (%)	14.8	5.0	5.6	14.5	8.1	9.2
GDP growth (%)	0.8	2.1	-0.8	1.6	4.5	5.9

Source: Own calculations based on World Bank Africa Development Indicators (2011) * Only four years

Between the periods 1980-84 and 1985-89, the public investment share of GDP rose by 1.6 percent. The private investment share of GDP however fell dramatically by 9.8 percent. The growth rate of GDP rose by 1.3 percent over the same period.

Between the two five year periods 1985-89 and 1990-94, public investment increased by 1 percent. Private investment also increased by 0.6 percent, while GDP growth fell by 2.9 percent.

Between the periods 1990-94 and 1995-99, public investment increased by 1.5 percent. Private investment also increased by 8.9 percent. Similarly, the growth rate of GDP also increased by 2.4 percent over the corresponding periods.

Analysing the two five year time periods 1995-99 and 2000-04 further reveals that while public investment increased by 3 percent, private investment actually fell by 6.4 percent. The growth rate of GDP increased by 2.9 percent.

For the two periods 2000-04 and 2005-08, public investment fell slightly by 0.9 percent. Private investment also increased 1.1 percent over the corresponding period. The growth rate of GDP also increased by 1.4 percent over the same period.

Table 2 below summarises changes in public investment, private investment and the growth rate of GDP between respective five year time periods.

Table 2: Trends In Changes in Public and Private GDFI (% GDP) and GDP Growth: 1980-2008

	1980-84 and 1985-89	**1985-89 and 1990-94**	**1990-94 and 1995-99**	**1995-99 and 2000-04**	**2000-04 and 2005-08***
Change in GDFI-Public sector	1.6	1.0	1.5	3.0	-0.9
Change in GDFI-Private sector	-9.8	0.6	8.9	-6.4	1.1
Change in GDP growth (%)	1.3	-2.9	2.4	2.9	1.4

Source: Own calculations based on World Bank Africa Development Indicators (2011) * Only four years

2.2 POSSIBLE EXPLANATIONS FOR THE OBSERVED TRENDS

Possible reasons for the above observed trends can be postulated. The sharp decline in private investment and GDP growth as well as the low levels of public investment in the 1980's could be related to the end of the copper boom, which was preceded by a decline in the price of Zambia's main export and increases in the price of crude oil on the international market in the mid to late 1970's. These factors in the context of highly centralized economic system favouring public sector activity adversely affected private investment and growth of the Zambian economy and brought about severe economic hardship (ADB/OECD, 2003).

The Structural Adjustment Programs (SAP's) advocated by the IMF and World Bank, were introduced in Zambia in the early 1990's. They involved market liberalization, deregulation,

abolition of exchange rate controls, deregulation of interest and foreign exchange markets, removal of price controls as well as a program of privatization of many state owned parastatals. These reforms aimed to transform the Zambian economy from a highly regulated command and control economy into a liberalized economy encouraging private sector activity through the provision of an enabling environment by the public sector (MOFNP, 2010). The increase in private investment noted in the mid to late 1990's and the low levels of public investment observed for most of the 1990's could thus possibly be due to the effects of the SAP's that aimed at encouraging greater private sector participation and also reducing public sector participation in the economy.

The sharp decline in private investment noted between 1999 and 2000 could have possibly been due to a decline in the price of copper in the late 1990's. This was coupled with forecasts of low copper prices in the early part of the new millennium and led to increased uncertainties about the prospects of the mining sector. A fall in investor confidence in the future of the Zambian economy and thus the decline in private investment came as no great surprise. This is clearly evident from the pulling out of Anglo American Corporation, a major shareholder in the Konkola Copper Mines (KCM) the largest mining company in Zambia at the time in 2002 (ADB/OECD, 2003).

Beginning in 2002, the Zambian economy received several positive boosts. Among these include the rebounding of the mining sector mainly due to a recovery in copper prices, a stable macroeconomic environment, the renewed fiscal discipline and the fight against corruption (Ibid). These factors can be linked to the increase in private investment and GDP growth noted in figure 1.

There could also be political economy reasons for the above observed trends. Immediate claims for current spending-to pay wages, benefit politically powerful groups, or protect the population against declines in consumption-could take away resources from public investment that is important for the long term growth and development (Commission on Growth and Development, 2008). This can help to explain the low levels of public investment during the 1980's and most of the 1990's.

The analysis of trends undertaken above reveals a complex relationship amount the variables. In fact it is the complexity of the relationship observed and the inability of the trend analysis to

provide a concrete relationship that justifies the undertaking of an empirical analysis utilising robust econometric techniques in order to unlock the impact of public investment on private investment and real output in the chapters below. However, before the empirical analysis is undertaken, the following chapter provides a review of the relevant theoretical and empirical literature underlying investigations of the impact of public investment.

CHAPTER THREE

LITERATURE REVIEW

Investment in the literature is usually taken to refer to increases in the capital stock (Reungsri, 2010). A distinction is made in the literature between investments in fixed capital, investments in human capital and purchases of financial assets such as stocks and bonds to which usage the term investment is at times attached. A further distinction is made between increases in the stocks of public and private capital in the economy.

Studies investigating the impact of public investment have focused mainly on developed countries owing to widely available and better quality investment data. Fewer studies have focused on developing countries mainly due to limitations as regards data availability and quality. However Straub, (2008) argues that it is in developing countries where infrastructure problems are more acute and policy lessons critically needed.

Of the relatively few studies including developing countries, most include Zambia as one among several African countries analysed; (Khan, 1996; Devarajan et.al, 1996; Anwer and Sampath; 1999). However, Anderson et.al (2006) argue that due to the importance of public investment to an economy and possible heterogeneity in public investment across countries, assessment of its impact should be done on a country by country basis, considering the structure of the economy of each country.

Studies exist particularly focusing on the relationship between public investment and real output or its growth across various regions and countries. Fewer studies have however focused on the public, private investment, real output relationship.

The literature investigating the impact of public investment is divided into distinct categories depending on the particular model and the measure of public investment utilised. The various measures and models used in the literature are closely linked and these are discussed in turn and follow a discussion of the main theoretical approaches used in investigating the impact of public investment.

3.1 Theoretical Literature Review

In the literature analysing the impact of public investment on real output of an economy, a Neoclassical economy is assumed (Ghali, 1998; Badawi, 2003; Ghani and Din, 2006; Brinca, 2006; Naqvi, 2002). This approach, discussed below, allows an investigation of the underlying relationship between changes in the public and private stocks of capital i.e. public and private investment.

3.1.1 Neoclassical Growth Theory

$$Y = Af(L, K_{p,} K_g) \qquad (3.1)$$

Where;

A represents technology or multifactor productivity,

Y represents real output,

K_p represents the private capital stock

K_g represents the public capital stock,

L represents the stock of labour.

It is assumed that,

$$\left(\frac{\partial Y}{\partial L}\right) > 0, \left(\frac{\partial Y}{\partial K_p}\right) > 0 \; and \; \left(\frac{\partial Y}{\partial K_g}\right) \gtreqless 0,$$

$$\left(\frac{\partial^2 Y}{\partial L^2}\right) < 0, \left(\frac{\partial^2 Y}{\partial K_p^2}\right) < 0 \; and \; \left(\frac{\partial^2 Y}{\partial K_g^2}\right) < 0,$$

In Neoclassical Growth theory, both the stocks of labour and capital enter the production function as factors of production as well as a time varying technology or multifactor productivity variable distinct from labour and capital. A distinction is often made between capital stocks of the public and public sectors respectively. The stock of public capital can either enter the production function solely as a third factor of production, or both as a third factor of production and as a determinant of multifactor productivity. Increases in the stocks of labour and private capital (private investment) both lead to increases in output, while increases in the public capital stock (public investment) can have potentially ambiguous effects on output.

Neoclassical theory also assumes constant returns to scale, diminishing returns with respect to each input and positive elasticity of substitution between inputs. Technological progress is however determined exogenously to the model, but allows greater options for input combinations to improve efficiency, leading potentially to a higher level of economic growth.

Despite relatively more predictable outcomes arising from increases in the stock of private capital (private investment) increases in the stock of public capital (public investment) can have ambiguous effects on output. The ambiguity arises from the fact that increases in the stocks of public and private capital can interact in numerous distinct ways.

Specifically, if public and private investments are complementary then public investment will unambiguously increase output both directly and indirectly by way of the increase in output resulting from an increase in private investment. However if public and private investment are substitutes, then it is possible that any positive effects of increased public investment on output can be overshadowed by the fall in output resulting from the decreased private investment.

If public and private investments are independent, then the two types of investment are not related. In this case, public investment will have only its direct impact on real output.

Thus a crucial issue involves the impact of public investment on private investment, which can take the form of crowding-in or crowding-out

3.1.2 Crowding-in/Crowding-out Hypothesis

If public and private investments are complementary, then public investment crowds-in private investment. Thus attempts to add to the stock of public capital through public investment will lead to increases in private investment as the private sector seeks to increase its stock of capital.

The crowding-in effect can arise in numerous ways, for instance public investment in infrastructure such as roads, highways, education, sewer and water systems and electricity generation capacity has been argued to reduce costs of production for the private sector. This can occur by way of reducing logistic costs and(or) allowing the substitution of high cost/less efficient investments for lower cost/more efficient investments, for example substitution of investment in electricity generators for more productive machinery investments. In turn this reduction in private sector costs raises the marginal productivity of private capital, raising the expected rate of return on private capital and thus leading to increased private sector investment

due to increased profit expectations. For instance a better road network may reduce the costs associated with the private sector construction of a new factory or the transport of heavy equipment (Boopen and Khadaroo, 2006).

The increase in national income that arises through public investment can also crowd-in private investment. This is because the increase in national income stimulates economic growth which can in turn induce the private sector to increase investment soas to exploit any resulting profit opportunities (Reungsri, 2010). This is in line with the accelerator theories of investment.

If public and private investments are substitutable, then public investment crowds-out private investment. In this case attempts to increase the stock of public capital through public investment inadvertedly lead to a reduction in private investment as the private sector decides to reduce its capital stock.

If crowding-out is present, then any potentially positive effects of public investment on private investment can be overshadowed by its adverse effects. This can be the case where increased public investment is financed through an increase in distortionary taxation. The distortionary taxation may provide an incentive for tax evasion or may reduce the expected rate of return and profit expectations from any investment projects. A similar effect can also arise where public investment is financed through increased borrowing from domestic financial markets. This reduces the flow of investible funds available for private sector investment and can also lead to increased costs of borrowing through higher interest rates in the domestic economy. Irrespective of the exact channel though which this occurs the net result will thus be that public investment will have an adverse effect on private investment leading to a crowding-out effect (Boopen and Khadaroo, 2006).

However, Agenor et.al (2005) argue that the direction and strength of the crowding-in and crowding-out effects may very well vary and depend on the specific environment in which private investors operate. As such the relationship between public and private investment may be one of substitution or crowding-out in the short run and one of complementarity or crowding-out in the long run, depending on the productivity of the investment. Thus use of dynamic modelling to study the relationship between public and private investment is particularly advantageous.

In the literature investigating the impact of public investment, the main contentions are less of a theoretical nature but are more empirical in nature. The main empirical issues revolve around the

measure of public investment chosen and the empirical model used to analyse its impact. These are discussed in turn below.

3.2 Empirical Literature review

3.2.1 Approaches to Measurement of Public Investment

Various approaches to the measurement of public investment are existent in the literature. These include the stock of public capital (physical indicators), public capital expenditure, public investment in human capital and public infrastructure investment (GDFI).The evolution of various measures can be linked to the evolution of the models used to investigate the impact of the public investment on the economy. The various models (VAR, production function, growth and cost function models) are discussed in detail below. However each particular model has been linked to a particular approach(s) to measurement.

The earliest studies investigating the impact of the public sector on the economy utilised the stock of public capital in the economy (Tatom, 1991; Merriman, 1991). Studies utilising this measure generally fall under the production function and cost/ profit function models. These studies use physical indicators such as telephone density, household electrification, paved road length and electricity generation capacity as proxies for capital stock. Results based on this measure reveal inconclusive effects of public capital on real output, productivity or its growth rate.

This arises because studies based on physical indicators of public capital can be particularly problematic, as noted by Calderon and Serven (2008). Public capital investment is a multidimensional concept, comprising services that range from transport to clean water. Thus taking a single physical indicator, such as telephone density to proxy for capital omit other indicators of capital investment and this may lead to invalid inferences owing to omitted variable biases.

Other early studies utilise public capital expenditure, or its GDP share (Aschauer, 1989; Devarajan et.al, 1996; Dalamagas, 1995). These studies also reveal inconclusive effects of public investment on real output. This is attributed to the fact that the link between observed public capital expenditure and the accumulation of infrastructure assets or the provision of infrastructure services may be weak, owing to inefficiencies in public procurement and outright corruption (Calderon and Serven, 2008).

In the case of measurement of public investment via investment in human capital (education and health expenditures), any constraints to private investment posed by human capital can easily be overcome, by the use of say expatriate labour, serving to weaken any links between such public investment and private investment. Numerous studies have also established that it is possible to make inferences concerning the productivity of human capital based on infrastructure investments (such as GDFI). For instance studies such as Galiani et.al (2005) have established that better infrastructure induces improvement in both education and health, in the short run by making the existing stock of human capital more effective. In the long run this effect induces additional investment in human capital.

Another measure used in the literature is public investment in infrastructure (GDFI). It comprises the monetary value of all additions to the stock of fixed capital in a given time period. This measure is utilised in the most recent studies following the VAR model (Khan 1996; Ghali, 1998; Badawi, 2003; Ghani and Din, 2006; Brinca, 2006; Naqvi, 2002). These studies disaggregate GDFI by the public and private sectors. However a problem of such an approach is that of data availability. Data on public and private fixed investment is rarely disaggregated for most countries. In those cases where it is disaggregated, it may not be available over very long time periods. However time periods suitably close to 30 years are taken as sufficient in the literature (Badawi, 2003; Naqvi, 2002; Brinca, 2006; Ghani and Din, 2006).

Another problem associated with GDFI is that of difficulties of measuring depreciation. There is a discrepancy between how private firms and the public sector measure depreciation of fixed assets. As such they are usually reported as gross domestic fixed investments and most studies use them in this manner (IMF, 2004). However this level of disaggregation has the important advantage of allowing estimation and comparison of the impacts of the two types of investment on the economies real output and also sheds light on the important question of whether or not public investment crowds-out private investment.

Measuring investments by the public and private sector by GDFI of the public and private sector respectively has inherent advantages over the other measures of investment as it is produces the most consistent results (Brinca, 2006). This is due to several reasons;

Firstly, fixed investment is argued to have the greatest potential impact on real output relative to other types of investment. Thus taking GDFI (of the public and private sectors) as measures of

investment in an empirical study allows the determination of whether such investments are having, in reality, the strong impacts on output that they are expected to have in theory (World Bank, 1994).

Secondly, it is argued that there is a close theoretical link between the public and private sectors fixed investment decisions. It is argued that private sector fixed investment is dependent on public sector fixed investment. This is because public sector fixed investments, particularly those with a public good nature, reduce the marginal costs of private fixed investment, increasing its marginal productivity and in turn increasing expected returns or profits ceteris paribus. Thus measuring public and private investments by public and private sector GDFI allows the determination of whether this theoretical link actually exists in practice (Ghali, 1998).

Thirdly, GDFI by the public and private sectors is able to capture the multidimensional nature public of investment. This is because GDFI not only captures expenditure on economic infrastructure such as roads and bridges, but also includes expenditure on social infrastructure such as schools and hospitals (Brinca, 2006). It is thus more preferable to physical indicators of capital stock.

Therefore as highlighted above, GDFI has inherent advantages over other measures of public investment. In addition to the above advantages, GDFI is also the most relevant measure in the context of a developing country such as Zambia owing to the availability of data for sufficiently long time periods relative to the other measures. Coupled with the objective of this study to examine the public investment, private investment and real output relationship, public and private sector GDFI were thus utilised as measures of public and private investments respectively.

Having discussed the various approaches to the measurement of public investment used in the literature, the various approaches to modelling the impact of public investment will now be discussed.

3.2.2 Approaches to Modelling the Impact of Public Investment

In the literature, studies investigating the impact of public investment on the economy are broken down into four distinct categories, depending on the type of empirical model employed. The alternative models are; The Vector Autoregressive model; The Production function model; The

Cross sectional growth model and The Cost or profit function model. These models and their inherent strengths and weaknesses are discussed in turn below. A choice of the most appropriate model used in the study is then made.

3.2.2.1 Vector Autoregressive (VAR) Model

This approach explores the time series properties of the public, private investment and real output relationship. It also accounts for the dynamic nature of the investment process without imposing a causal structure a priori. This approach is thus argued to adequately capture the nature of the investment process and to be well suited to time series data (IMF, 2004). By definition, the VAR model has very loose theoretical foundations, owing to the fact that it is not a structural model derived from a specific economic theory. Despite this fact, most studies utilising this model in the literature link it to the neoclassical growth as well as crowding in/crowding out theories. The neoclassical theory of crowding in/crowding out is also known as the neoclassical loanable funds theory. The grounding of the model on these two theories in the literature is argued to be appropriate as it allows the simultaneous investigation of how public investment affects both private investment and real output (Pereira and Andraz, 2010).

The VAR model is the latest and most preferred type of modelling in the literature and it involves a dynamic multi-variate, multi-equation analysis of the impact of public investment on the economy. Studies utilising VAR modelling (Ghali, 1998; Badawi, 2003; Ghani and Din, 2006; Brinca, 2006; Naqvi, 2002) have been carried out at national level and utilise public and private sector GDFI as measures of public and private investment respectively. VAR modelling has been argued to produce the most consistent and conclusive results as the regards the impact of public investment because it is best suited to deal with issues of reverse causality, non stationarity, endogeneity as well as the dynamic nature of the investment process. Relative to other competing models, VAR modelling also imposes less restrictive structural modelling and data requirements. Owing to these factors it is particularly suited to empirical investigations in developing countries.

Badawi (2003) investigated the impact of public investment on private investment and economic growth in Sudan for the period 1970-1998 using VAR modelling. Variables used in the study included real output, private investment, public sector investment , banking sector credit to the

private sector and the lending rate on banking sectors advances to the private sector. Public and private investments were measured as real GDFI (GFCF) by the public and private sector respectively. The Augmented Dickey-Fuller (ADF) test revealed that all variables were non stationary and were integrated of order one. The order of the VAR or lag length used was set to two based on various lag length selection procedures. The Cointergration rank was determined based on Johansen's procedure and revealed the existence of at most one Cointergrating vector.

Results of Badawi (2003) suggest that both private and public investment had a positive significant long run impact on real output. However the impact of private investment on real output was found to be more pronounced than that of public investment, owing to the larger elasticity of output with respect to private investment, than that reported for public sector investment. Public investment was also revealed to have had a negative impact on private sector investment, implying that the impact of crowding out categories of public sector investment had been large enough to offset any crowding in effects. Granger causality test results indicated that public and private investment and real interest rate Granger caused real output, while real output also Granger caused private investment and real interest rate, but not public investment and real credit to the private sector. Thus a bi-directional relationship was identified between private investment and real output, and between real output and real interest rate while public investment was revealed to Granger cause growth.

Badawi (2003) also estimated the short run dynamics of the stationary VAR system, using an Error Correction Model. The system was estimated via unrestricted OLS. Results indicated that private investment had a significantly positive short term impact on growth, while public investment had significantly negative effects on growth. Further, public investment was found to have a significantly negative effect on private investment.

Badawi (2003) further noted that given the positive effect of private investment on growth revealed by the study, the key policy issue involved how to achieve a sustainable high private investment share of GDP that would facilitate both economic growth and poverty reduction. This in part was argued to rest on tailoring a suitable, enabling macroeconomic environment to facilitate the required increases in private investment expenditure.

3.2.2.2 Production Function Model

This model focuses on the relationship between real output and the stock of public capital. It has its theoretical foundations within the framework of neoclassical theory of economic growth and involves the estimation of an aggregate neo-classical production function, with specific interest in the impact of the public capital stock. Public capital is viewed as either an input entering the production function in its own right, or as a factor improving the productivity of other factor inputs, such as private capital (IMF, 2004). This approach was widely utilised in the early years of the investigation of the impact of public capital specifically in developed countries. In recent years, this approach has however received less attention due to inherent weaknesses highlighted below.

Aggregate output is regressed on various independent variables and the effects of public investment are measured by the coefficient of the public capital stock variable in the regression, interpreted as the elasticity of output with respect to public investment (Pereira and Andraz, 2010). This approach however focuses solely on the impact of public capital on output, while ignoring the equally important effect of public capital on private capital.

The production function model has been applied in both national as well as regional/cross country studies;

National Level Production Function Model Studies

National level studies utilising the production function approach are largely undertaken for developed countries due to the stringent data requirements needed for the estimation of single structural production functions (Pereira and Andraz, 2010).

In a seminal paper, Aschauer (1989), using time series data for the U.S economy for the period 1945-1985, found that public capital had a positive effect on output. However his estimate of the marginal product of capital obtained, has been argued to be implausibly high (Calderon and Serven 2008).

However Tatom (1991) using time series data, also for the U.S. economy covering the period 1949-1989 found that public capital had insignificant effects on real output of the US economy.

Kavanagh (1997) using time series data for the Irish economy for the period 1958-1990 found that public capital expenditure had insignificant effects on real output.

Cross Country/regional Production Function Model Studies

Cross country studies following the production function approach and utilising panel data have been widely undertaken for developed countries. This has been attributed to the greater availability of higher quality investment data. Studies incorporating developing countries are less common owing to the less readily available and lower quality investment data (Pereira and Andraz, 2010).

Kelejian and Robinson (1997) analyse the impact of public capital expenditure on output for a panel of 48 U.S states for the period 1970-1986 using a Cobb Douglas production function specification in logs. Their findings suggested that public capital had insignificant effects on output. However Evans and Karras (1994) find a negative and significant effect of public capital expenditure on real output for the panel of the same 48 U.S states, over the same time period, but using a Cobb Douglas production function specified in log difference form.

Calderon and Serven (2003) in a study based on a panel of 101 developed and developing countries, covering the period 1960-1997 find a positive relationship between public capital investment and output per worker.

Devarajan et.al (1996) analyse the impact of public capital and current expenditures in a panel of 43 developing countries covering the period 1970-1990. Results reveal that public capital expenditure had a negative effect on growth.

La ferrara and Marcellino (2000) using Italian regional panel data for the period 1970-1994 find a negative effect of public capital on real output.

De La Fuente and Vives (1995) used panel data for 17 Spanish regions covering the period from 1981 to 1990. Results revealed a positive effect of public capital on output.

National level and Cross country/regional studies utilising the production function approach produce inconclusive results as regards the impact of public investment on the economy. This is clearly evident from the variability of results obtained based on the studies reviewed above. This is attributable to the numerous weaknesses of the production function model, such as inability to adequately deal with identification problems, non stationarity of data, dynamic (non-contemporaneous) effects of investment and autocorrelation. These are discussed in detail further

below. The use of public capital expenditure and physical indicators of the capital stock also contributes to the lack of consensus in the results of studies utilising this model.

3.2.2.3 Growth Model

This approach focuses on the growth rate of output, rather than the level of output and essentially involves a process of growth accounting. This model has its theoretical foundations in the Endogenous theories of growth which place a premium, not only on physical capital but also human and knowledge capital. It examines the role played by public investment in explaining differences in cross-country or cross regional growth (IMF, 2004). The model has mainly been applied to cross country panel studies.

Cross Country Growth Model Studies

The growth model is applied in cross country studies accessing the impact of public investment. This model also reveals inconsistencies as regards the impact of public investment, with negative positive and (or) insignificant results obtained. This can be attributed to weaknesses inherent in both the model itself, as well as weaknesses in the measures of public investment utilised in these studies as highlighted above.

Mas et.al (1996) investigated the impact of public capital on growth on a panel of 17 regions of Spain covering the period 1955 to 1991. Results indicated that public capital had an insignificant effect on the growth of GDP per capita.

Calderon and Serven (2008) assessed the impact of public capital investment on growth and economic development for a panel of Sub Saharan African countries, covering the period 1960-2005. Their results indicated that such investment contributes positively towards growth and equality across Africa.

Easterly and Rebelo (1993) investigated the impact of public capital on growth for a panel of 100 developed and developing countries covering the period 1970-1988. Results revealed that public capital investment has insignificant effects on per capita GDP growth.

La Ferrara and Marcellino (2000) also used the growth model to estimate the impact of public capital investment on the growth of per capita output using Italian regional panel data for the

period 1970-1994. Results revealed a positive effect of public capital investment on the growth of per capita output.

3.2.2.4 **Cost / Profit Function Model**

This approach uses cost or profit functions to assess whether public investment lowers business costs, or increases profits (IMF, 2004). The approach fully accounts for the direct effect of public investment and its indirect effects on private input demands. The signs of these indirect effects on private inputs provide information about the nature of the relationships between inputs (Pereira and Andraz, 2010).

3.2.3 Weaknesses associated with the various approaches to Modelling the Impact of Public Investment

3.2.3.1 Weaknesses associated with the VAR Model

The Cointegrated VAR model is affected by inherent theoretical assumptions concerning the ordering of the variables in the model. Simply put, assumptions concerning the most exogenous variable that is the source of shocks in the model (this variable comes first in ordering) have to be based on sound and accurate theoretical foundations. This poses a potential weakness associated with erroneous causation in cases where the variable assumed to be the source of shocks (the most exogenous in the model) is found to actually be endogenous.

However, Brinca 2006 argues that in a VAR model investigating the impact of public investment, the public investment variable is most likely to be the source of an initial shock to the system and as such the most exogenous variable that should be ordered first. This arises because it is essentially a policy variable determined in the public sector budget formulation process. Once the level of public investment is determined in the government budget, other variables such as private investment and domestic credit can then respond appropriately. As such, a system assuming public investment as the most exogenous is argued make correct causality assumptions. Formal tests of exogeneity might however have to be utilised to confirm variable exogeneity.

3.2.3.2 Weaknesses associated production function and growth models

In analysing the production function and growth approaches to assessing the impact of public investment, it is evident that a great deal of inconsistency is evident in the results.

For instance, Mas et.al (1996) and De La Fuente and Vives (1995) find differing results for Spanish regional data based on the growth and production function models respectively. Similarly Kelejian and Robinson (1997) and Evans and Karras (1994) find different results based on U.S. regional data using the growth model. Aschauer (1989) and Tatom (1991) also find differing results based the production function model and U.S. national level time series data. Similarly Easterly and Rebelo (1993) and Calderon and Serven (2003) find widely differing results based on panels consisting of both developing and developed countries utilising the production function and growth models respectively. La Ferrara and Marcellino (2000) also found both negative and positive effects of public capital investment based on both the production function and growth models estimated for Italian regional panel data.

This lack of consistency and variability in results obtained based on these models have been attributed to several inherent weaknesses;

Firstly, a problematic issue for these models involves identification. Public investment, private investment and real output may be subject to two way (reverse) causality. A faster growing economy may systematically devote more resources to investment and higher levels of investment may more often than not lead to higher growth. Any empirical assessment of the impact of investment that fails to take this issue into account may be subject to upward simultaneity biases. However the two approaches inherently assume and require that the direction of causality move from public / private investment to growth. Attempts to deal with this issue within a structural model via Instrumental Variables may however be difficult to implement in practice particularly in developing countries, due to stringent data requirements. (Calderon and Seven, 2008).

Time series data on such studies may pose a problem of spurious correlation, which if untreated results in upward biased estimates. Output (or productivity) and capital/investment typically display stochastic trends and failing to account for them could lead to spurious findings of a positive and significant association between variables when in reality there might be none (Calderon and Serven, 2008). A standard solution to this problem involves differencing the data.

However the long run relationship between the variables cannot be captured in such a static relationship and often implausible output elasticities are the result (Brinca, 2006). This problem can be avoided by following Cointergration methods to estimate the long run relationship between investment, aggregate output or productivity and other production inputs.

The relationship between output, labour and the stocks of public and private capital is unlikely to be static as the production function and growth approaches assume. However, it is more likely that this relationship is dynamic in nature, whereby growth may not only be affected by current values of these inputs, but also by their lagged values. Autocorrelation is an endemic problem when estimating static production functions. The estimated output elasticities might be unbiased and consistent in the presence of autocorrelation, but are inefficient (donot have minimum variance) and the estimated standard errors will be biased and inconsistent. However including lagged values in the empirical methodology usually makes such autocorrelation disappear (Brinca, 2006).

Thus the argument in the literature is that the production function and growth models are not well suited in dealing with problems of identification (reverse causality), non stationarity and autocorrelation, identified as prevalent in investigations of the impact of public investment on the economy. The measures utilised in these studies (physical indicators of the capital stock and capital expenditure) have also been identified as possessing inherent weaknesses as discussed above. These factors have been identified as being responsible for the inconsistency and lack of clear cut consensus in results of studies based on these two approaches.

The relevance of these approaches in the context of developing countries, of which Zambia is but one has also been questioned in the literature. As eluded to above, application of the production function and growth models posses challenges in terms of availability of quality data at country level. Such high quality data country level data is more readily available in the case of developed countries and not for developing countries. As such, in the case of developing countries, the two approaches are applied to panel data. However, the use of panel data posses its own challenges associated with heterogeneity. This arises because the effects of public investment on output or its growth rate has been agued to possibly vary across countries and time periods (Calderon and Serven, 2008).

This is evident in the variability, inconsistency and lack of robustness in results discussed above.

3.2.3.3 Weaknesses of the Cost/ Profit Function Model

However given the preoccupation with issues of economic growth and (or) development both in developed and especially in developing countries, the cost/ production function approach has received limited attention in the literature. This is due to its sole focus on the impacts of public investments on business costs and (or) profits. Furthermore, in analysing the cost/profit function approach, Pereira and Andraz (2010) argue that this framework simply assumes exogeneity of the various variables and it is not possible to explicitly test for it. The analysis is also static in nature and doers not account for potentially non contemporaneous effects as is the case with the production function and growth approaches. Straub (2008) further argues that this approach is better suited in an analysis of industry level data. However this type of data is not available for Zambia. The non availability of data posses a further problem as regards the relevance of this model in the Zambian context.

Having discussed the various approaches to the measurement of public and private investment and the various alternative models used in the literature and their strengths and weaknesses, the next step involves a choice of the most appropriate model and measure.

3.3 Choice of Most relevant Model in the Zambian Context

In analysing the four methodological approaches employed in the literature, it is evident that the VARS approach has inherent advantages particularly in the Zambian context over the other approaches. This is because it has inherent strengths that best suit it to overcome the challenges associated with analysing the impact of public investment. These challenges relate to both the nature of public investment itself, but also revolve around the investigation of its impact in a developing country such as Zambia.

3.3.1 Relevance of the VAR model related to the Nature of Public Investment

Firstly, as noted in the literature (Badawi, 2003; Fedderke et.al, 2005; Naqvi, 2002 and Ghani and Din, 2006) causality between output and investment (public/ private) can be bi-directional and can thus be characterized by potential endogeneity. This is evident in Badawi (2003) finding a bi-directional relationship between real output and the other explanatory variables (real interest rate, real domestic credit, real private and public investment) taken together. The VAR modelling technique imposes less restrictive structural modelling by imposing no a-priori endo-exogenous

categorisation or causality conditions (all variables are assumed endogenous). Thus VAR modelling is not affected by any potential endogeneity, whereas the production function and growth models require exogeneity of all regressors.

VAR modelling incorporating Cointergration methods helps to overcome problems associated with stochastic trends or non stationarity in investment and growth series overtime. Even if variables are non-stationary, they can be used in estimations even without differencing as long as they are Cointergrated. This helps to preserve long run relationships. Under the production function and growth approaches, a standard approach to the treatment of non stationarity involves differencing until the series is stationary. However this approach to dealing with non stationarity has been argued not to capture long run relationships between variables. This is a critical issue in investment analysis because investment has been argued to be undertaken with a long run perspective in mind. Thus the use of a Cointegrated VAR eliminates the need to difference the data, which results in the preservation of information on long run relationships in the data (Calderon and Serven, 2008).

VAR modelling combined with Granger causality analysis allows the determination of the direction of causality; whether investment (public/private) Granger causes growth or vice versa or whether the relationship is bi-directional. Intuitively, such an analysis of the direction of causality can have important policy implications. This is because public policy makers can obtain important feedback on the responsiveness of public investment to the needs of private investment in addition to its impact on growth. This is evident in the policy recommendations offered by Badawi (2003) on the need for policy makers to use public infrastructure investment to crowd in private investment.

VAR modelling also incorporates an in-built mechanism to deal with any potential autocorrelation noted to characterize the investment-output relationship. This is arises via the inclusion of an optimal number of lags in the model (Ghani and Din, 2006).

3.3.2 Relevance of the VAR model in the Zambian Context

The VAR model has also been argued to be well suited in the context of a developing country such as Zambia. In fact, virtually all country level investigations of the impact of public investment in the literature employ this model- Badawi (2003) for Sudan, Ghani and Din (2006) for Pakistan and Ghali (1998) for Tunisia are all cases in point. This is owing to the fact that

GDFI the measure of investment utilised by this model, is relatively available at country level relative to other measures of public investment (physical indicators, public capital expenditure and public investment in human capital) used by alternative models. As such, the effects of public investment can be fully explored at country level without the possibility of the data limitations and pervasive econometric effects associated with the use of the production function, growth and cost/profit function models affecting results obtained. Simply put, the VAR model is the best model (due to its inherent econometric strengths relative to other models) and it also utilises the best measure of public investment relatively more available for Zambia.

Owing to its inherent advantages discussed at length above, which far outweigh any shortcomings, the VAR model was utilised in this study to investigate the impact of public investment on the economy. With an appropriate model and measures of public and private investments at hand, the next chapter presents an exposition of the methodological framework of the study.

CHAPTER FOUR

METHODOLOGY

4.1 Theoretical Framework

4.1.1 Neoclassical Growth Theory

Following Brinca, 2006; Ghali, 1998; Badawi, 2003; Ghani and Din, 2006; Brinca, 2006; Naqvi, 2002, the study assumes a modified Neoclassical production function of the economy be given by equation 3.1 above. Within this framework, the underlying relationship between public and private investment in terms of crowding in/crowding out, and the implications for real output are explored.

4.2 Empirical Framework

Equation (3.1) above can be specified in practical application in double log form and the parameters of the inputs can be estimated as marginal products. This would constitute an application of the production function model.

However due to the practical challenges associated with such an approach noted in the review of the literature above, (Endogeneity/reverse causality, spurious correlation estimation and Autocorrelation) estimation was based on the VAR model, which in addition to inherent advantages also noted above, has the additional advantage of requiring less restrictive structural modelling to derive unbiased and consistent estimates.

Following Badawi (2003), testing for unit roots in the data preceded Cointergration analysis based on Johansen's procedure.

4.2.1 Unit Root Tests

Non stationarity of a series can result in the phenomenon of establishing relationships among economic variables that seem to be valid, yet are spurious. It is thus now standard practice to conduct unit root tests before any econometric estimation is carried out.

A series x_t is said to be integrated of order d if it becomes stationary after differencing d times and thus x_t contains d unit roots. A series which is $I(0)$ is said to be stationary. The Augmented Dickey Fuller (ADF) and Philips-Perron (PP) unit root/ stationarity tests were used to test for the presence of unit roots.

4.2.1.1 Augmented Dickey Fuller (ADF) test

Augmented Dickey Fuller (ADF) test employed to determine the order of integration of variables.

The ADF test equation employed was;

$$\Delta x_t = \mu + \gamma T + \beta x_{t-1} + \sum_{i=1}^{k} \lambda_i \, \Delta \mathrm{x_{t-i}} + \mathrm{u_t} \qquad (4.1)$$

Where;

x_t is the variable in question,

T is the time trend,

k is the lag length, and

$\mathrm{u_t}$ is the error term assumed to be white noise.

In the ADF test, the null hypothesis of a unit root/non stationarity ($H_0: \beta = 0$) is tested against the alternative hypothesis that no unit root is present/stationarity ($H_1: \beta \neq 0$)

The calculated t-statistic of the estimated β is compared with Mackinnon critical values. If the absolute value of the calculated t statistic is greater than the critical value, then the null hypothesis of a unit root (non-stationarity) is rejected and we conclude that the series is stationary. In this case the level of the time series x_t is said to be integrated of order zero .i.e. $I(0)$

4.2.1.2 Phillips-Perron (PP) test

The PP test differs from the ADF test in that it does not assume white noise residuals, but corrects for serial correlation in the residuals. The test uses a non-parametric method to account for serial correlation in the residuals. It does not augment the Dickey-Fuller test equation when accounting for serial correlation but it instead adjusts the test (t)statistic to account for serial correlation. The modified t statistic of the PP test however follows the same distribution as the ADF statistic.

As with the ADF test, in the PP test, the null hypothesis of a unit root/non stationarity ($H_0: \beta = 0$), is tested against the alternative hypothesis that no unit root is present/stationarity ($H_1: \beta \neq 0$)

The calculated t-statistic of the estimated β is compared with its respective critical value. If the absolute value of the calculated t statistic is greater than the critical value, then the null hypothesis of a unit root (non-stationarity) is rejected and we conclude that the series is stationary. In this case the level of the time series x_t is said to be integrated of order zero .i.e. $I(0)$

4.2.2 Cointegration Test

4.2.2.1 Johansen's procedure

The study employed the Johansen procedure to test whether the variables were Cointegrated or reached a stationary, long run equilibrium.

With non-stationary variables that are integrated of the same order, a Cointegration test can help to determine the number of long-run Cointegrating/equilibrium relationships among the variables.

The test equation takes the form;

$$\boldsymbol{Z_t = A_0 D_t + A_1 Z_{t-1} + A_2 Z_{t-2} + \cdots + A_k Z_{t-k} + \epsilon_t} \qquad (4.2)$$

Where;

Z is an n × 1 vector containing all n (n=5) variables in the system: **Z**= (lrgdp lrip lrdcp lrcg Irig)'

D is a vector containing deterministic terms (intercepts, trends) and

$\boldsymbol{\epsilon}$ is an n dimensional vector of multivariate random errors with zero mean and covariance matrix Σ.

Contingent on the existence Cointegration, the VAR system in (3.2) can be represented as a Cointegrated VAR;

$$\mathbf{\Delta Z_t = A_0 D_t + \Pi Z_{t-1} + \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \cdots + \Gamma_{k-1} \Delta Z_{t-k+1} + V_t} \quad (4.3)$$

Where **Π** is the long run matrix.

The Johansen procedure uses the Trace,

$\lambda_{trace}(r_0) = -T \sum_{j=r_0+1}^{k} log(1 - \widehat{\lambda_j})$,

and Maximum Eigen value,

$\lambda_{max}(r_0) = -T\left(1 - \widehat{\lambda_{r_0}}\right)$,

test statistics respectively.

The null hypothesis tested for under both statistics is;

$H_0: rank\ (\Pi) \leq r$,

The alternative hypothesis for the trace statistic is;

$H_1: rank\ (\Pi) > r + 1$

The alternative for the Maximum Eigen value statistic is;

$H_1 = rank\ (\Pi) = r + 1$

Where r is the rank of the long run matrix, Π or the number of long-run Cointegrating relationships.

Under the null hypothesis, matrix **Π** can be decomposed into a product of two non-null matrices such that **Π**=$\propto \boldsymbol{\beta}'$. Matrices $\propto and\ \boldsymbol{\beta}$ hold adjustment coefficients and long run parameters respectively, and are both $n \times r$.

The stationary VAR system (in level or difference form, depending on order of integration of variables) was then used to test for Granger causality.

4.2.3 Error Correction Model

Contingent on the existence of a long run Cointegration relationship among the variables, the short term dynamics was then investigated using the Error Correction Model;

$$\Delta lrgdp_t = \mu_1 + \alpha_1 EC_{t-1} + \sum_{i=1}^{k} \gamma_{1i} \Delta lrgdp_{t-i} + \sum_{i=1}^{k} \gamma_{2i} \Delta lrip_{t-i} + \sum_{i=1}^{k} \gamma_{3i} \Delta lrdcp_{t-i} + \sum_{i=1}^{k} \gamma_{4i} \Delta lrcg_{t-i} + \sum_{i=1}^{k} \gamma_{5i} \Delta lrig_{t-i} + \varepsilon_{1t} \quad (4.4)$$

$$\Delta lrip_t = \mu_2 + \alpha_2 EC_{t-1} + \sum_{i=1}^{k} \delta_{1i} \Delta lrgdp_{t-i} + \sum_{i=1}^{k} \delta_{2i} \Delta lrip_{t-i} + \sum_{i=1}^{k} \delta_{3i} \Delta lrdcp_{t-i} + \sum_{i=1}^{k} \delta_{4i} \Delta lrcg_{t-i} + \sum_{i=1}^{k} \delta_{5i} \Delta lrig_{t-i} + \varepsilon_{2t} \quad (4.5)$$

$$\Delta lrdcp_t = \mu_3 + \alpha_3 EC_{t-1} + \sum_{i=1}^{k} \theta_{1i} \Delta lrgdp_{t-i} + \sum_{i=1}^{k} \theta_{2i} \Delta lrip_{t-i} + \sum_{i=1}^{k} \theta_{3i} \Delta lrdcp_{t-i} + \sum_{i=1}^{k} \theta_{4i} \Delta lrcg_{t-i} + \sum_{i=1}^{k} \theta_{5i} \Delta lrig_{t-i} + \varepsilon_{3t} \quad (4.6)$$

$$\Delta lrcg_t = \mu_4 + \alpha_4 EC_{t-1} + \sum_{i=1}^{k} \lambda_{1i} \Delta lrgdp_{t-i} + \sum_{i=1}^{k} \lambda_{2i} \Delta lrip_{t-i} + \sum_{i=1}^{k} \lambda_{3i} \Delta lrdcp_{t-i} + \sum_{i=1}^{k} \lambda_{4i} \Delta lrcg_{t-i} + \sum_{i=1}^{k} \lambda_{5i} \Delta lrig_{t-i} + \varepsilon_{4t} \quad (4.7)$$

$$\Delta lrig_t = \mu_5 + \alpha_5 EC_{t-1} + \sum_{i=1}^{k} \psi_{1i} \Delta lrgdp_{t-i} + \sum_{i=1}^{k} \psi_{2i} \Delta lrip_{t-i} + \sum_{i=1}^{k} \psi_{3i} \Delta lrdcp_{t-i} + \sum_{i=1}^{k} \psi_{4i} \Delta lrcg_{t-i} + \varepsilon_{5t} \quad (4.8)$$

Where

$lrgdp$ = log of real output,

$lrip$ = log of real investment by the private sector,

$lrdcp$ = log of banking sector credit to the private sector

$lrcg$ = log of consumption by the public sector

$lrig$ = log of real investment by the public sector,

EC_{t-1} is the Error Correction Term lagged one period.

The μ's contain exogenous elements such as a time trend and intercept term, k indicates the number of lags of the regressand variables as well as for the regressors in a given equation.

The ε's represent white noise error terms that are independent of the history of the variables in the VECM.

The statistical significance of the adjustment parameters provides evidence of long run causality, whereas the joint significance of lagged first differences in the Error Correction Model indicates the presence of short run causality.

4.2.4 Granger Causality Test

Given two variables x and w, x is said to granger-cause w if lagged values of x help in the prediction of w or if the coefficients on the lagged values of x are statistically significant in the equation of w.

The test equation would thus take the form;

$w_t = \alpha + \sum_{j=0}^{k} \beta_j x_{t-j} + \sum_{i=1}^{k} \lambda_i w_{t-i} + \epsilon_t$ (4.9)

The null hypothesis is that β_j=0 and its rejection implies that x can be said to Granger-cause w.

4.2.5 Specification Tests

The Jarque-Bera Normality Test and the LM Serial Correlation Test were used to arrive at parsimonious results. They are explained in detail in appendix 1.

4.2.6 Data and Measurement of Variables

4.2.6.1 Data

For the purposes of this study, time series data on Zambia covering the period 1980-2008 was used. The series real output, real private investment, real public consumption, real public investment and real banking sector credit to the private sector were obtained from The World Banks Africa Development Indicators (2011). All data will be measured in constant 2000 prices.

The year 1980 constituted the earliest year for which data on GDFI disaggregated by the public and private sector for Zambia was available. Similarly GDFI data for the years 2009 and 2010 was collected under the framework of the newly introduced Economic Census phase 2, under the auspices of the Central Statistical Office. Thus data for these years was unavailable though The World Banks Africa Development Indicators (2011) and the Central Statistical Office at the time of writing.

The sample thus consisted of 29 observations spanning the period under review. Analysis of the empirical literature reveals numerous studies utilising the VAR model based on sample sizes of a similar size. This is attributed to challenges in obtaining time series investment data covering very long time span especially in developing countries. For instance, Ghali (1998) utilized a

VAR model with sample size of 30 years, Ghani and Din (2006) utilized a VAR model with a sample size 31 years while Badawi (2003), also utilised a VAR model with a sample covering a time span of 28 years. Despite the size of samples, the authors were able to obtain unbiased and consistent results with the various sample sizes not adversely affecting the estimation methodology/model used, the results obtained and their interpretation.. Thus in this light, results of this study were expected to be unbiased and consistent with the sample size not adversely affecting the estimation methodology chosen, the results obtained as well as their explanation and interpretation.

4.2.6.2 Measurement of Variables

Real Gross Domestic Product (lrgdp): Real Gross Domestic Product was used as a measure of Real Output. It is defined as the natural logarithm of Gross Domestic product (GDP) at market prices, in constant local 2000 prices. It provides a measure of the total output of goods and services for final use occurring within the domestic territory of a given country, regardless of the allocation to domestic and foreign claims.

Public investment increases aggregate demand in the economy and this ultimately implies an increase in output of goods and services to meet that demand, hence an increase in real GDP. An increase in real output implies economic growth. This measure is widely used in the literature by among others Badawi (2003), Ghani and Din (2006), Brinca (2006), Naqvi (2002), Ghali (1998).

Real Public Investment (lrig)

Is defined as the natural logarithm of the public sector's Gross Domestic Fixed Investment – Gross Fixed Capital Formation, at constant 2000 prices. It comprises all additions to the stocks of fixed assets (including purchases and own-account capital formation), land improvements-fences, ditches, drains etc.-plant, machinery and equipment purchases (including imports), construction of roads, railways, schools, hospitals, office buildings, less any sales of second-hand and scrapped fixed assets, by government units and non-financial public enterprises. Outlays by government on military equipment are excluded.

Fixed Investment by the public sector is expected to have a positive effect on real output. In Neo Classical growth theory, increases in the level of public capital stock (public investment) are argued to lead to increases in the capital stock and this in turn should lead to increases in real

output. This effect however only occurs if the public investment is coupled with increased private investment or if the reductions in real output due to any reductions in private investment are offset by the increase in output due to an increase in public investment.

Public sector GDFI is used in the literature as a measure of public investment by among others Badawi (2003), Ghani and Din (2006), Brinca (2006), Naqvi (2002), Boopen and Khadaroo (2006).

Real Private Investment (Irip)

Is defined as the natural logarithm of private sectors Gross Fixed Capital Formation – Gross Domestic Fixed Investment, at constant 2000 prices. It comprises gross outlays by the private sector (including private non-profit agencies) on additions to its fixed domestic assets, including land improvements (fences, ditches, drains, etc.), plant, machinery and equipment purchases (including imports), construction of private residential dwellings, commercial and industrial buildings and net acquisitions of valuables.

In Neo classical growth theory, private GDFI is argued to lead to increases in real output. Private investors spurred by a desire to make profits are led to exploit the most profitable investment opportunities. The increased supply of goods and services arising from such investments, in turn lead to increases in an economies real output. Private investment is however closely related to and very much dependent on public investment. The efficiency and productivity of private investment is dependent on the availability of high quality public investment goods such as roads, bridges and other public goods. Similarly, if private investors have to compete with the public sector for the same pool of investible resources in the domestic economy, then private investment may very well fall.

Private sector GDFI is widely used in the literature as a measure of private investment by among others Badawi (2003), Ghani and Din (2006), Brinca (2006), Naqvi (2002), Boopen and Khadaroo (2006).

Control Variables

Real Public Consumption (lrcg)

Is defined as the natural logarithm of public sector consumption expenditures at constant 2000 prices. It comprises government purchases of goods and services, including office supplies and maintenance charges, wages and salaries of employees and expenditures on national defence.

Public consumption leads to an increase in real output in the economy. This is particularly the case when it is used to encourage private investment to meet the additional demand, by way of supply of goods and services purchased by the government. However if public consumption is financed by borrowing from the domestic economy it can reduce private investment. Similarly, if say for political economy reasons, public consumption is encouraged at the expense of public investment, it can have potentially deleterious effects on real output.

Public consumption has been used in the literature by Ghani and Din (2006).

Domestic Credit to the Private Sector (lrdcp)

Is defined as the natural logarithm of the ratio of banking sector credit to the private sector to nominal GDP, at constant 2000 prices. Domestic credit to the private sector refers to financial resources provided to the private sector, such as through loans, purchases of non-equity securities and trade credits and other accounts receivable, that establish a claim for repayment.

Domestic credit thus represents the investible resources devoted to productive activities in the economy. Credit provision to the private sector is a critical determinant of the quantity as well as the quality of private investments that are undertaken. In a situation where policies are implemented that facilitate increased private sector participation such as increased financial sector liberalization, these should have a positive effect on domestic credit to the private sector, leading in turn to greater investment and in turn economic growth.

Domestic credit is widely used in the literature including by Badawi (2003), Boopen and Khadaroo (2006).

4.2.7 Estimation Method

In investigating the public, private investment, real output relationship, a Dynamic Vector Autoregressive (VAR) model was employed. The statistical package STATA 11 was used.

Forecast error variance decomposition was also performed in order to determine the proportion of the forecast error of the variance of each variable accounted for by shocks to each variable in the system. In addition, the LM serial correlation and the Jarque-Bera Normality diagnostic tests were carried out to establish the models adequacy.

Model selection criteria used in the analysis included Final Prediction Error (FPE), Akaike Information Criterion (AIC), Hanna and Quinn Information Criteria (HQIC) and Schwartz Bayesian Information Criterion (SBC). These were used in choosing between alternative models in the process of estimation.

With an appropriate theoretical and empirical framework and a set of variables at hand, the next chapter presents an empirical analysis of results obtained.

CHAPTER FIVE

EMPIRICAL ANALYSIS

5.1 Descriptive Statistics

Before results of the empirical analysis are presented, descriptive statistics for the data used in the analysis are presented. Table 3 below presents these descriptive statistics for all the variables used in the analysis.

Table 2: Descriptive Statistics of the Variables

Variable	**lrig**	**lrcg**	**lrdcp**	**lrip**	**lrgdp**
Mean	25.804	26.783	2.297	26.052	28.539
Maximum	26.641	27.800	1.566	26.977	28.959
Minimum	25.073	26.027	3.312	24.437	28.376
Std. Deviation	0.472	0.399	0.447	0.596	0.161
Kurtosis	2.953	2.472	1.988	2.805	2.905
Skewness	-0.354	0.380	-0.051	-0.532	0.379
Probability	0.961	0.582	0.292	0.839	0.921
observations	29	29	29	29	29

lrig= Public GDFI, lrcg=Public Consumption, lrdcp=Domestic Credit to the Private Sector, lrip=Private GDFI, lrgdp= Gross Domestic Product

The descriptive statistics contained in table 3 above give a broad picture of normality of the variables. This is particularly the case with the skewness and kurtosis statistics. This implies that that the residuals from the regression using these variables were expected to be normally distributed leading to efficient and unbiased estimators.

5.2 Unit Root Test Results

Analysis of the literature revealed non stationarity of macroeconomic time series (Ghali, 1998; Ghani and Din, 2006; Badawi, 2003). Non stationarity can lead to spurious regression results based on OLS estimation. Thus before inferences can be drawn based on macroeconomic time series, we must determine whether or not they are stationary. A variables order of integration indicates the number of times that the variable must be differenced in order become stationary.

This study utilised the ADF and PP tests to test for stationarity and the order of integration of the variables of interest; lrip, lrcg, lrdcp, lrip and lrgdp. Unit root test results based on the ADF and PP tests are shown in table 4 below.

Table 3: Unit Root Test Results in Levels and First Differences

	ADF					PP		
		Levels		1st Diff		Levels	1st Diff	
Variable	**LL**	**t-stat**	**LL**	**t-stat**	**I(d)**	**t-stat**	**t-stat**	**I(d)**
lrig	1	-0.546	0	-5.376*	1	-1.15	-8.830*	1
lrcg	1	-1.751	0	-3.421**	1	-1.042	-3.344**	1
lrdcp	1	-2.373	0	-3.558**	1	-1.638	-3.391**	1
lrip	3	-1.946	2	-4.961*	1	-2.464	-7.879*	1
lrgdp	2	0.839	1	-4.449*	1	0.642	-5.831*	1

*(**) indicates significance at 1% and 5% respectively. LL is lag length. 1st Diff stands for first difference. t- stat stands for the test statistic. I (d) stands for the order of integration

Results of the ADF and PP tests indicate that all variables in their levels were non-stationary. ADF and PP tests conducted on all variables at their first differences indicate that all variables were stationary. This implies that all variables were integrated of order one. For lrig, lrip and lrgdp, the null hypothesis of a unit root was rejected at 1 percent level of significance while for lrcg and lrdcp, the null hypothesis of a unit root was rejected at the 5 percent level of significance. A constant and trend were included in the estimations.

Given that the variables were all found to be integrated of order one as shown above, a test of Cointegration was undertaken. This test included all the five variables.

5.3 Cointegration Test Results

Cointegration testing enables us to determine the existence of a long-run Cointegrating (equilibrium) relationship among variables that are integrated of the same order. Given that the variables lrgdg, lrip, lrig, lrcg, lrdcp are integrated of order one, the Johansen Maximum likelihood test was used within a VAR model to test for Cointegration among the variables.

A critical issue in VAR specification is the choice of lag length. This involves a delicate balance between incorporating the number of lags that adequately capture the dynamic nature of the investment-output relationship and eliminate serial correlation on one hand, but do not excessively reduce degrees of freedom in the model on the other.

Lag length of the underlying VAR was chosen based on various lag length selection criteria including Final Prediction Error (FPE), Akaike Information Criteria (AIC), Hanna and Quinn Information Criteria (HQIC) and Schwartz Bayesian Information Criteria (SBC). The procedure employed was to begin from a sufficiently long lag length of five lags and successively reduce the lag length, choosing the optimal number of lags that yielded the smallest values of the respective lag length selection criteria. The SBC, AIC and HQIC all indicated a lag length of three lags while the FPE indicated a lag length of four lags. The lag length chosen as being optimal to enable the model to capture the dynamics of the system as well as deal with serial correlation observed in the literature investigating the investment output relationship and conserve degrees of freedom was three lags. This was consistent with the empirical literature where all studies reviewed investigating the impact of public investment on private investment using the Cointegrated VAR modelling utilize VAR models with lag lengths greater than zero. For instance Ghali (1998) utilised a VAR incorporating four lags, while Badawi (2003) and Ghani and Din (2006) utilised VAR models incorporating two lags in the underlying VAR.

Thus a lag length chosen for the underlying VAR was set at three lags, implying that the VECM, if estimated would include two lags. Following lag length determination, Johansens Cointegration test was used to determine the existence of a Cointegrating relationship among the variables. Results for the Trace and Eigen value statistics are shown in tables 5 and 6 respectively below.

Table 4: Johansens' Cointegration test using the Trace statistic

Hypothesed number of Cointegrating relationships (r)	Eigen value	Trace statistic
$r = 0$	.	128.362**
$r \leq 1$	0.863	76.716**
$r \leq 2$	0.827	30.969**
$r \leq 3$	0.471	14.406

* (**) indicates significance at 1% and 5% respectively

Table 5: Johansens' Cointegration test using the Maximum Eigen value statistic

Hypothesed number of Cointegrating relationships (r)	Eigen value	Max-Eigen Statistic
$r = 0$	.	51.646**
$r = 1$	0.863	45.747**
$r = 2$	0.828	16.563
$r = 3$	0.471	11.377

*(**) Indicates significance at 1% and 5% respectively

The null hypothesis of no Cointegration is rejected at 5 percent for both the Trace and Maximum Eigen value statistics as the respective statistics were significant at this level. The Trace statistic fails to reject the null hypothesis that there are at most three Cointegrating relationships. The Maximum Eigen value statistic on the other hand fails to reject the null hypothesis that there are exactly two Cointegrating relationships among the variables. These results indicated that exactly two Cointegrating relationships among the variables existed.

Given the existence of Cointegration (long run equilibrium) among the variables, the next step involved the estimation of a VECM.

5.4 Vector Error Correction Model

Given the existence of two Cointegrating relationships among the variables of interest, a VECM was estimated. A VECM reveals the nature of short-run interaction among variables of interest as well as the adjustment mechanism towards long run stationary equilibrium, when there is deviation from the long run equilibrium. However before results from the VECM are presented, we firstly present results of diagnostic tests-tests of normality and autocorrelation in the VECM

5.5 Diagnostic Test Results

The Lagrange Multiplier (LM) test for autocorrelation was used to test for autocorrelation in the residuals of the VECM. The null hypothesis of the LM test is that of no autocorrelation in the residuals. The Jarque-Bera test was also used to test for normality of residuals. This test has a null hypothesis of normality of the residuals.

If the results point to non rejection of the respective null hypotheses, then inferences based on x^2, t and F tests produce valid inferences as regards the significance of coefficient estimates and we can have confidence that the model is correctly specified and all important or relevant variables included. Results of the Lagrange multiplier test are presented in table 7 below.

Table 6: Lagrange Multiplier test results

Lag	X^2	p-value
1	37.323	0.054
2	21.311	0.675
3	26.731	0.369
4	35.716	0.076
5	33.641	0.116

Test was carried out at 5% level of significance

As is evident from the table above, the test for fifth order serial correlation shows that LM statistics at lags one, two, three, four and five were not significant at 5 percent respectively. Thus the null hypothesis of no autocorrelation could not be rejected at 5 percent level of significance for all five equations estimated in the VECM.

Table 7: Jarque-Bera test results

Equation	JB Statistic	p-value
Δ lrgdp	0.792	0.673
Δ lrip	3.806	0.149
Δ lrdcp	0.546	0.076
Δlrcg	1.167	0.558
Δ lrig	0.497	0.780
ALL	6.806	0.744

d(lrgdp), d(lrip), d(lrdcp), d(lrcg), d(lrig) are the dependent variables in the VECM equations tested for serial correlation

Results of the Jarque-Bera normality test are shown in table 8 above. They reveal that the null hypothesis of normality of the error terms of each as well as all five equations included in the VECM could not be rejected at 5 percent significance. This is a confirmation of the observation made in table 3 above based on the descriptive statistics.

Results of the LM and Jarque-Bera tests revealed that the VECM was neither plagued by serial correlation nor non normality of error terms. This implies that estimates based on OLS are linear, unbiased, consistent, asymptotically normally distributed and also have minimum variance in the class of all linear, unbiased estimators. We can thus be confident that inferences based on x^2, t and F tests will produce valid inferences as regards the significance of coefficient estimates and that the model is correctly specified and all important variables are included in the model.

Given that the VECM passed the diagnostic tests, estimates of the unrestricted coefficients of the long run Cointegrating relationships as well as the speed of adjustment parameters or loading coefficients are presented in tables 9 and 10 below. Given the identification of two Cointegrating relationships among the variables, the coefficients of each of these Cointegrating vectors are shown below. Table 9 contains estimates of the coefficients of the Cointegrating vector and speed of adjustment parameters for the first Cointegrating relationship, while table 10 contains those of the second. The restrictions on the coefficients of lrgdp and lrip in the first and second Cointegrating vectors respectively, simply refer to Johansens normalised restrictions placed for purposes of exact identification on the Cointegrating vector.

Table 8: Unrestricted Cointegrating Coefficients and Speed of adjustment Parameters for the first Cointegrating relationship

Variable	Coefficients of Cointegrating vector (β')	Speed of Adjustment Parameters (α)
lrgdp	1 (restricted)	0.167 (0.369)
lrip	0 (restricted)	0.943 (4.900)
lrdcp	-0.015 (0.014)	3.075 *** (1.396)
lrcg	-0.174 * (0.016)	4.919 * (1.021)
lrig	-0.250 * (0.011)	2.074 (3.055)
constant	-17.376	-

*(**) indicates significance at 1% and 5% respectively. Standard Errors in parenthesis

The Cointegrating vector β' in table 9 above constitutes an unrestricted long-run stationary relationship and describes the first error correction term;

$$ECT_1 = lrgdp - 17.376 - 0.015lrdcp - 0.174lrcg - 0.25lrig$$

The coefficients of the first Cointegrating vector indicate that public investment and public consumption have positive and significant long-run effects on real output. Domestic credit to the private sector however has insignificant effects on real output. The coefficients of this Cointegrating vector constitute long-run elasticities or marginal impact on real output with respect to each variable. Thus it is evident that the largest marginal impact on real output was exerted by public investment, followed by public consumption and domestic credit to the private sector. This finding is in line with that of Badawi (2003) who found that public investment had positive significant effects on real output in the case of Sudan.

Similarly the Cointegrating vector β' in table 10 below constitutes an unrestricted long-run stationary relationship and describes the second error correction term;

$$ECT_2 = lrip + 1.527 - 3.192lrdcp + 1.392lrcg - 2.236lrig$$

The coefficients of the second Cointegrating vector indicate that domestic credit to the private sector and public investment exert positive and significant effects on private investment, while public consumption exerts a negative and significant effect on private investment.

Table 9: Unrestricted Cointegrating Coefficients and Speed of adjustment Parameters for the second Cointegrating relationship

Variable	Coefficients of Cointegrating vector (β')	Speed of Adjustment Parameters (α)	
lrgdp	0 (restricted)	-0.001	(0.016)
lrip	1 (restricted)	0.310	(0.210)
lrdcp	-3.192 * (0.337)	-0.071	(0.060)
lrcg	1.392 * (0.401)	-0.251 *	(0.044)
lrig	-2.236 * (0.331)	0.085	(0.131)
constant	1.527		

*(**) indicates significance at 1% and 5% respectively. Standard Errors in parenthesis

The results thus indicate a crowding in effect of public investment on private investment and a crowding out effect of public consumption on private investment in the long run. These results differ with those of Ghani and Din (2006) whose results revealed a crowding out effect of public investment on private investment in the case of Pakistan.

The speed of adjustment parameters for the first Cointegrating relationship reveal that public consumption adjusts the fastest to long run equilibrium, followed by domestic credit to the private sector. Adjustment parameters of public investment, private investment and real output were observed to be insignificant in this Cointegrating relationship. Similarly for the second Cointegrating relationship, only the speed of adjustment parameter of public consumption is significant. Adjustment parameters of real output, private investment, public investment and domestic credit to the private sector were insignificant.

The insignificance of the speed of adjustment parameters in tables 9 and 10 seemed to imply possible weak exogeneity of real output, private investment, domestic credit and public investment with respect to the Cointegrating vectors (Ericson et.al, 1998; Badawi, 2003; Naqvi, 2002).

These observations thus necessitated a formal test for weak exogeneity of all variables in the model as well as tests for identification and zero restrictions on the speed of adjustment

parameters of the Cointegrating relationships found above. Also requiring investigation was the possibility of the existence of a Cointegrating relationship in a conditional model involving only variables revealed to be endogenous by the test for weak exogeneity, conditioned on those variables found to be exogenous.

5.6 Test for Weak Exogeneity

Testing for weak exogeneity of the speed of adjustment parameters involved a Likelihood Ratio (LR) test of the null hypothesis that the speed of adjustment parameters of each variable are equal to zero (indicating that the variable is weakly exogenous). The Chi-squared LR test statistic is then compared to the respective critical value and a decision is made whether or not to accept the null hypothesis. This test of weak exogeneity is consistent with the necessary and sufficient conditions provided by Engel et.al (1983) and Rault (2005) for weak exogeneity. Testing for weak exogeneity using the LR test based on a Chi-squared statistic, has been argued to be superior to alternative tests such as the Lagrange Multiplier test and the Wald test in that it is invariant to how non linear restrictions on the long run coefficient matrix in the Cointegrating vector are expressed. Results of the LR test are shown in table 11 below.

Table 10: Likelihood Ratio test for Long Run Weak exogeneity

Variable	Chi-squared Test Statistic	Inference
lrgdp	0.32	Exogenous
lrip	4.75 ***	Endogenous
lrdcp	5.00 ***	Endogenous
lrcg	34.73 *	Endogenous
lrig	2.72	Exogenous

*(**)*** indicates significance at 1%, 5% and 10% respectively

Test results in table 11 reveal that the null hypothesis of weak exogeneity could not be rejected in the cases of real output and public investment. However for private investment, domestic credit and public consumption, the test statistics were significant at 5 percent and 1 percent respectively leading to the conclusion that the variables were not exogenous (are endogenous) to the Cointegrating vectors.

Weakly exogenous variables may be Cointergrated with endogenous variables. However the long run behaviour of endogenous responds to trend movements in the weakly exogenous variables. However in the short term, changes in the weakly exogenous variables lead to changes in the endogenous variables. Thus and in his way, weakly exogenous variables behave like a random walk variables with a drift term (Ghali, 1998).

According to Ericsson et.al. (1998), weak exogeneity in Cointegrated systems arises with considerable regularity and depending on how many variables are included in the system weak exogeneity may entail a conditional subsystem within the model

These results indicated that the VECM should be re-estimated. Following Pesaran et.al. (2000), Naqvi (2002), Badawi (2006) and Ericsson et.al. (1998) this involves re-estimating the VECM with the respective insignificant adjustment parameters restricted to zero.

Tables 12 and 13 below, present results for the testing of identification and zero restrictions on the Cointegrating vectors. The Cointegration rank was preserved at two, the identification restrictions on the coefficients of the Cointegrating vector ensuring over identification were preserved as above while zero restrictions were imposed on the speed of adjustment parameters of real output and public investment.

Table 11: Restricted Cointegrating Coefficients and Speed of adjustment Parameters for the first Cointegrating relationship

Variable	**Coefficients of Cointegrating vector** $(\boldsymbol{\beta}')$	**Speed of Adjustment Parameters** $(\boldsymbol{\alpha})$
lrgdp	1(restricted)	0 (restricted)
lrip	0(restricted)	3.192 (2.633)
lrdcp	-0.033** (0.015)	2.874** (1.316)
lrcg	-0.162* (0.018)	5.362* (0.693)
lrig	-0.256* (0.015)	0 (restricted)
constant	-17.509	-

*(**)*** indicates significance at 1% , 5% and 10% respectively. Standard Errors in parenthesis

Table 12: Restricted Cointegrating Coefficients and Speed of adjustment Parameters for the second Cointegrating relationship

Variable	Coefficients of Cointegrating vector (β')	Speed of Adjustment Parameters (α)
lrgdp	0(restricted)	0 (restricted)
lrip	1(restricted)	0.363 * (0.110)
lrdcp	-3.604* (0.377)	-0.083 (0.055)
lrcg	1.663* (0.449)	-0.249* (1.270)
lrig	-2.551* (0.370)	0 (restricted)
constant	-2.551	-

*(**) *** indicates significance at 1%, 5% and 10% respectively. Standard Errors in parenthesis

From tables 12 and 13 it is evident that the signs and significance of the coefficients of the Cointegrating vectors are very similar to those in tables 9 and 10. This is particularly the case in table 12 for instance, which shows that public investment and public consumption continue to have positive and significant impacts on real output in the long run. However the effect of domestic credit to the private sector on real output is now both positive and significant, while in table 9, its effects were seen to be insignificant.

Similarly, table 13 reveals that domestic credit to the private sector and public investment continue to have positive and significant effects on private investment, while public consumption has a negative and significant effect on private investment. The effects are very similar to those in table 10 above.

The Likelihood Ratio (LR) test of identifying restrictions was found to have a Chi-squared value of 4.858, with four degrees of freedom, which is insignificant at conventional significance levels. This implies that it is not possible to reject the null hypothesis that the restricted model above is binding (true). This implies that the restricted model estimated in tables 12 and 13 above was more appropriate relative to the unrestricted model in tables 9 and 10. Similarly, in comparisons between the restricted and unrestricted models, the SBIC, HQIC, and AIC all indicated that the restricted model was more appropriate.

Given the acceptance of the restricted model relative to the unrestricted model, the next step involved the estimation of a conditional error correction model. This involved a test of Cointegration among the endogenous variables, conditioned on the weakly exogenous variables.

5.7 Conditional Cointegrating Relationship

A conditional error correction model involving a test of Cointegration on the endogenous variables conditioned on the weakly exogenous variables in the model was also estimated. The aim of this test was to determine whether the impact of public consumption and domestic credit on private investment would differ between the conditional and unconditional models. Johansen's Cointegration test was used to test for Cointegration among private investment, domestic credit to the private sector and public consumption treating public investment and real output as exogenous variables. Table 16 in appendix 2 below contains results of the Cointegration test and reveals that based on both the Trace and Maximum Eigen value statistics, one Cointegrating vector existed among the endogenous variables.

Table 17, also contained in appendix 2, shows estimates of the coefficients of the conditional Cointegrating vector. The coefficients of this Cointegrating vector are very similar with those estimated for the second Cointegrating relationship above. They indicate that domestic credit to the private sector has a positive and significant impact on private investment while public consumption has a negative and significant impact on private investment.

Investigations of the impact of public investment on the economy following the Cointegrated VAR empirical methodology employed in this study seemed to be characterized by weak exogeneity. This was evident from the fact that numerous studies have revealed insignificant adjustment parameters on at least some of the included variables (Badawi, 2003; Ghali, 1998; Ghani and Din, 2006)

For instance Ghani and Din (2006) estimate a VECM revealing insignificant adjustment parameters on public consumption and real GDP, while those of public and private investment were revealed to have significant adjustment parameters. The insignificant parameters were taken to infer weak exogeneity of public consumption and GDP. Test of zero restrictions on the Cointegrating vector for the coefficients public consumption and real output were found to be binding, indicating that the restricted model was true. Johansens' Cointegration test revealed the existence of a Cointegrating relationship between public and private investment conditioned on

real GDP and public consumption. The coefficient of the Cointegrating relationship revealed a crowding-out effect of public investment on private investment in the long run.

Following the acceptance of the restricted model as shown above, the next step involved the estimation of a VECM. The VECM was estimated based on the restricted model.

5.8 Estimates of the Vector Error Correction Model

Based on the existence of Cointegration among the variables noted above, a VECM was estimated. The VECM provides insight into the dynamics of the short run as well as adjustment towards long run equilibrium. The VECM was estimated based on the restricted model-with an identification restriction on the parameters of the Cointegrating vectors equivalent to Johansen's normalisation restrictions as well as zero restrictions on the speed of adjustment parameters of all weakly exogenous variables (real output and public investment). Results are presented in table 14 below.

Analysis of table 14 reveals the marked insignificance of lagged terms in the equations of real output and public investment, those variables found to be weakly exogenous above. This observation is in line with of Badawi (2006), Ghali (1998) and Naqvi (2002) whose VECM estimates were also generally characterized by insignificance of lagged terms in the equations of weakly exogenous variables.

From table 14, the real output equation (column two) reveals that domestic credit lagged one period exerted a positive and significant effect on real output. However private investment at both lags one and two has a negative and insignificant effect on real output. This finding would seem to suggest that even after two years, private investment does not have an appreciable impact on real output. This finding differs with that of Ghali (1998) who found that for Tunisia, private investment only exerted a significant positive effect on the growth rate of real output after a lag of three years.

The real output equation further reveals that public investment both at lags one and two exerts a negative though insignificant effect on real output. This finding is in line with the findings of Naqvi (2002) and Ghali (1998) who both found that public investment at lags one and two respectively exerted a negative but insignificant influence on the growth rate of real output. Though surprising, these results can be explained by recalling that the investment process

involves a balance between two opposing forces; resources are shifted from present consumption or usage on one hand, into activities whose full returns will only accrue in the future on the other. Thus a crucial issue in investment analysis is the rate at which returns to the investments accrue. This implies that if investments are productive, then the negative effect due to the transfer of resources from present to future usage will be offset by the productivity of those ventures chosen for investment, leading to an overall positive net effect on real output. However when the returns to investments take too long to begin to accrue, the negative effect due to the transfer of resources may very well be large enough to offset any positive returns to the investment, resulting in an overall negative effect of public investment. This may very well be the reason for this observed result.

The equation of private investment (third column) reveals that public investment has a positive and significant effect on private investment. This implies that in the short run, public investment has a significant crowding in effect on private investment.

This finding is in line with that of Boopen and Khadaroo (2006) who found a positive and significant crowding in effect of public investment on private investment in Mauritius.

The domestic credit to the private sector equation (column four) revealed a positive and significant relationship between domestic credit and private investment at lags one and two respectively. This implied that with greater credit provision to the private sector, levels of private investment could very well be higher.

Similarly the public consumption equation (column five) revealed a negative and significant relationship between public consumption and domestic credit to the private sector both at lags one and two. Furthermore, real output at lags one and two was revealed to exert a negative and significant effect on public consumption. Private investment at lags one and two however was found to exert a positive and significant effect on public consumption.

Table 13: Estimates of the Vector Error Correction Model

Equation	Δlrgdp	Δ lrip	Δ lrdcp	Δ lrcg	Δ lrig
Constant	0.020 **	0.004	-0.040	0.019	0.063
	(0.009)	(0.116)	(0.033)	(0.024)	(0.075)
$\Delta (lrgdp)_{t-1}$	0.240	-5.523	-1.843	-3.687*	-0.394
	(0.219)	(4.284)	(1.761)	(1.018)	(1.982)
$\Delta (lrgdp)_{t-2}$	-0.201	1.638	-0.284	-2.241*	0.956
	(0.213)	(3.181)	(1.061)	(0.693)	(1.925)
$\Delta (lrip)_{t-1}$	-0.008	-1.289*	0.263**	0.194**	0.068
	(0.019)	(0.301)	(0.105)	(0.067)	(0.175)
$\Delta (lrip)_{t-1}$	-0.032	-0.605**	0.161**	0.165**	0.069
	(0.017)	(0.262)	(0.083)	(0.056)	(0.164)
$\Delta (lrdcp)_{t-1}$	0.084 *	0.211	0.313	-0.413**	-0.487
	(0.044)	(0.628)	(0.198)	(0.149)	(0.395)
$\Delta (lrdcp)_{t-2}$	-0.047	0.613	-0.635**	-0.348**	0.494
	(0.045)	(0.649)	(0.209)	(0.140)	(0.404)
$\Delta (lrcg)_{t-1}$	0.055	-0.091	-0.081	0.458*	0.257
	(0.040)	(0.536)	(0.152)	(0.126)	(0.359)
$\Delta (lrcg)_{t-2}$	0.047	0.844	0.331	0.316**	0.024
	(0.044)	(0.700)	(0.252)	(0.156)	(0.395)
$\Delta (lrig)_{t-1}$	-0.013	1.105***	0.302	0.372*	-0.472
	(0.032)	(0.541)	(0.204)	(0.124)	(0.290)
$\Delta (lrig)_{t-2}$	-0.006	0.810***	0.062	0.054	-0.211
	(0.030)	(0.451)	(0.148)	(0.097)	(0.276)
$(ECT_1)_{t-1}$	-	3.192	2.874***	5.362*	-
		(2.633)	(1.316)	(0.693)	
$(ECT_2)_{t-1}$	-	0.363*	-0.083	-0.248*	-
		(0.110)	(0.055)	(0.029)	
R^2	0.661	0.558	0.797	0.909	0.450

*(**) *** indicates significance at 1%, 5% and 10% respectively. Standard errors in parenthesis….lrig= Public GDFI, lrcg=Public Consumption, lrdcp=Domestic Credit to the Private Sector, lrip=Private GDFI, lrgdp= Gross Domestic Product

Following the estimation of a VECM, the next step involved the testing of the direction of causality among the variables. This involved Granger causality tests based on the VECM.

5.9 Granger Causality test results

Granger causality tests were also carried out. Granger causality helps in determining whether contemporaneous or present values of a variable can be better explained/predicted by the inclusion of lagged values of another variable than by their exclusion, ceteris paribus. Acceptance of the null hypothesis that lagged values of a variable are not significantly different from zero in the equation of another variable implies that the former does not Granger cause the latter.

Following Badawi (2006), Naqvi (2002), Boopen and Khadaroo (2006) and Ghali (1998), the test comprised a Wald test using an Chi-squared statistic, of the joint hypothesis that all lagged values of a variable included in an equation as regressors are equal to zero. In Monte Carlo experiments conducted by Geweke et.al (1983), the Chi-squared test of Granger causality within a VECM was found to out-perform alternative tests of Granger causality.

Results of the Granger causality test are presented in table 15 below. In the table, columns represent the respective equations while rows the variables whose lagged terms were being tested for Granger causality. The first noteworthy comment is the finding of Granger non causality in the equation of public investment, one of the two variables discovered to be weakly exogenous. Public investment Granger causes other variables in the system but is not Granger caused by any of the variables in the system. This observation provided evidence of strong exogeneity of public investment being present in the system as opposed to mere weak exogeneity in the case of real output (Engel et.al, 1983; Ericson et.al, 1998). Real output is only weakly exogenous, due to the fact that in addition to Granger causing other variables in the system, it is Granger caused by other variables both individually as well as collectively.

Engel et.al (1983) argue that for a variable to be strongly exogenous as regards the Cointegrating vector in a Cointegrated system , the variable must be characterized by both Granger non causality and weak exogeneity. Thus the existence of weak exogeneity and Granger non causality of public investment implies that strong exogeneity of this variable is present and that

weak exogeneity is only true in the case of real output. However Granger non causality is neither necessary nor sufficient for the existence of weak exogeneity.

The finding noted above is in line with Badawi (2003). Granger causality tests revealed that public investment and domestic credit, the variables found to be weakly exogenous, were not Granger caused by any of the other variables, while they Granger caused a number of the other variables. This led the author to conclude that domestic credit and public investment were super or strongly exogenous with respect to the Cointegrating vector.

Analysis of the results of the Granger causality test in table 15 reveals that in the equation for real output, (column two) individually only government consumption Granger causes real output at 10 percent significance, while domestic credit, public investment and private investment donot. However the set of all variables were revealed to jointly Granger cause real output at 10 percent significance.

Table 14: Granger Causality Test Results

Dependent variable	**Δlrgdp**	**Δlrip**	**Δlrdcp**	**Δlrcg**	**Δlrig**
Δlrgdp	-	2.22	1.17	18.16 *	0.25
Δlrip	3.17	-	6.91 **	12.36 **	0.28
Δlrdcp	3.71	1.33	-	20.01 *	2.02
Δlrcg	5.98 ***	1.62	1.73	-	0.74
Δlrig	0.17	4.76 ***	3.00	11.88 **	-
ALL	16.08***	41.85 *	29.38 **	60.71 *	10.09
ECT_1	-	1.47	4.77 **	59.91 *	-
ECT_2	-	10.92 *	2.30	73.99 *	-

*(**) *** indicates significance at 1%, 5% and 10% respectively.

The equation of private investment (column three) indicates that individually, only public investment Granger causes private investment. This finding is in line with the significant crowding in effect of public investment on private investment identified above. Real output, domestic credit to the private sector and public consumption donot Granger cause private

investment. However all variables jointly Granger cause private investment at the 10 percent level of significance.

Based on the results in table 15 above, domestic credit to the private sector (column four) is Granger caused individually by private investment at the 5 percent level of significance. Real output, public consumption and public investment do not seem to Granger cause real domestic credit to the private sector. At 1 percent, all variables jointly Granger cause domestic credit to the private sector.

Public consumption is revealed to be jointly Granger caused by all variables at the 1 percent significance level. Individually, real output and public investment Granger cause public consumption at the 1 percent level of significance. However private investment Granger causes public consumption at the 5 percent level of significance.

Bi directional causality

The only evidence of significant bi-directional causality was between real output and public consumption.

One way causality

One way causality is evident in the fact that public investment Granger causes private investment, public consumption Granger causes real output, private investment Granger causes domestic credit to the private sector and real output Granger causes public consumption. Also private investment, domestic credit to the private sector and public investment individually Granger cause public consumption.

Results of the Granger causality analysis reveal that in the short run, there is no causal link from both public and private investments to real output. This finding can be linked to the finding of impacts no different from zero (insignificant) of public and private investments in the VECM analysis above. This result is quite surprising indeed and differs with Badawi (2003), who found that both public and private investments Granger caused real output in the short run. Ghani and Din (2006) also found that both public and private investments did not Granger cause real output.

Similarly, Ghali (1998) revealed no evidence of Granger causality from public investment to real output. The lack of evidence of a causal link from public and private investments to real output was attributed to inefficiencies inherent in the nature of the public investment process. These

inefficiencies constrain the role that public investment is expected to play as the foundation for increases in real output.

The observations based on the above analysis imply that the short run impact of public investment on real output only accrue through its indirect impact on public consumption. A similar argument is valid in the case of private investment, which Granger causes public consumption, which in turn Granger causes real output.

The finding of strong exogeneity of public investment in the Granger causality analysis is quite surprising indeed. This is because theoretically we would expect public investment to both Granger cause and to be Granger caused by most of the variables included in the model. This is particularly true in the case of private investment and real output. The public sector in making its capital formation decisions can be expected to take into account both the needs of the private sector and aim to alleviate the constraints impeding private capital formation and real output in the economy. The finding of Granger non causality from real output and private investment (in addition to domestic credit and public consumption) to public investment is thus particularly surprising. This observation points to the non responsiveness of public investment to the needs of the economy. Thus the public sector in its investment decisions would seem not to be taking into account the specific needs and constraints facing the economy

Thus public investment in Zambia in the short run would seem not to be having its maximum potential impact on both private investment and real output. This points to the fact that there are factors that constrain public investment from having the full impact on the Zambian economy.

5.10 Innovation Accounting

Innovation accounting involves analysing the dynamics of an autoregressive system. It involves the observation of the time path value of each variable as a response to a shock in another variable. The observed time path values are known as impulse response functions, while the proportion of the forecast error in a variable accounted for by shocks to the errors of another variable over a given forecast horizon is known as forecast error variance decomposition of the variable.

However Ericson et.al (1998) advise against the use of orthogonalised Impulse response functions in a Cointegrated system characterized by significant exogeneity for several reasons;

Firstly the authors argue that impulse response functions provide no additional information for evaluating the model, beyond that available from the coefficient estimates of the model. Secondly, they argue that data properties affect impulse response functions. Specifying whether a variable is weakly or strongly exogenous can directly affect impulse response functions, independently of whether that variable is weakly or strongly exogenous. Lastly, the authors argue that many orthogonalisations violate weak exogeneity and different exogeneity specifications directly affect impulse responses. Thus the authors argue that faced with significant exogeneity, it is preferable to develop a valid conditional representation and to avoid the use of orthogonalised impulse response analysis.

Engel et.al (1983) instead advocate that strong exogeneity is essential for models formulated for forecasting purposes. Thus in a system with strongly exogenous variables, model forecasting is particularly attractive. Hence presented below are estimates of the forecast error variance decomposition.

5.10.1 Forecast Error Variance Decomposition

Variance decomposition tells us the proportion of the variance of the forecast error of a variable that can be attributed to exogenous shocks (innovations) in each of the variables within the system, including the variable itself, at different forecast horizons. In other words, variance decomposition reveals how a variable responds to exogenous innovations to its own error terms and to those arising from the error terms of the other variables. Variance decompositions at a horizon of up to thirty periods were carried out for each of the variables and results are shown in appendix 3 and are discussed below.

5.10.1.1 Forecast Error Variance Decomposition of Real Output

Error variance decompositions for real output reveal that in the first period, own innovations account for 100 percent of the variation in real output, implying that innovations in real output account for all the variation in real output in the first period. However, after five periods, own account innovations account for only 80.4 percent of the variation in real output, representing a significant decline in the proportion of the variance in real output. After ten, twenty and thirty periods, own account innovations account for 78.4 percent, 76.9 percent and 76.6 percent of the

variation in real output over the forecast horizon. The average variation in real output owing to own account innovations is 82.5 percent.

Error variances in real output arising from innovations in public investment for the first, fifth, tenth, twentieth and thirtieth periods respectively are 0 percent, 3.1 percent, 2.4 percent, 1.4 per cent and 1.2 percent. The average variation in real output over the forecast horizon owing to innovations in public investment is 2.3 percent. It is thus evident that innovations in public investment account for a minimal proportion of the variation in real output over the forecast horizon.

Shocks to public consumption account for 0 percent, 0.3 percent, 0.1 percent, 0.3 percent and 0.4 percent, of the error variance in real output for the first, fifth, tenth, twentieth and thirtieth periods respectively. The average proportion of the error variance owing to innovations in public consumption is 0.3 percent over the entire forecast horizon.

Similarly, shocks to domestic credit to the private sector account for 0 percent, 12 percent, 13.7 percent, 15.5 percent and 16.1 percent of the error variance in real output respectively. The average proportion of the forecast error owing to innovations in domestic credit to the private sector over the entire forecast horizon is 14.4 percent.

Private investment on the other hand would seem to account for 0 percent of the error variance in real output in the first period, 1.1 percent in the fifth period, 0.8 percent in the tenth period, 2.0 percent in the twentieth period and 2.4 percent in the thirtieth period respectively. The proportion of the forecast error variance owing to innovations in private investment is 1.6 percent over the entire forecast horizon.

Thus shocks to real output would seem to explain a significant proportion of the error variance of real output. This observation would seem to support the earlier finding of weak exogeneity of real output. Innovations in domestic credit to the private sector would also seem to account, on average, for a modest proportion of the variation in real output. Innovations in public investment would seem to account for a minimal proportion of the variation in real output, followed by private investment and lastly by public consumption.

These observations would seem to point to a weak causal link from public and private investments to real output and in the short run. This finding is consistent with inferences based

on the VECM and Granger causality analysed above. Public investment would also seem to account for a slightly higher proportion of variation in real output relative to private investment. This result is somewhat surprising in that we would ordinarily expect private investment to account for a greater proportion of the variation in real output relative to public investment, particularly in a liberalised economy like Zambia. This expectation arises from the fact that the private sectors decisions to form capital are expected to be spurred by the public sectors decision to form capital. Thus if public investment provides capital that is relevant and beneficial to the private sector, then the private sector, driven by a motivation to exploit profit making opportunities can be expected to investment in capital that allows the private sector to produce goods and services most beneficial to the economy. In this way, the impact of private sector investment on real output can be expected to be much larger than that of public investment due to the argument that the profit making motive encourages private investment to be far more efficient relative to public investment. However the finding above would seem to contradict this logical process and implies that the private sector is constrained in the process of fully and efficiently exploiting profit making opportunities in the economy.

5.10.1.2 Forecast Error Variance Decomposition of Private Investment

The forecast error variance decomposition for private investment reveals that own account innovations account for 97.2 percent, 75 percent, 63.5 percent, 50.6 percent and 46.2 percent of the error variance in the first, fifth, tenth, twentieth and thirtieth periods respectively. Thus own account innovations account for a significant proportion of the variance in private investment, accounting on average for 66.5 percent.

Forecast error variance decomposition of private investment conducted by Brinca (2006) revealed that in Sweden, own account shocks to private investment accounted on average for only 53.9 percent of the variance in private investment over a forecast horizon of fifteen years. For Zambia, on average, own account innovations in private investment accounted for a slightly higher proportion of the variation in private investment.

Shocks to public investment account for 0 percent, 5 percent, 5.4 percent, 3.5 percent and 2.9 percent of the forecast error variance of private investment at the first, fifth, tenth, twentieth and thirtieth periods respectively. This observation implies that innovations in public investment

accounted for a minimal proportion of the variance of private investment. Forecast error variance decompositions conducted by Brinca (2006) revealed that in the case of Sweden, shocks to public investment on average accounted for 9.3 percent of the variation in the variance of private investment over a forecast horizon of fifteen periods. This despite being a modest share of the variation is much higher than in the case is for Zambia, where the average variation due to public investment was 4.2 percent on average over a forecast horizon of thirty years.

Given the critical role that public capital formation plays in the success of the private investment process, public investment should ordinarily account for a more significant proportion of the variation in private investment than the minimal share observed above. Despite the crowding in effect of public on private investment observed above, the observation that public investment accounts for a modest proportion of the variation in private investment for the case of the Zambian economy is quite alarming indeed. This observation raises serious concerns as regards whether an appropriate level of public investment is being undertaken and more importantly whether the existing public investment undertaken meets the productivity needs of the private sector.

The proportion of the error variance in private investment accounted for by shocks in real output were also investigated. In the first, fifth, tenth, twentieth and thirtieth periods respectively real output innovations explain 2.8 percent, 12 percent, 19.1 percent, 30.1 percent and 33.9 percent of the variation in private investment respectively. The average variation in private investment over the forecast horizon due to real output innovations was estimated at 19.6 percent. This can be contrasted with Brinca (2006) finding an average variation of 12.5 percent in private investment arising from innovations in real output, which is marginally lower the average variation for Zambia.

Shocks to public consumption were revealed to account for a small proportion of the variation in private investment at the first, second, tenth, twentieth and thirtieth periods respectively. The variation was revealed to amount to 0 percent, 2.9 percent, 3.4 percent, 3.4 percent and 3.4 percent respectively. The average variance in private investment owing to shocks to public consumption was found to be 4.1 percent over the forecast horizon of thirty years.

In the case of shocks to domestic credit to the private sector, in the first period these explain 0 per cent of the variance in private investment. In the fifth, tenth, twentieth and thirtieth periods,

shocks to domestic credit account for 4.5 percent, 8.7 percent, 12.4 percent and 13.5 percent of the variance in private investment respectively, reflecting an average variation of 9.8 percent over the entire forecast horizon.

Analysis of the calculated error variances in private investment arising from various sources yields some very important insights. The greatest proportion of the variation in private investment would seem to be accounted for by own account innovations, followed by innovations in real output, domestic credit to the private sector, public investment and public consumption respectively.

Given the importance of public capital formation decisions to the productivity and expected profitability of private sector investment, the modest proportion of the variation in private investment arising from innovations in public investment point to constraints and impediments to the productivity and efficiency of public investment. This in turn implies that private investment is constrained in terms of its productivity and the role it plays in contributing more substantially to real output. In other words, in the face of efficiency and productivity constraints to private sector investment in Zambia, it would seem that public investment undertaken to alleviate some of these constraints does not seem to be leading to an alleviation of these constraints to an appropriate extent. This finding while surprising in its own right, but can also be linked to the finding above of private investment accounting for a very minimal proportion of the variation in real output. This finding is particularly significant given the critical importance placed on the role that private investment plays in determining economic growth, employment and wealth creation in an economy. The finding also points to the fact that private investment can play a more substantial role in the economy and real output can be increased simply by improving the impact of public investment on private investment.

Secondly, the modest proportion of the variation in private investment accounted for by domestic credit to the private sector is also particularly noteworthy. This is particularly so in the light of the observation of Granger non causality of domestic credit to private investment and would seem to point to the fact that there are constraints that impede the potentially significant role that domestic credit to the private sector can play in the private investment process. Given the importance of credit provision to the productivity and efficiency of private investment, this finding points to another constraint to private investment in Zambia. Thus increased credit

provision to the private sector and an alleviation of possible constraints in accessing credit, can both play a more significant role in enhancing the productivity of private investment in Zambia.

Thirdly, the proportion of the variation accounted for due to shocks in real output would seem to conform to the accelerator theories of investment, which point to the significant role that real output plays in determining private investment. Another noteworthy observation is fact that real output takes a long duration to account for a significant proportion of the variation in private investment. Thus it would seem that private investment responds to real output with a significant lag. An implication of this result is that the process of increasing real output can lead to a potential stimulation of private investment, particularly if other impediments to private investment such as credit provision are removed.

5.10.1.3 Forecast Error Variance Decomposition of Public Investment

The forecast error variance decomposition of public investment reveals that own account innovations account for 19.7 percent, 18.5 percent, 13.6 percent, 10.8 percent and 9.5 percent of the variation in the first, fifth, tenth, twentieth and thirtieth periods respectively. The average variation in public investment due to own account innovations was found to be approximately equal to 14.4 percent over the forecast period. In the case of Sweden, own account innovations were revealed to account on average for 82.9 percent of the variance in public investment, significantly higher than the average proportion for Zambia.

Shocks to private investment at the first, fifth, tenth, twentieth and thirtieth periods were revealed to account for 57.9 percent, 51 percent, 41.4 percent, 36.7 percent and 36.4 percent of the variance in public investment. On average, shocks to private investment accounted for 44.7 percent of the variance in public investment. In the case of Sweden, shocks to private investment were revealed to account on average for 9.6 percent of the variance in public investment, a significantly lower proportion relative to the average value for Zambia.

Similarly, shocks to real output were found to account for 16.8 percent, 22.3 percent, 39.3 percent, 48.7 percent and 52.8 percent of the variance in public investment at the first, fifth, tenth, twentieth and thirtieth periods respectively. The average proportion of the variance in public investment due to shocks in real output was estimated to approximately equal to 35.9 percent. Thus innovations in real output rise sharply from modest levels in the first and fifth

periods and would seem to account for a significant proportion of the variation in public investment over the forecast horizon, relative to shocks in the other variables. In contrast, Brinca (2006) revealed that in the case of Sweden, shocks to real output accounted on average for 8.2percent of the variance in public investment over a forecast horizon of fifteen periods.

In the case of public consumption, shocks to its errors were found to account on average for 2.3 percent of the variance in public investment over the forecast horizon. Specifically at the first, fifth, tenth, twentieth and thirtieth periods, innovations in public consumption accounted for 2.9 percent, 2.9 percent, 2.3 percent, 2 percent and 1.2 percent of the variance in public investment.

Domestic credit to the private sector was revealed to account for less substantial proportion of the variation in public investment. Specifically, shocks to domestic credit accounted for 2.7 percent, 5.2 percent, 3.2 percent, 1.7 percent and 1.2 percent of the variance in public investment in the first, fifth, tenth, twentieth and thirtieth periods respectively. The average proportion of the variation in public investment owing to innovations in domestic credit to the private sector is 2.8 percent over the forecast horizon.

The highest proportion of the variance in public investment would seem to be accounted for by private investment, followed by real output. Relative to real output, the other exogenous variable in the system, own account innovations for public investment account for only a modest proportion of the variance in public investment. Domestic credit to the private sector and public consumption comprise the lowest proportion of the variance in public investment over the forecast horizon.

Analysis of the calculated error variances in public investment arising from various sources yields some very important insights. Firstly, the causal link between public investment and private investment would seem to be reasonably strong. This is evident in the fact that private investment accounts for a substantial proportion of the variance in public investment over the forecast horizon. This observation is similar to that noted in the case of the error variance decomposition of private investment.

Though real output accounts for a substantial proportion of the variation in public investment over the forecast horizon, this effect would only seem to accrue over an extended period of time. This would seem to point to the fact that it takes a significant amount of time for public investment to become productive and have a significant impact on real output.

5.10.1.4 Forecast Error Variance Decomposition of Domestic Credit to the Private Sector

The forecast error variance decomposition of domestic credit to the private sector reveals that own account innovations account for a significant proportion of the variance in domestic credit. In the first period, own account innovations account for 82.1 percent of the variance in domestic credit. However after five periods the own account proportion of the variance in domestic credit falls significantly to 34.3 percent. For the tenth, twentieth and thirtieth periods, own account innovations account for 16 percent, 9.9 percent and 6.7 percent of the variance in domestic credit. On average, own account innovations account for 29.8 percent of the variance in domestic credit.

Over the thirty year forecast period, innovations in public investment account, on average for 19.1 percent of the variance in domestic credit to the private sector. In the case of public consumption, innovations in this variable, on average over the thirty year forecast horizon account for 2.4 percent of the variance in domestic credit to the private sector.

Private investment innovations account on average for 45.9 percent of the variance in domestic credit over the thirty year forecast horizon. In the case of real output, calculated over the thirty year forecast horizon, shocks to this variable account on average for 6.8 percent of the variance in domestic credit to the private sector.

Decomposition of the forecast error variance in domestic credit arising from shock to various variables revealed that innovations to private investment and own account innovations account for the greatest proportion of the variance in domestic credit respectively. Shocks to public investment, followed by shocks to real output followed by shocks to public consumption accounted for the least proportion of the variance in domestic credit to the private sector over the forecast horizon respectively.

Given the critical role that credit can potentially play in the private sectors decisions to invest, the substantial proportion owing to private investment to the variance of domestic credit is particularly noteworthy. Most investors will rely less on their own resources in the investment process, but rely more on resources saved by other economic agents, channelled through the banking system in the financial intermediation process and borrowed to exploit profit making opportunities in the economy. Thus the strong causal link between domestic credit and private

investment points greater credit provision as a potential channel through which private investment can be promoted.

5.10.1.5 Forecast Error Variance Decomposition of Public Consumption

The forecast error variance decomposition of public consumption reveals that own account innovations account for 50.1 percent of the variance on public consumption in the initial period. This proportion falls significantly in the fifth period to only 1.7 percent. In the tenth period own account innovations account for 0.6 percent, while in both the twentieth and thirtieth periods they account for 0.3 percent of the variance in public consumption. On average over the entire forecast horizon, own account innovations are responsible for approximately 10.6 percent of the variance in public consumption.

Decomposition of the forecast error variance owing to various sources reveals that innovations in real output account for a significant proportion of the variation in public consumption, on average equalling approximately 57 percent. Public investment innovations on average account for 2 percent of the variance in public consumption, while those of domestic credit account, on average for 24 percent of the variation in public consumption. Private investment innovations would seem to account on average for approximately 7.9 percent of the variation in public consumption.

Innovations in real output would seem to account for the greatest proportion of the forecast error variance of public consumption. This is followed by innovations owing to domestic credit to the private sector, own account innovations and innovations owing to private and public investments respectively.

The proportion of the variation in public consumption owing to real output points to a causal link between the two. Similarly there would seem to be a causal link between public consumption and domestic credit to the private sector.

5.11 Discussion of Results

Several aspects of the dynamic interaction among public investment, private investment and real output conducted above are noteworthy. Crucially, results of the study point to the fact that public investment has its expected positive and significant impact on private investment and real output of the Zambian economy in the long run. Given the lack of consensus in the empirical

literature as regards the impact of public investment on the economy, this finding is particularly significant. This is because it provides solid empirical evidence that public investment is having beneficial effects on the Zambian economy in terms of crowding in private investment and increasing real output in the long run.

Also noteworthy is the finding of a negative effect of public consumption on private investment. In the light of the positive effect of public consumption on real output, the former effect would point to the fact that public policy makers face a trade off between the positive effects of public consumption on real output and its negative effect on private investment.

Analysis of several aspects of the short run interaction of the variables as well as the adjustment towards equilibrium (The VECM, Granger causality and variance decomposition analyses) reveals further insights. The results reveal a strong causal link from public investment to private investment in the short run. This implies that even in the short run, public investment has a significant crowding in effect on private investment by way of increasing the efficiency of private investment.

However results would also seem to point to a weak causal link from both public and private investments to real output in the short run. This is evident from the insignificant effects of both types of investment on real output in the VECM analysis, Granger non causality from public and private investments to real output and in the low proportion of the forecast error of real output attributed to public and private investments respectively. Thus public and private investments would seem only to only have their expected effect on real output in the economy with a significant short run lag.

The results would also point to a strong causal link from domestic credit to the private sector and real output respectively, to private investment. This implies that greater credit provision to the private sector for investment purposes and increases in real output can be potentially useful for purposes of encouraging or stimulating greater investment by the private sector in Zambia.

The finding of weak exogeneity of real output is consistent with Naqvi (2002), King and Levine (1994) and Easterly and Levine (2001) who argue that weak exogeneity of real output in such a context supports arguments against the capital fundamentalist view of the growth process. This view of the growth process argues for the complete indispensability of capital in the growth process. Thus attempts to increase the stock of capital through investment are particularly critical

to the growth process relative to other contributors to the growth process. According to this view, causality runs from investment to economic growth. However the finding of weak exogeneity of real output in Zambia would seem to imply that despite the importance of investments in the capital stock, these are by no means a panacea in the growth process. Thus determinants or sources of growth not directly related to investment in the physical capital stock are also vital in the process of achieving long term sustainable economic growth.

The finding of strong exogeneity of public investment is also a particularly important result. It points to a complete lack of responsiveness of public investment. This is a particularly surprising result because it implies that public policy makers, in formulating capital formation decisions do not take into account various aspects of the economy such as the needs of private investment and the evolution of real output. What we would expect is for public policy makers in determining the type of public investment to undertake, where, when and how much to undertake it, to consider very carefully such characteristics of the economy. In this way, public investment is expected to be very responsive to the needs of the economy. However the results reveal that this is simply not occurring to any appreciable extent.

Strong exogeneity of public investment thus raises serious questions as regards the efficiency of public investment. If there is no consideration of the precise characteristics or needs of the economy, then this implies that there is a risk of so called 'white elephant' public investments being undertaken in Zambia, which simply refer to haphazard and non efficient public investment projects.

Thus, the results of this study point to the fact that public investment undertaken in Zambia is characterised by the following:

i. It is undertaken without public policy makers considering the specific constraints, bottlenecks and capital formation needs and requirements of the economy in general and the private sector in particular.
ii. It takes an inordinate amount of time to become productive and exert a positive and significant effect on real output.

Using an analogy from the medical field, the public investment process in Zambia can be likened to the prescription of medical treatment in the absence of an appropriate diagnosis of the particular malady present in a given case.

This would seem to imply that there are factors that constrain the productivity, efficiency and quality of public investment. Because public investment cannot become fully efficient and productive in the shortest possible time, the efficiency and productivity of private investment, whose productivity is inherently dependent on public investment, is also inadvertently constrained and thus their individual impact on real output is likewise affected.

The findings of this study and implications and inferences based upon them are consistent with the findings of other studies specifically analysing the efficiency and productivity of public investment in Zambia. Discussion of the results of this study would thus be incomplete without leaning on the findings of these studies to highlight some of the major constraints to the productivity, efficiency of public investment.

For instance Public Expenditure Reviews (PER's) conducted in Zambia by the World Bank since 2001 have highlighted several key issues as regards the management and efficiency of the public sector in Zambia. The 2010 PER (World Bank, 2010) assessed the management of public expenditure in Zambia by various criteria including;

Strategic guidance and project appraisal

Review in this area assessed whether investment projects are chosen based on developmental priorities and for their social, environmental and economic significance. Among the criteria assessed included the extent to which public investment projects conformed to medium and long term planning instruments developed for purposes of guiding the annual budgeting process in general and particularly the capital budgeting process. These include The Vision 2030, The Fifth and Sixth National Development Plans, sector specific development strategies and The Medium Term Expenditure Framework (MTEF).

Project selection and budgeting

Review in this area assessed whether the process of selecting public investment projects is linked to the budget cycle and medium term budget frameworks that ensured fiscal discipline and a link between short, medium term and long term country objectives.

The poor quality of medium term strategic guidance was argued to lead to inefficient investment prioritization and poor investment screening and appraisal. The quality of the MTEF was also questioned as it was argued to be too significantly influenced by the annual budget cycle process.

Donor project appraisal in some cases reflected the specific priorities of the specific donor and not local needs, while appraisal of government funded projects was argued to be characterized by lack of an appropriate mix of central guidance and sectoral consultation on project selection an appraisal.

Project management and implementation

Review in this area focused on whether the process of public investment involves timely budget execution, efficient procurement, sound internal budgetary monitoring and controls supporting financial and program management.

The process of project management and implementation was also noted to be characterised by the absence of appropriate guidelines. Also agencies charged with the task of project implementation –the Ministries of Finance and National Planning as well as Works and Supply were also identified as not possessing the capacity to identify and analyse early symptoms of project delays and incompleteness or cost overruns.

Project evaluation and audit

Review under this component focused on whether public investment management systems include an ex post evaluation of completed projects. Also a comparison of project costs with those established during the project design, maintenance of comprehensive and reliable asset registers that are subject to external audit.

The process of project evaluation and audit was identified as lacking a formal institutional arrangement to allow for effective central monitoring and feeding the evaluation results into learning, communicating and drawing lessons for new project cycles.

Dabla-Norris et.al (2010) went a step further and developed a Public Investment Management Index (PIMI) which attempts to capture efficiency issues in the assessment of public investment. The PIMI is a multidimensional index of public investment management efficiency and quality composed of 17 indicators grouped into four consecutive stages of the public investment management cycle. Each country is given an overall score (composed of sub scores in each category) between 0 and 4, with a higher score reflecting better public investment management performance and vice versa. The four categories assessed correspond to the categories of the

PER and include; Strategic guidance and project appraisal, Project selection and budgeting, Project evaluation and audit and Project management and implementation

The overall PIMI country score for Zambia was reported as 1.87 out of 4. This implies that public investment in Zambia was assessed as being only 47 percent efficient. This can be compared against the mean overall index score of 1.68 or 42 percent, for all 70 countries for whom a PIMI index was constructed. Thus public investment in Zambia was assessed as being less than 50 percent efficient due to various factors and was also marginally more efficient relative to the average score.

To shed more light on the specific areas where public investment management was falling short Dabla-Norris et.al (2010) also provide PIMI sub scores for Zambia. These sub scores corresponding to the consecutive stages of the public investment management cycle; strategic guidance and project appraisal, project selection and budgeting, project evaluation and audit and project management and implementation.

The sub score for the appraisal sub component was found to be 1.50 out of a possible sub score of 4. This implies that project appraisal in the process of public investment in Zambia was only 38 percent efficient. The project selection sub score was found to be 2.80 out of 4, reflecting 70 percent efficiency of project selection in Zambia. The implementation sub score was found to be 1.87 out of 4, reflecting 47 percent efficiency of project implementation in Zambia. Lastly, the project evaluation sub score was found to be 1.33 out of a possible 4, reflecting an efficiency level of project evaluation of 33 percent.

It is thus evident that the greatest deficiencies contributing to the observed less than 50 percent efficiency of public investment in Zambia are as a result of lack of adequate ex post evaluation of completed projects incorporating a comparison of project costs with those established during the project design, which only occurred 33 percent of the time.

Utilising the results of studies specifically assessing the efficiency of public investment in Zambia thus sheds light on the important findings of this study contained above. It is now clearly evident that inefficiencies inherent in the nature of the public investment process in Zambia are more than likely responsible for the nature of the results discussed above.

Specifically, inefficiencies identified as inherent in the processes of strategic guidance and project appraisal, as well as project selection and budgeting of public investment projects, may very well be responsible for the lack of responsiveness of public investment to private investment and real output identified based on the results above. Similarly, inefficiencies identified as inherent in the processes of project management and implementation, as well as project evaluation and audit of public investment projects, may very well explain the study finding of public investment taking an inordinate amount of time to become productive and exert a positive and significant effect, particularly on real output.

With the empirical results obtained, analysed and discussed, the next chapter concludes the study and presents policy recommendations and suggestions for future research.

CHAPTER SIX

POLICY RECOMMENDATIONS AND CONCLUSION

6.1 Main Findings of the Study, Policy Recommendations and Conclusion

This study examined the impact of public investment on private investment and real output in Zambia during the period 1980-2008. A Cointegrated Vector Autoregressive Model was utilised to characterize the short run and long run relationships among the variables, as well as the adjustment to long run equilibrium.

The long run results indicated that public investment exerts a positive and significant effect on private investment and real output. Thus as the Zambian government attempts to close the infrastructure gap (which has been estimated to be $500 million per year by Foster and Dominguez, 2010) with increased public sector investment, it can be assured that such public investments crowd in private sector investment and increase real output of the Zambian economy in the long run.

Similarly, domestic credit to the private sector has a positive effect on both real output and private investment. However, public consumption has a positive effect on real output but a negative effect on private investment in the long run.

Furthermore, the results of the study revealed that inefficiencies and constraints inherent in the nature of public investment are pervasive on the short run dynamics, the adjustment mechanism towards the long run as well as in the nature of the long run impact of public investment on private investment and real output in Zambia. This was evident from the finding of a weak causal link from public and private investments to real output in the short run. These surprising results were linked to the pervasive effects of inefficiencies inherent in the public investment management process in Zambia whose effects imply that public and private investments have their impacts on real output with a significant time lag.

Crucially, these observations points to the fact that attempts implemented thus far in the Zambian economy to alleviate the constraints faced by private investment, improve public investment management and correct the inefficiencies inherent in the public investment process in Zambia including privatization and liberalization of the economy, have not yielded expected results.

Thus as the government attempts to close the infrastructure gap, eliminate supply bottlenecks and provide an enabling environment for increased private investment and economic growth, increased public investments will be critical. However, equally critical are renewed attempts to improve the efficiency and management of public investment. Thus going forward, a four pronged approach is recommended to Zambian public policy makers:

Firstly the study points to the fact that public investment has the potential to greatly increase real output and promote the much needed growth of the Zambian economy. Thus fiscal space must be created in the government budget to finance greater public investments. This can arise by way of broadening the tax base, reducing exemptions and simplifying the tax system soas to include elements in the informal sector not currently captured by the tax system. Also the Zambian government must utilise the country's recently acquired B+ sovereign credit rating in accessing the international capital markets so as to borrow for purposes of financing public investment projects that enhance the efficiency of private investment and thus lead to increases in real output.

Secondly the study points to an important route through which private sector investment can be encouraged. The link between domestic credit and private investment can be potentially exploited so as to stimulate increased private investment. Improved credit creation initiatives to the private sector specifically in the banking sector are also to be encouraged and implemented. A special facility under the Citizens Economic Empowerment Commission (CEEC) can be created. Under this facility, government can publicise investment goods that it purchases and guarantee to purchase any that can be competitively produced locally. The lending facility under CEEC can then extend credit to any private agents that demonstrate capability to invest in capital and supply these goods and services to the government. Special incentives such as longer repayment periods on loans or duty free importation of inputs can also be extended to those investing. Private sector investment arising from this initiative would be critical in employment and wealth creation and increases in real output in the domestic economy.

Thirdly, public policy makers are advised to cap or even curb public consumption. This is owing to its deleterious effects on private investment. Where possible, public policy makers are advised to substitute consumption expenditure with appropriate investment expenditure soas to increase both private investment and real output of the Zambian economy.

Fourthly, initiatives embarked on to improve the efficiency and quality of public investment must be bolstered and revamped. This will help to ensure that the potential benefits of public investment accrue within the shortest possible time. This can come about owing to initiatives in various stages of the public investment process;

Strategic guidance and project appraisal

Despite the emergence of the MTEF as a medium term expenditure management tool, there is further need to strengthen it. Specifically the MTEF must foster an adequate link between national development priorities and the annual budgeting process. Also recurrent costs of capital projects must be adequately incorporated in the MTEF.

Appraisal of public investment projects must be based on an evaluation of their viability and socio-economic benefits with projects promising the greatest developmental benefits being prioritised.

Project Selection

This can arise through formalisation and institutionalising the process of consultation of the private sector as public policy makers make public investment decisions. Specifically this can be done through the process of submissions to the annual budget, Sectoral Advisory Groups in ministries such as the Ministry of Commerce and The Ministry of Works and Supply as well as various private sector associations such as the Zambia Business Forum, The Private Sector Development Association, The Zambia Association of Manufacturers and The Chamber of Commerce and Industry. Information can be obtained from these institutions as to the specific capital formation constraints the private sector is facing and this information can then be utilised to make specific public investment decisions.

Project management and implementation

Procurement procedures must be made more efficient with awarding of contracts being based on a process of open tenders and competitive bidding.

A planning and budget act must be developed and implemented. This act will in turn set out effective guidelines that can be utilised in the process of management and implementation of public investment projects.

Adequate capacity must also be developed within the monitoring and evaluation and implementation departments of the Ministries of Finance and National Planning as well as Works and Supply. This must also extend to the provision of adequate staffing levels, transportation as well as other incentives required for their effective operation.

Project evaluation and audit

Capacity building initiatives must be embarked on in critical areas of monitoring and evaluation. Such capacity building must specifically focus on monitoring, evaluation and implementation departments in critical ministries such as Finance and National planning and Works and Supply. This will enable identification and analysis of and solution to, root causes of project delays or incompleteness as well as adequate evaluation of contractors for such projects.

An effective database must be developed that can be used to trace progress in projects and detect early symptoms of project delays or incompleteness

6.2 Limitations of the Study and Recommendations for Future Research

This study focused on investigating the link between investment and real output by disaggregating the investment into public and private investment measured by public and private sector capital formation or GDFI. Other measures of public investment such as expenditures on education and health were not examined in this study. This was due to the convention observed in the empirical literature towards examining the nature of the close link between public and private investment capital formation decisions as well as the impact of these decisions on real output. Also a need to preserve degrees of freedom was identified and these would have been consumed with the estimation of additional parameters arising from the inclusion of additional variables.

However disaggregating GDFI further to analyse the link between public and private investment at sectoral level say for the transport, agriculture, mining and manufacturing sectors may also yield interesting results. Such a investigation will become possible as longer time series of disaggregated data on GDFI, at present unavailable, become available through the Economic Census phase 2, recently embarked upon by the by the Central Statistical Office.

REFERENCES

Africa Development Bank/Organization for Economic Cooperation and Development, 2003. "Africa Economic Outlook: Zambia," Organisation for Economic Cooperation and Development, Paris.

Agenor, P., M.K. Nabli and Y.M. Tarik, 2005. "Public Infrastructure and Private Investment in the Middle East and North Africa," World Bank Research Working Paper 3661, Washington.

Anderson, E., P. De Renzio and S. Levy, 2006. "The Role of Public Investment in Poverty Reduction: Theories, Evidence and Methods," Overseas Development Institute, Working Paper 263, London.

Anwer, M.S., and R.K. Sampath, 1999. "Investment and Economic Growth," Paper Presented at the Western Agricultural Economics Association Annual Meeting, July 11-14, 1999, Colorado.

Aschauer, D., 1989. "Is Public Expenditure Productive?" Journal of Monetary Economics, 23 (March), 177-200.

Ayogu, M., 2007. "Infrastructure and Economic Development in Africa: A Review," Journal of African Economies, Supplement 1, 75-126.

Badawi, A., 2003. "Private Capital Formation and Public Investment in Sudan: Testing the Substitutability and Complementarity Hypothesis in a Growth Framework," Institute for Development Policy and Management (IDPM), University of Manchester, Manchester.

Blomstrom, M., R.E. Lipsey and M. Zejan, 1996. "Is Fixed Investment the Key to Economic Growth?" Quarterly Journal of Economics, 51(1), 269-276.

Boopen, S. and A.J. Khadaroo, 2006. "Transport Capital and Private Capital Formation in Mauritius: Testing the Substitutability and Complementarity Hypotheses," Working Paper 341, The University of Mauritius.

Brinca, P., 2006. The Impact of Public Investment in Sweden: A VAR Approach, Msc in Economics Thesis, Stockholm University.

Bukhari, S., L. Ali, and M. Saddaqat, 2007. "Public Investment and Economic Growth in The Three little Dragons: Evidence from Heterogeneous Panel Data," International Journal of Business an information, 2(1), 57-79.

Calderon, C., and L. Serven, 2008. "Infrastructure and Economic Development in Sub-Saharan Africa," Policy and Research Working Paper 4712, The World Bank, Washington D.C.

Calderon, C., and L. Serven, 2003. "The Output Cost of Latin America's Infrastructure Gap," in The Limits of Stabilization- Infrastructure, Public Deficits and Growth in Latin America, Ed. Easterly, W. and L. Serven, The World Bank, Washington D.C.

Charemza, W.W., and D.F. Deadman, 1997. New Directions in Econometric Practice: General to Specific Modelling, Cointegration and Vector Autoregression, 2nd Edition, Edward Elgar Publishing, Cheltenham.

Clements, B., R. Bhattacharya and Q.N. Toan, 2003. "External debt, Public Investment and Growth in Low Income Countries," International Monetary Fund, Washington D.C.

Commission on Growth and Development, 2008. "Strategies for Sustained Growth and Inclusive Development," The International Bank for Reconstruction and Development/ The World Bank, Washington, D.C.

Dabla-Norris, E., J. Brumby, A. Kyobe, Z. Mills and C. Papageorgiou, 2010. "Investing in Public Investment: An Index OF Public Investment Efficiency," IMF Working Paper, IMF, Washington D.C.

Dalamagas, B., 1995. "A Reconsideration of the Public Sector's Contribution to Growth," Empirical Economics, 20(3), 385-414.

De La Fuente, A., and X. Vives, 1995. "Infrastructure and Education as Instruments of Regional Policy-Evidence from Spain," Economic Policy, 20, 11-54.

Devarajan, S., V. Swaroop and H. Zou, 1996. "The Composition of Public Expenditure and Economic Growth," Journal of Monetary Economics, 32(December), 417-458.

Development Committee, 2006. "Fiscal Policy for Growth and Development-An Interim Report," The World Bank, Washington D.C.

Diao, X., and Y. Yanoma, 2003. "Exploring Regional Dynamics in Sub-Saharan African Agriculture," International Food Policy Research Institute Discussion Paper (2).

Easterly, W., and R. Levine, 2001. "It's Not Factor Accumulation: Stylized Facts and Growth Models," World Bank, Washington .D.C.

Easterly, W. and S. Rebelo, 1993. "Fiscal Policy and Economic Growth," Journal of Monetary Economics, 32 (December), 417-58.

Enders, W., 1995. Applied Econometric Times Series, John Wiley and Sons Inc., Singapore.

Engel R.F., D.F. Hendry and J.F. Richard, 1983. "Exogeneity," Econometrica, 51, 277-304.

Ericsson N.R., D.F. Hendry, G.E. Mizon. 1998. "Exogeneity, Cointegration and Economic Policy Analysis," Board of Governors of the Federal Reserve System, International Finance Discussion Paper, 616, Washington, D.C.

Estache, A., 2005. "What do we know about Sub-Saharan Africa's Infrastructure and the Impact of its 1990's Reforms?" The World Bank, *Universite' Libre de Bruxelles.*

Evans, P., and G. Karras, 1994. "Are Government Activities Productive? Evidence from a Panel of U.S. States," The Review of Economics and Statistics, 76(1), 1-11.

Fan, S., and N. Rao, 2003. "Public Spending in Developing Countries: Trends, Determinants and Impact," International Food Policy Research Institute, Washington D.C.

Fan, S., J. Somchai and R. Neetha, 2004. "Rural Infrastructure Development and Poverty Reduction in Rural Thailand," Project Report Submitted to the Asia Development Bank by International Food Policy Research Institute (IFPRI).

Fedderke, J.W., R.D. Kadt and J.M. Luiz, 2005. "Indicators of Political Liberty, Property Rights and Political Instability in South Africa: 1935-1997," International Review of law and Economics, 21, 103-134.

Foster, V., and C. Dominguez, 2010. "African Infrastructure Country Diagnostic Country Report on Zambia's Infrastructure: A Continental Perspective," The World Bank, Washington D.C.

Galiani, S., P. Gertler and E. Schargrodsky, 2005. "Water for Life: The Impact of Privatization of Water Services on Child Mortality," Journal of Political Economy, 113, 83-120.

Geweke, J., R. Meese and W. Dent, 1983. "Comparing Alternative Tests of Causality in Temporal Systems: Analytic Results and Experimental Evidence," Journal of Econometrics, 21, 161-194.

Ghali, K.H., 1998. "Public Investment and Private Capital Formation in a Vector Error Correction Model of Growth, Applied Economics, 30, 837-844.

Ghani, E., and M. Din, 2006. "The Impact of Public Investment on Economic Growth in Pakistan," The Pakistan Development Review, Spring (2006), 87-98.

Gupta, S., B. Clemens, E. Baldacci and C. Mulas-Granados, 2004. "Fiscal Policy, Expenditure Composition and Growth in Low Income Countries," International Monetary Fund, Washington, D.C.

Gupta, S., Powell .R. and Y. Yang, 2006. "Macroeconomic Challenges of Scaling up Aid to Africa: A Checklist for Practitioners," International Monetary Fund, Washington D.C.

International Monetary Fund, 2004. "Public Investment and Fiscal Policy," The Fiscal Affairs Department, I.M.F. Washington, D.C.

Ismihan, M., K. Metin-Ozcan and A. Tansel, (2002). "Macroeconomic Instability, Capital Accumulation and Growth: The Case of Turkey 1963-1999," Economic Research Centre Working Papers in Economics 02/04, Middle East Technical University, Ankara.

Jones, C., 1995. "Time Series Tests of Endogenous Growth Models," The Quarterly Journal of Economics, 110, 495-525.

Kandenge, F., 2010. "Public and Private Investment and Economic Growth in Namibia: 1970-2005," The Botswana Journal of Economics, 7, (11), 2-15.

Kavanagh, C., 1997. "Public Capital and Private Sector Productivity in Ireland 1958-1990," Journal of Economic Studies, 24, 74-94.

Kelejian, H., and D. Robinson (1997). "Infrastructure Productivity Estimation: A Sensitivity Analysis," Papers in Regional Science, 76, 115-131.

Khan, M., 1996. "Government Investment and Economic Growth in the Developing World," The Pakistan Development Review, Winter (1996), 416-439.

Khan, M., and C. Reinhart, 1990. "Private Investment and Economic Growth in Developing Countries," World Development, 18(1), 19-27.

King, R.G., and R. Levine, 1994. "Capital Fundamentalism, Economic Development and Economic Growth," Carnegie-Rochester Series on Public Policy, 40, 259-292.

La Ferrara, E., and M. Marcellino, 2000. "Total Factor Productivity, Costs and Public Infrastructure: An Equivocal Relationship," Innocenza Gasparini Institute for Economic Research Working Paper No. 176, Milan.

Lanchovichina, E., and S. Lundstrum, 2008. "What Are the Constraints to Inclusive Growth in Zambia," The World Bank, Washington D.C.

Longa, K.W., 2011. "Financial Development and Economic Growth: Evidence from Botswana, Mauritius and Zambia," M.A. in Economics Thesis, University of Malawi.

Mas, M., J. Maudos, F. Perez and E. Uriel, 1996. "Infrastructures and Productivity in the Spanish Regions," Regional Studies, 30(7), 641-650.

Merriman, D., (1991). "Public Capital and Regional Output: Another Look at Some Japanese and American Data," Regional Science and Urban Economics, 20 (February), 437-58.

Ministry of Finance and National Planning, 2010. "Economic Report 2009," Government of the Republic of Zambia, Lusaka.

Ministry of Finance and National Planning, 2011. "Sixth National Development Plan 2011-2015: Executive Summary," Government of the Republic of Zambia, Lusaka.

Mittnik, S., and T. Neumann, 2001. "Dynamic Effects of Public Investment: Vector Autoregressive Evidence from Six Industrialized Countries," Empirical Economics, 26, 429-446.

Morrison, C.J., and A.E. Schwartz, 1996. "State Infrastructure and Productive Performance," American Economic Review, 86 (December), 1095-111.

Muqtada, M., 2010. "The Crisis of Orthodox Macroeconomic Policy: The Case for a Renewed Commitment to Full Employment," Employment Sector Working Paper No. 53, ILO, Geneva.

Nasmi, N., and M.D. Ramirez, (2003). "Public Investment and Economic Growth in Latin America: An Empirical Test," Review of Development Economics, 7, 115-126, Hartford, Connecticut.

Nasmi, R., and M.D. Ramirez, 1997. "Public and Private Investment in Mexico 1950-90: An Empirical Analysis," Southern Economic Journal, 61(1), 112-153.

Naqvi, N., (2002). "Crowding-in or Crowding-out? Modelling the Relationship between Public and Private Fixed Capital Formation Using Co-integration Analysis: The Case of Pakistan 1964-2000," The Pakistan Development review, 41(3), 255-276.

Ndulu, B., 2006. "Infrastructure, Regional Integration and Growth in Sub Saharan Africa: Dealing with the Disadvantages of Geography and Sovereign Fragmentation," Journal of African Economies, 15 (AECR Supplement 2), 212-224.

Pereira, A.M., and J.M. Andraz, (2010). "On the Economic Effects of Public Infrastructure Investment: A Survey of International Evidence," Working Paper Number 108, Department of Economics, College of William and Mary.

Pesaran M.H., Y. Shin and R.J. Smith, (2000). "Structural Analysis of Vector Error Correction Models with Exogenous I (1) Variables," Journal of Econometrics, 97(2000), 293-343.

Rault, C., 2005. "Further Results on Weak Exogeneity in Vector Error Correction Models," Brazilian Review of Econometrics, 25(2), 159-172.

Reungsri, T., (2010). "The Impact of Public Infrastructure Investment on Economic Growth in Thailand," Doctor of Philosophy Thesis, Victoria University.

Roy, R., Heuty, A. and E. Letouze, 2006. "Fiscal Space for Public Investment: Towards a Human Development Approach," United Nations Development Program, New York.

Roy, R., and J. Weeks, 2004. "Making Fiscal Policy Work for the Poor," Paper presented to the G24 Meeting, Washington D.C.

Sims, C.A., 1980. "Macroeconomics and Reality," Econometrica, 48(1), 1-48.

Straub, S., 2008. "Infrastructure and Growth in Developing Countries: Recent Advances and Research Challenges," Policy Research Working Paper 4460, The World Bank, Washington, D.C.

Tatom, J., 1991. "Public Capital and Private Sector Performance," Review of the Federal Bank of St. Louis, 78, (3), 3-15

United Nations Development Program and Japan International Cooperation Agency, 2005. "Making Infrastructure Work for the Poor," United Nations Development Program, New York.

United Nations Economic Commission for Africa, 2011. "Economic Report on Africa 2011: Governing Development in Africa-The Role of the State in Economic Transformation," United Nations Economic Commission for Africa, Addis Ababa

Willoughby, C., 2004. "How Important is Infrastructure for Pro-Poor Growth?" Organisation for Economic Cooperation and Development, Paris.

World Bank, 2011. "African Development Indicators-ADI," The World Bank, Washington, D.C.

World Bank, 1994. "World Development Report: Infrastructure for Development," The World Bank, Washington, D.C.

World Bank, 2010. "Zambia Public Expenditure Management and Financial Accountability Review," The World Bank, Washington D.C.

Zambia Development Agency, 2011. "Public-Private Partnerships," Government of the Republic of Zambia, Lusaka.

APPENDICES

APPENDIX 1: Specification Tests

The Jarque-Bera Normality Test

Non normally distributed residuals can result in invalid statistical inference based on the t, x^2 and F statistics. This implies for instance, that coefficients may be erroneously found to be insignificant when in actual fact they are significant. Thus normality testing must be carried out.

The Jarque-Bera normality test tests the joint hypothesis that there is no skewness in the series and that the series have a kurtosis of three, implying that the kurtosis is mesokurtic.

The test statistic is given by;

$$JB = n\left[\frac{S^2}{6} + \frac{(K-3)^2}{24}\right]$$

Where;

n is the sample size

S is the skewness and,

K is kurtosis

Given a normally distributed series the JB statistic is expected to be zero. The JB statistic follows the Chi-Squared (X^2) distribution with 2 degrees of freedom. The test specifies a null-hypothesis of a normally distributed series and thus its rejection implies that the series under consideration is not normally distributed.

The LM Serial Correlation Test.

Serial correlation is said to be present when regression residuals are correlated. The estimated coefficients from such a regression are linear, unbiased, consistent and asymptotically normally distributed. However the coefficients are no longer efficient, that is to say, they longer have minimum variance. Larger than optimal variances in turn imply that there is a greater likelihood of invalid inferences based on x^2, t and F tests. This implies for instance, that coefficients may be erroneously found to be insignificant when in actual fact they are significant.

The LM test is superior to other tests for serial correlation in that it allows for lagged values of the regressand to be used as explanatory variables and for the serial correlation of an autoregressive scheme greater than one.

The test is conducted by regressing the residuals from the OLS regression on the initial vector of explanatory variables, as well as lagged residuals. The LM test statistic is then obtained as the product of the number of observations and the R^2 from the auxiliary regression. The LM statistic is asymptotically distributed as a Chi-squared statistic$X^2(p)$, p is the number of lags of the residuals in the auxiliary regression. As with the Jarque-Bera test, the LM test specifies a null-hypothesis of no autocorrelation in the series and thus its rejection implies that the series under consideration is not plagued with autocorrelation.

APPENDIX 2: Conditional Cointegrating Relationship

Table 15: Johansens' Cointegration test on the conditional model using the Trace and Maximum Eigen value statistics

Hypothesed number of Cointegrating relationships (r)	Eigen Value	Trace Statistic	Max-Eigen Statistic
$r = 0$	.	30.088**	20.822**
$r \leq 1$	0.538	9.266	6.109
$r \leq 2$	0.202	3.157	3.157

*(**)*** indicates significance at 1% , 5% and 10% respectively.

Table 16: Unrestricted Cointegrating Coefficients and Speed of adjustment Parameters Based on the Conditional Cointegrating Relationship

Variable	Coefficients of Cointegrating vector ($\boldsymbol{\beta}'$)	Speed of Adjustment Parameters ($\boldsymbol{\alpha}$)
lrip	1(restricted)	0.079 (0.051)
lrdcp	-5.144 * (0.957)	0.053 *(0.019)
lrcg	3.986 * (1.244)	-0.012 (0.025)
constant	-121.074	

*(**)*** indicates significance at 1% , 5% and 10% respectively.

APPENDIX 3: Forecast Error Variance Decomposition

Table 17: Variance Decomposition of lrgdp

period	lrig	lrcg	lrdcp	lrip	lrgdp
0	0	0	0	0	0
1	0	0	0	0	1
2	0.001	0.007	0.043	0.007	0.943
3	0.012	0.006	0.092	0.007	0.883
4	0.026	0.004	0.113	0.018	0.839
5	0.031	0.003	0.120	0.011	0.835
6	0.026	0.002	0.125	0.011	0.836
7	0.027	0.001	0.132	0.008	0.832
8	0.027	0.001	0.134	0.007	0.831
9	0.025	0.001	0.133	0.008	0.832
10	0.024	0.001	0.137	0.008	0.829
11	0.022	0.002	0.141	0.011	0.823
12	0.020	0.002	0.144	0.012	0.822
13	0.019	0.002	0.145	0.013	0.820
14	0.018	0.002	0.147	0.015	0.818
15	0.017	0.003	0.149	0.016	0.815
16	0.017	0.003	0.151	0.017	0.813
17	0.016	0.003	0.152	0.018	0.811
18	0.015	0.003	0.153	0.018	0.810
19	0.015	0.003	0.155	0.019	0.809
20	0.014	0.003	0.155	0.020	0.807
21	0.014	0.003	0.156	0.020	0.806
22	0.014	0.004	0.157	0.021	0.805
23	0.013	0.004	0.158	0.021	0.804
24	0.013	0.004	0.159	0.022	0.803
25	0.013	0.004	0.159	0.022	0.802
26	0.013	0.004	0.160	0.022	0.801
27	0.012	0.004	0.160	0.023	0.801
28	0.012	0.004	0.161	0.023	0.800
29	0.012	0.004	0.161	0.023	0.800
30	0.012	0.004	0.161	0.024	0.799

Table 18: Variance Decomposition of lrip

period	lrig	lrcg	lrdcp	lrip	lrgdp
0	0	0	0	0	0
1	0	0	0	0.972	0.028
2	0.019	0.003	0.039	0.815	0.124
3	0.016	0.029	0.062	0.792	0.100
4	0.047	0.022	0.041	0.789	0.100
5	0.056	0.029	0.045	0.750	0.120
6	0.059	0.028	0.052	0.748	0.112
7	0.060	0.030	0.058	0.724	0.127
8	0.060	0.033	0.073	0.686	0.149
9	0.056	0.034	0.080	0.664	0.166
10	0.054	0.034	0.087	0.635	0.191
11	0.051	0.034	0.095	0.612	0.208
12	0.048	0.034	0.010	0.597	0.222
13	0.045	0.034	0.105	0.576	0.240
14	0.043	0.034	0.110	0.560	0.253
15	0.041	0.034	0.113	0.549	0.264
16	0.039	0.034	0.116	0.537	0.274
17	0.038	0.034	0.118	0.528	0.282
18	0.037	0.034	0.120	0.520	0.288
19	0.036	0.034	0.123	0.512	0.295
20	0.035	0.034	0.124	0.506	0.301
21	0.034	0.034	0.126	0.500	0.306
22	0.033	0.034	0.128	0.494	0.311
23	0.032	0.034	0.129	0.489	0.315
24	0.032	0.034	0.130	0.484	0.320
25	0.031	0.034	0.131	0.479	0.323
26	0.031	0.034	0.132	0.476	0.327
27	0.030	0.034	0.133	0.472	0.330
28	0.030	0.034	0.134	0.468	0.333
29	0.029	0.034	0.135	0.465	0.336
30	0.029	0.034	0.135	0.462	0.339

Table 19: Variance Decomposition of lrdcp

period	lrig	lrcg	lrdcp	lrip	lrgdp
0	0	0	0	0	0
1	0	0	0.821	0.150	0.028
2	0.018	0.019	0.774	0.102	0.087
3	0.057	0.013	0.563	0.262	0.106
4	0.093	0.011	0.448	0.283	0.166
5	0.126	0.017	0.343	0.363	0.152
6	0.164	0.019	0.272	0.431	0.114
7	0.186	0.019	0.235	0.461	0.100
8	0.197	0.018	0.207	0.486	0.093
9	0.205	0.019	0.190	0.501	0.085
10	0.209	0.021	0.160	0.517	0.077
11	0.211	0.022	0.160	0.537	0.070
12	0.214	0.023	0.150	0.548	0.065
13	0.215	0.024	0.143	0.558	0.061
14	0.215	0.024	0.135	0.569	0.057
15	0.215	0.025	0.128	0.578	0.054
16	0.215	0.026	0.121	0.587	0.052
17	0.215	0.026	0.114	0.595	0.050
18	0.215	0.027	0.109	0.601	0.048
19	0.215	0.027	0.104	0.608	0.046
20	0.215	0.028	0.099	0.614	0.044
21	0.215	0.028	0.094	0.619	0.043
22	0.215	0.028	0.090	0.624	0.042
23	0.215	0.029	0.086	0.628	0.042
24	0.214	0.029	0.083	0.623	0.041
25	0.214	0.030	0.080	0.636	0.040
26	0.214	0.030	0.077	0.639	0.040
27	0.213	0.031	0.074	0.642	0.040
28	0.213	0.031	0.071	0.645	0.040
29	0.212	0.031	0.069	0.649	0.040
30	0.212	0.031	0.067	0.650	0.040

Table 20: Variance Decomposition of lrcg

period	lrig	lrcg	lrdcp	lrip	lrgdp
0	0	0	0	0	0
1	0	0.501	0.019	0.001	0.479
2	0.164	0.272	0.178	0.179	0.207
3	0.168	0.083	0.345	0.178	0.229
4	0.117	0.031	0.348	0.068	0.436
5	0.094	0.017	0.330	0.052	0.506
6	0.103	0.012	0.309	0.052	0.523
7	0.107	0.011	0.292	0.048	0.541
8	0.111	0.009	0.285	0.044	0.551
9	0.107	0.007	0.288	0.037	0.561
10	0.099	0.006	0.287	0.031	0.577
11	0.094	0.005	0.285	0.026	0.590
12	0.089	0.005	0.283	0.023	0.600
13	0.082	0.004	0.284	0.020	0.606
14	0.082	0.004	0.285	0.018	0.611
15	0.078	0.004	0.285	0.016	0.616
16	0.074	0.004	0.285	0.014	0.622
17	0.072	0.004	0.285	0.013	0.626
18	0.070	0.003	0.285	0.012	0.630
19	0.068	0.003	0.285	0.011	0.633
20	0.066	0.003	0.284	0.010	0.636
21	0.064	0.003	0.285	0.010	0.639
22	0.063	0.003	0.284	0.092	0.641
23	0.061	0.003	0.283	0.009	0.643
24	0.060	0.003	0.283	0.008	0.645
25	0.059	0.003	0.283	0.008	0.647
26	0.058	0.003	0.283	0.008	0.648
27	0.057	0.003	0.283	0.007	0.650
28	0.056	0.003	0.283	0.007	0.651
29	0.055	0.003	0.282	0.007	0.652
30	0.055	0.003	0.282	0.007	0.653

Table 21: Variance Decomposition of lrig

period	lrig	lrcg	lrdcp	lrip	lrgdp
0	0	0	0	0	0
1	0.197	0.029	0.027	0.579	0.168
2	0.215	0.026	0.080	0.532	0.146
3	0.203	0.021	0.069	0.562	0.145
4	0.192	0.023	0.056	0.545	0.183
5	0.185	0.029	0.052	0.510	0.223
6	0.169	0.027	0.045	0.484	0.275
7	0.158	0.025	0.040	0.457	0.321
8	0.152	0.024	0.037	0.443	0.345
9	0.144	0.023	0.034	0.432	0.366
10	0.136	0.023	0.032	0.414	0.396
11	0.130	0.022	0.029	0.403	0.416
12	0.126	0.023	0.026	0.397	0.428
13	0.123	0.021	0.026	0.392	0.438
14	0.121	0.021	0.024	0.389	0.445
15	0.118	0.021	0.023	0.385	0.453
16	0.115	0.021	0.021	0.380	0.462
17	0.113	0.021	0.020	0.377	0.469
18	0.111	0.021	0.019	0.373	0.475
19	0.110	0.020	0.018	0.340	0.482
20	0.108	0.020	0.017	0.367	0.487
21	0.106	0.020	0.017	0.364	0.493
22	0.104	0.020	0.016	0.361	0.499
23	0.103	0.020	0.015	0.359	0.503
24	0.101	0.012	0.015	0.356	0.512
25	0.100	0.012	0.014	0.354	0.512
26	0.099	0.012	0.013	0.352	0.515
27	0.098	0.012	0.013	0.350	0.519
28	0.097	0.012	0.012	0.348	0.522
29	0.096	0.012	0.012	0.347	0.525
30	0.095	0.012	0.012	0.346	0.528