ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

PUBLIC INFRASTRUCTURE INVESTMENT, PRIVATE INVESTMENT AND ECONOMIC GROWTH IN ETHIOPIA: CO-INTEGRATED VAR APPROACH

By

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July, 2015

Addis Ababa, Ethiopia

Public Infrastructure Investment, Private Investment and Economic Growth in Ethiopia: Co-Integrated VAR Approach

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A Thesis Submitted to

The Department of Economics

Presented in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Economics (Economic Policy Analysis)

Addis Ababa University

Addis Ababa, Ethiopia

July, 2015

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Teklebirhan Alemnew, entitled: *Public Infrastructure Investment, Private Investment and Economic Growth in Ethiopia* and submitted in partial fulfillment of the requirements for the degree of Master of Science (Economic Policy Analysis) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Chair of department or graduate program coordinator

Abstract

Public Infrastructure Investment, Private Investment, and Economic Growth in Ethiopia: Co-integrated VAR Approach.

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Addis Ababa University, 2015

This study investigates the relationship between private investment and public infrastructure investment, as well as their relative impact on economic growth in Ethiopia. Moreover, the study carried out through analyzing the impact of the two broad categories of public infrastructure investments: physical and social. In order to achieve the stated objective the private investment and the growth model were estimated separately using cointegrated VAR approach for the period 1974/75-2013/14. The study reveals that physical public infrastructure investment has a crowding-in effect on private investment both in the short run and long-run. On the other hand, social public infrastructure investment is found to deleteriously impacted private investment in the long run while in the short-run it has insignificant impact, implying that the crowding out impact of social public infrastructure investment have been large enough to offset any crowding-in effects in the long-run. Moreover, the study shows the significant and positive impact of output growth in stimulating private investment both in the short-run and long-run. The contribution of physical public infrastructure investment to the real GDP is positive and significant in the long-run while it has a significant negative impact in the short run. In the long run, social public infrastructure investment exerts negative and significant effect on economic growth while in the short run it has insignificant impact. Finally, as a policy implication, it will be natural to think of supplementary reforms so as to tackle the negative impact of social public infrastructure investment on private investment and economic growth.

Acknowledgment

I would like to extend my gratitude to my Advisor **Dr. Alemayehu Geda** (PhD) for his guidance, suggestions and constructive comments throughout the work. His brotherly and friendly treatment gives me the courage to finalize this study and inspiration to be a better academician.

Besides, this paper has benefited a lot from the valuable comments and guidance of **Dr. Fantu Guta, Addis Yimer,** and **Alemnesh Tadesse**. I want to extend my sincere thanks to all of them.

Last but not least, I want to extend my gratitude to all my friends and parents who have shared their affections and knowledge in all the matters I needed.

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Acronyms

ADF : Augmented Dickey-Fuller

ADLI : Agricultural Development Led Industrialization

AIC : Akaiki Information Criterion

ARDL : Autoregressive-Distributed Lag

CE : Cointegrating equation

CPI : Consumer Price Index

CRS : Constant Returns to Scale

CSA : Central Statistical Agency

EAL : Ethiopian Airline

ECM : Error Correction Model

EEPCo : Ethiopian Electric Power Corporation

EIA : Ethiopian Investment Agency

EPA : Ethiopian Privatization Agency

EPRDF : Ethiopian People Revolutionary Democratic Front

ERA : Ethiopian Road Authority

ESDP : Education Sector Development Programme

ETA : Ethiopian Telecommunication Agency

ETB : Ethiopian Birr

ETC : Ethiopian Telecommunications Corporation

ETP : Educational and Training Policy

EU : European Union

EXP : Total Value of Export

FMoH : Federal Ministry of Health

FPE : Final Prediction Error

GDP: : Gross Domestic Product

GNP : Gross National Product

GTP : Growth and Transformation Plan

GWh : Giga watt –hour

HQ : Hannan-Quinn Information Criterion

HSDPs : Health Sector Development Plans

IBTE : Imperial Board of Telecommunications

ICT : Information Communication Technology

IDI : Information and Communication Technology Development Index

IEA : International Energy Agency

IMF : International Monetary Fund

ITU : International Telecommunications Union

LAB : Active labour force

LDCs : Least developing countries

LR : Likelihood Ratio test statistics

MDGs : Millennium Development goals

MoE : Ministry of Education

MoFED : Ministry of Finance and Economic Development

MW : Mega watt

NBE : National Bank of Ethiopia

REER : Real effective exchange rate

RER : Real exchange rate

RGDP : Real Gross Domestic Product

RIR : Real interest rate

RPII : Real physical public infrastructure investment

RPIV : Real private investment

RSDP : Road Sector Development Program

RSII : Real social public infrastructure investment

SAP : Structural Adjustment Program

SDPRP: : Sustainable Development and Poverty Reduction Program

SFDP : Second Five Year Development Plan

SIC : Schwarz Information Criterion

SIDS : Small Island Developing States

SSA: : Sub-Saharan Africa

TFP : Total Factor Productivity

TGE : Transitional Government of Ethiopia

TVET : Technical and Vocational Education and Training

TWA : Trans World Airlines

US : United State

USD : United States Dollar

VAR : Vector Autoregression

VEC : Vector Error correction

VECM : Vector Error Correction Estimate

WB : World Bank

WEF : World Economic Forum

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CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

In the last decades, investment in public infrastructure has come to be seen as central to any sustained growth strategy in developed and developing countries alike. Due to this, the impact of public infrastructure investments on private investment, as well as the respective roles of public infrastructure investment and private investment in the economic growth process of developing countries constitutes one of the central issues in empirical and policy debates (Adam & Bevan, 2014; Estache et al, 2013; Agenor et al, 2005).

The economic concepts behind the public infrastructure investment are relatively straightforward. A rise in public infrastructure investments can have two effects on private investments: complementarity or substitutability effects. First, the complementarity effect argument asserts that public infrastructure investments can create additional favorable conditions for private investment, for instance, by providing or promoting relevant infrastructure, such as roads, high ways, sewage systems, harbours or airports. The existence of public infrastructure facilities may increase the productivity of private investment, which can then take advantage of better overall infrastructures and potentially improved business conditions (Adam &Beven, 2014; Afonso & Aubyn, 2008; Agenor et al, 2005). The theoretical linkages of public infrastructure investments and private investment outlined above suggest that, by lowering production costs and raising the expected rate of return, public capital in infrastructure may have a strong positive impact on private capital formation.

On the other hand, crowding-out effects of private investments occur if the public sector finances the increase in public infrastructure investments through an increase in distortionary taxes, or reduce the expected net rate of return to private capital, and therefore the propensity to invest. A similar effect may occur when a public infrastructure investment impose a higher demand for funds from the government in the domestic financial markets, therefore causing interest rates to rise or a greater incidence of rationing of credit to the private sector (Phetsavong and Ichihashi, 2012; Afonso & Aubya, 2008; Aschauer, 1989).

Another eye-catching issue is the impact of public infrastructure investments on the economic growth. Disentangling the size and magnitude of the direct and indirect effects of public infrastructure investment on economic growth remain a key issue in empirical studies. The direct effect is related with the contribution of new capital on nation's production process as capital enters directly in the country's production function. The indirect effect relates to the possibility that public infrastructure investments enhance growth through creating a better infrastructure, increasing the amount of capital competing in the economy, facilitating the flow of goods and services, decreasing the cost of transportation, and cost of acquiring private investments. Another indirect effect comes through employment creation, and increasing the amount of capital per worker, thus increasing workers' productivity (Warner, 2014; Gjini, 2012).

By and large, governments are still the most prominent financiers of infrastructure investment in Sub-Saharan Africa. Currently, Governments in Sub-Saharan Africa (SSA) spend on average between 6‑12 percent of their GDP on infrastructure each year. Countries such as Cape Verde, Ethiopia, and Namibia spend well above 10 percent of their GDP on infrastructure annually (Jerome, 2011).

Surprisingly enough, as a developing country, the relationship between public infrastructure investment, private investment, and economic growth has always been an important issue for Ethiopia since Ethiopian government has devoted significant public funds to finance public infrastructure in order to achieve its sustainable development and poverty reduction program (SDPRP) and meeting of both MDGs and GTP of Ethiopia. Hence, an empirical investigation to determine the contribution of public infrastructure investment to private investment and economic growth is essential. In general, the main aim of this paper is to empirically analyze the impact of public infrastructure investment on private investment and economic growth in Ethiopia.

1.2. Statement of the Problem

Public infrastructure investments makes substantial contributions in terms of economic growth, productivity improvement, employment, trade competitiveness, environmental sustainability and people's safety (Zhang, 2011; Agenor, 2010; Heintz et al, 2009; Rioja, 2001).

The decline in public infrastructure investment and neglect of this issue over the last generation has left Ethiopia with a critical infrastructure deficit. The result of such declining and insufficient investments has been a worsening infrastructure deficit and mounting investment needs. According to the overall competitiveness index in the "2013-2014 Global Competitiveness Report" Ethiopia ranked just 124th among 148 countries in terms of infrastructure (WEF, 2013). Furthermore, the country has been operating a *"Patch and Pray"* system of infrastructure.[1]

[1] That is, *patch* something and *pray* that it holds up, instead of providing regular maintenance and improvements for aging facilities.

To address the country's infrastructure deficit the Ethiopian government began spending huge amount of money in each fiscal year in addition to public enterprises investment. In the 1999/00 fiscal year the total physical public infrastructure investments (on transport, road construction, energy and telecommunication) equaled 5.82 percent of GDP and the total social public infrastructure investments (on education and health) equaled 0.69 percent of GDP; in 2009/10 fiscal year the gross capital formation of physical and social infrastructure increased impressively to 10.65 percent and 2.63 % of GDP respectively. In the 2013/14 fiscal year the physical and social infrastructure investment was 9.83% and 2.42% of GDP, in this fiscal year the infrastructure investment as percentage of GDP decrease but it doesn't mean the total investment amount is decreased rather it is due to the expansion of the country's economic base (MoFED data base).[2] The above quantitative figures show the growth of public infrastructure investment in Ethiopia is quite impressive. So, the increase in the amount of public investment from time to time has the implication of how crucial this spending is for development.

Despite this huge investment spending, the extent to which public investment, especially, in infrastructure complements or crowds out private investment, its impact on economic growth in Ethiopia largely unknown. To date, there have been very few empirical studies focusing on the aggregate public investment issues in the country without analyzing the separate (disaggregate) effects of infrastructure investment from non-infrastructure public investments. In an early paper; Workie (1997) and Mohammed (2006) finds no significant effect of public investment on private investment in Ethiopia. Furthermore, Mohammed (2006) revealed that the positive and significant contribution of both private and public investment to real GDP growth. However, Lulseged (2011), using an ARDL Cointegration Approach, finds that public investment affects

[2] The physical & social public infrastructure investment figures includes not only government expenditure but also investment expenditures undertaken by state-owned enterprises in sectors -like tele and EEPCo sectors.

private investment negatively in the short run and positively in the long-run. Most recently, Alemnesh (2012) finds that the long-run impact of real public investment on private investment is found to be negative but no statistically significant in Ethiopia. Furthermore, she found that both public and private investment have complementing effect on long run economic growth of the country.

However, existing studies are lacking in at least the following three respects. First, all the above studies have focused on the economic impact of the aggregate public investment. As a result, they seldom make a clear distinction between the public non-infrastructure and infrastructure investment effects. But this is crucial, given that the transmission channels are substantially different. Therefore, this study examined the separate economic impact of public infrastructure investments; because infrastructure that makes more sense from an economic standpoint consists of large capital intensive natural monopolies such as highways, other transportation facilities, energy, water and sewerage lines, education, health, transportation and communications system. And its linkages to the economy are multiple and complex, because it affects production and consumption directly, creates positive and negative spillover effects and involves large inflow of expenditure.

The second problem of the above investment studies conducted in Ethiopia is that all studies regression process used directly the total investment data series into the production function, as a result they seldom make a clear distinction between the *flow* effect of public investment and the *stock* effect of public capital. Theoretically, however, it is not logical to use investment data in to the output function without constructing the capital stock series since it is the function of capital stock. Therefore, this study construct the capital stock series using the perpetual inventory

method using the time series data on physical and social public infrastructure investment, and private investment since there is no any capital stock data in Ethiopia.

Finally, in addition to failing to make a clear distinction between the public non-infrastructure and infrastructure investment effects the existing studies also failed to address the following important issue; they didn't show the separate effect of the two categories of public infrastructure investment (economic/physical infrastructure and social infrastructure investment). According to World Development Report (1994), the former includes investment on services such as electricity, transport, roads, water system, communications, irrigation etc., while the latter includes investment on education and health facilities. All the above issues are addressed in this paper. The study also assessed quantitatively the impact of public infrastructure investment on private investment and economic growth in Ethiopia.

1.3. Objectives of the Study

The general objective of this study is to examine the impact of public infrastructure investment on private investment, as well as their respective impact on the economic growth of Ethiopia. The study has the following specific objectives,

1. To analyze whether private business investment encouraged or deterred with additional public infrastructure investment.
2. To identify the relative significance of public infrastructure and private investment to economic growth.
3. To analyze the trends and magnitudes of private investment, public infrastructure investment, and economic growth in Ethiopia, and
4. To give possible policy recommendations regarding the issue.

1.4. Significance of the Study

As there is no any study conducted so far on the separate economic impact of public investment in infrastructure this study, besides being a partial fulfillment for a master's degree, will provide a perceivable guideline for infrastructure policy. And, it may also give a good basis for further research on economic impact of public infrastructure investments in Ethiopia.

1.5. Research questions

This study poses and tries to answer the following three major questions:

1) Does public infrastructure investment crowd-in or crowd-out private investment?
2) How much public infrastructure and private investment explains the performance of the economy of Ethiopia? And
3) Which one of the two components of public infrastructure investment (i.e. physical and social public infrastructure) does have a noticeably strong impact on the economic growth of Ethiopia?

1.6. Scope of the Study

This study focused on the private investment and economic growth impacts of public infrastructure investments in Ethiopia, and doesn't take into account the economic impact of non-infrastructure public investments.

1.7. Organization of the Study

The remaining part of this paper is organized as follows. The next chapter presents a brief review of theoretical and empirical literatures followed by explanations of issues relating to public

infrastructure investment, private investment, and economic growth in Ethiopia. The fourth chapter describes the data, discusses the model specification, and estimation techniques. In chapter five the model estimation and discussion of the result is presented. Finally, policy implications are drawn.

CHAPTER TWO

REVIEW OF RELATED LITERATURES

2.1 Review of the Theoretical Literatures

2.1.1 Public Infrastructure & Private Investment: Transmission Channels

Public infrastructure investment can affect private investment through various channels. It is convenient to classify these channels into two broad sets of effects: crowding-in and crowding-out effects (direct effect), and output and relative price effects (indirect effect).

Direct Effect: Crowding-In and Crowding-Out Effects

The complementarity (crowding-in) effect view asserts that if government expenditure is geared towards public capital (as opposed to public investment) in infrastructure instead of non-infrastructure may stimulate private physical capital formation by raising the marginal productivity of private inputs (Argimón et al, 1995). Alternatively, a complementarity effect between public capital in infrastructure and private investment may operate through adjustment costs thereby raising expected profitability. In a context of economic growth, this idea is found on the availability and the quality of public capital in infrastructure (Turnovsky, 1996). For example, a better integrated road can reduce costs associated with the construction of innovative and new factories or the displacement of heavy equipments. Cohen and Paul (2004) analyze that in many countries, the effect of private investment on unit production expenses and the productivity can be substantial. The above arguments suggest that, by lowering production costs

and raising the expected rate of return, public capital in infrastructure may have a strong impact on private capital formation.

Of course, the positive effect of public capital on the marginal productivity of private inputs may hold not only for physical infrastructure but also for social infrastructure capital in education and health, which may enhance the productivity of private inputs -both labour and capital (Agenor et al, 2005). Nevertheless, to the extent that public investment in infrastructure displaces or crowds out private investment, its net positive impact on private capital formation can be highly mitigated (Boopen & Khadaroo, 2009).

In fact, public investment in infrastructure displaces or crowds out private investment if the public sector finances the increase in public investment through an increase in distortionary taxes which may increase incentives for private agents to evade taxation, or reduce the expected net rate of return to private capital, and therefore reduce the propensity to invest (Badawi, 2005). A similar effect on private capital formation may occur if the public infrastructure investment is financed through borrowing on domestic financial markets by driving interest rates up (in countries where market forces are relatively free to operate) or increasing the incidence of credit rationing to the private sector; therefore, minimizing the private sector's ability to access to monetary markets (Dehn, 2000).[3] In addition to this, if the increase in public infrastructure investment is paid for by borrowing on external financial markets, according to Boopen &

[3] In a small open economy with open capital markets facing a fixed world interest rate, crowding-out effects through a rise in domestic interest rates cannot occur. But for small developing countries, the supply curve of foreign capital is upward-sloping rather than horizontal. In such conditions, and if the risk premium faced on world capital markets is positively related to the debt-to-GDP ratio, an increase in domestic public debt induced by a rise in public investment in infrastructure may lead to both lower credit to the private sector and higher domestic interest rates.

Khadaroo (2009) this debt burden can have a negative effect on investment through each of the following three channels. First, there may be a reduction in investible resources as debt service requires external financing, leads to. Second, the anticipated tax associated with future debt service hampers the anticipated return on investment. Third, as Serven and Solimano (1993) argued, uncertainty about policies needed in the future to meet an equally uncertain debt service also tends to depress investment. The implication of the above theoretical literatures is that, by raising the cost of capital and negatively affecting expected after-tax rates of return on private capital, this increase may have a compounding effect on private investment. Therefore, private investors may revise downward their investment plans because of anticipated hikes in tax rates to cover the increase in government investment.

Indirect Effect: Output and Relative Price Effects

Through changes in output and relative prices, public investment and capital in infrastructure may also affect private capital formation indirectly. As noted earlier, Easterly and Rebelo (1993) and Ramirez (1994) have argued that public capital in infrastructure may increase the marginal productivity of existing factor inputs (both capital and labor), thereby lowering marginal production costs and increasing the level of private production. In turn, as postulated by Chirinko (1993), this scale effect on output may lead, through the standard accelerator effect, to higher private investment.

Public infrastructure can also affect private investment indirectly through its "flow" effect on the price of domestic consumption goods relative to the price of imported goods, that is, the real exchange rate. An increase in public investment in infrastructure for instance will raise aggregate demand and domestic prices (in addition to stimulating output). In the eventuality that nominal

exchange rate does not depreciate fully to offset the increase in domestic prices it is likely that the domestic-currency price of imported consumption goods will fall in relative terms (real exchange rate appreciation), thereby stimulating demand for these goods and dampening domestic activity (Boopen & Khadaroo, 2009). The net effect on output may be positive or negative, depending on the intra-temporal elasticity of substitution between domestic and imported goods. If this elasticity is low (as one would expect in the short run), the net effect on output may be positive, so that private investment may indeed increase (Agenor et al, 2005).

In addition, public investment in infrastructure may affect private investment through both demand- and supply-side effects on output. On the demand side, the increase in domestic prices may lower private sector real wealth and thus expenditure; if this effect is sufficiently large (relative to the increase in public spending) to entail a fall in domestic absorption, firms may revise their expectations of future demand and lower investment outlays, through a "reverse" accelerator effect (Boopen & Khadaroo, 2009). On the supply side, the real appreciation may lead to a shift in resource allocation toward the non-tradable goods sector, thereby stimulating investment in that sector and depressing capital formation in the tradable goods sector. So, the net effect may thus be uncertain. There may be an increase in private investment if the nominal exchange rate does not depreciate fully in response to the increase in domestic prices which implies a fall in the real cost of imported intermediate inputs. (Agenor et al, 2005).

The above theoretical linkages of public infrastructure and private investment implied that, the net effect of public investment on private investment is an empirical question, since public infrastructure investments plays many competing and offsetting roles in its effect on the investment activities of the private sector.

2.1.2. Infrastructure and Growth: Transmission Channels

Before discussing the various approaches used to model infrastructure in growth models, it may be useful to provide the rationale behind using infrastructure as an argument of an economy-wide production function.

It is important to highlight the various transmission mechanisms through which infrastructure affects growth. Actually, macroeconomists typically emphasize three "conventional" channels through which public infrastructure may affect growth: a direct productivity effect on private production inputs, a complementarity effect on private investment, and a crowding-out effect on private spending through the financial system.

The most conventional channel- because the argument that is most commonly proposed to account for a growth effect of public capital, first described in Aschauer (1989) and Barro (1990), is that public infrastructure investments enhance private sector productivity. Indeed, Aschauer (1989) attributed the 1970s U.S. productivity slowdown to the lack of infrastructural investment. This direct productivity effect of infrastructure investment captures the idea that an increase in public capital stocks (relative to private capital) has a positive but decreasing impact on the marginal product of all factor inputs (such as capital and labour). Hence, the cost of production inputs falls and the level of private production increases. As Agenor and Moreno-Dodson (2006) point out, "this scale effect on output may lead, through the standard accelerator effect, to higher private investment – there by raising production capacity over time and making the growth effect more persistent."

Agenor and Moreno-Dodson (2006) identify two additional conventional channels through which infrastructure may affect growth, namely complementarity and crowding out effects. The

first channel promotes growth through private capital formation. That is, public infrastructure raises the marginal productivity of private inputs, thereby raising the perceived rate of return on private capital and possibly also increasing private sector demand for physical capital. The second channel, crowding out, captures the idea that, in the short run, an increase in public capital stocks may displace or crowd out private investment if the public sector finances the expansion of public capital through an increase in distortionary taxes and if the increase in public infrastructure outlays is paid for by borrowing on domestic financial markets. This negative crowding out effect of infrastructure may turn into a long-term negative effect if the decrease in private capital formation persists over time. Moreover, Agenor and Moreno-Dodson (2006) add labour productivity as another channel whereby public infrastructure indirectly increases growth. Better access to infrastructural facilities means that workers can get to their jobs more easily and perform their job-related tasks more rapidly.

Recently, Estache and Fay (2009) suggest that, in addition to the channels mentioned above, investment in public infrastructure can also impact investment adjustment costs, the durability of private capital, and both the demand for and supply of health and education services. In the same vein, Agenor and Moreno- Dodson (2006) argue that infrastructure may reduce investment adjustment costs via two channels: through complementarity between public capital and private investment and through the decreased costs associated with capital reallocation between sectors following a shock.

Infrastructure could be modeled as having an effect on any given measure of output via two channels: directly as a production factor and indirectly by influencing total factor productivity (TFP). The general production function would take the following form:

$$\boldsymbol{Y = f(A(K_{PUB}), K, L, K_{PUB})} \quad \ldots \quad \boldsymbol{(2.1)}$$

Where: $\boldsymbol{Y}$ is output, $\boldsymbol{K}$ is private capital, $\boldsymbol{L}$ is labour, $\boldsymbol{A}$ is TFP and $\boldsymbol{K_{PUB}}$ is public capital.

2.1.3. Review of Growth Models

Before going to directly the approaches of infrastructure modeling, in this section, we should discuss various growth models that used for infrastructure modeling.

Solow-Swan Growth Model

Robert Solow and Trevor Swan developed a growth model in 1956 that can help to think about the approximate causes and the mechanics of the process of economic growth and cross-country income differences. The model is called Solow-Swan model or simply Solow model. This model has shaped the way we approach not only economic growth but the entire field of macroeconomics (Acemoglu, 2008).

Before the advent of the Solow growth model, the most common approach to economic growth was based on the model developed by Roy Harrod and Evsey Domar (Harrod, 1939; Domar, 1946), so called the Harrod-Domar growth model. The Harrod-Domar model emphasized potential dysfunctional aspects of economic growth, for example, how economic growth could go hand in hand with increasing unemployment. The Solow model demonstrated why the Harrod-Domar model was not an attractive place to start. At the center of the Solow growth model, distinguishing it from the Harrod-Domar model, is the neoclassical aggregate production function. This function not only enables the Solow model to make contact with microeconomics, but it also serves as a bridge between the model and the data (Acemoglu, 2008).

An important feature of the Solow model is that it is simple and abstract representation of a complex economy. At first, it may appear too simple or too abstract. After all, to do justice to the

process of growth or macroeconomic equilibrium, we have to think of many different individuals with different tastes, abilities, incomes and roles in society, many different sectors and multiple social interactions (Barro & Sala-i-Martin's, 2004). Instead, the Solow model cuts through these complications by constructing a simple one-good economy, with little reference to individual decisions. Therefore, the Solow model will be both a starting point and a spring board for richer models (Jones, 1998). Furthermore, Solow & Swan assumed the saving rate, the population growth rate and the rate of the technological progress to be the main determinants of the economic growth (Jones, 2002).

The Solow model is a dynamic model that is built up on the neoclassical aggregate production (Koutun & Karabona, 2013):

$$\boldsymbol{Y(t) = F[A(t), K(t), L(t)]} \quad \ldots\ldots (\mathbf{2.2})$$

Where, $Y(t)$ is the aggregate output or real income at time t which is usually measured as real GDP total output is presented as a function of a capital input at time t, $K(t)$, labour input at time t, $L(t)$, and measure of productivity or the level of technology at time t, $A(t)$.

According to the assumptions of the Solow model labour and the factor of technology will grow at constant exogenous rates. The neoclassical aggregate production function used in the Solow model is characterized by the constant return to scale and the diminishing marginal returns to capital and labour (Barro & Sala-i-Martin, 2003). When the production function exhibits constant returns to scale, the increase in the factors of production by some equal portion will increase the final output by the same proportion with the increase of one of the factors of production the total output will increase but it will increase each time by a smaller amount. This

means that the factor of production is characterized by diminishing marginal returns (Koutun and Karabona, 2013).

The neoclassical production function of the Solow model can be represented in the form of the Cobb-Douglas production function (Weil, 2013).

$$\boldsymbol{Y(t) = A(t)K(t)^{\alpha}L(t)^{1-\alpha}}, \qquad \boldsymbol{0 < \alpha < 1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{(2.3)}$$

Where, α is a share of output paid to capital and $1-\alpha$ is a share of output paid to labour Assuming that technology increases labour productivity; the Cobb-Douglas production function will take the following form (Jones, 2002):

$$\boldsymbol{Y(t) = K(t)^{\alpha}[A(t)L(t)]^{1-\alpha}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{(2.4)}$$

Where: $A(t)L(t)$ is the amount of effective labour.

By presenting A as a factor that makes labour more productive, we can express the income per unit of effective labour as a function of the capital per unit of effective labour (Jones, 2002). Thus, in the Solow model the main source of economic growth is capital accumulation. The change in capital leads to the change in level of total income and the capital change it is seen that the growth in capital is positively related to the level of investments and negatively related to the depreciation rate, the growth rate of the population and the rate of technological change (Jones, 2002; Weil, 2013; Acemoglu,2008).

Endogenous Growth Model

Historically, the engine of growth as depicted in Slow & Swan seminal work on the topic (1956) was the assumption of exogenous technical change (Acemoglu, 2007). However, in the mid-

1980s the standard neoclassical growth model was theoretically unsatisfactory as a tool to explore the determinants of long-run growth, because it distinguishes itself from neoclassical growth by emphasizing that economic growth is an endogenous outcome of an economic system, not the result of forces that impinge from outside (Romer, 1994). For this reason, it became a priority to go beyond the treatment of technological progress as exogenous and, instead, to explain this progress with in the model of growth (Barro & Sala-i-Martin, 2003).

According to Jones and Manuelli (2004) Solow growth model approach has weakness in two distinct areas. First, it is difficult using the exogenous growth model to explain the observed long-run differences in performance exhibited by different countries. Second, the productivity changes that are assumed exogenous in the Solow model are, in fact, the results of conscious decisions on the part of economic agents. This basic weakness in the Solow model (and its followers) was the driving force behind the development of the class of endogenous growth models (Jones and Manuelli, 2004). Moreover, by the same token, Ickes (1996) noted that the important difference between the growth models is that in the Solow model the steady-state growth rate is determined exogenously, e.g., technical change. In the Endogenous growth model, it is determined endogenously. The models are interesting because they often leave a role for policy (Ickes, 1996).

As a topic, irrespective of its intellectual antecedents, endogenous growth theory is extremely recent, only dating back in acknowledged published form to Romer's (1986) article which is usually coupled with Lucas' (1988) contribution (Fine, 2000). Romer (1986) started the endogenous growth literature by considering a model with increasing returns to scale at the economy-wide level, but constant returns to scale at the firm level. The model then supports a competitive equilibrium, but this equilibrium is non-optimal. A higher growth rate could be

achieved if the externality associated with investment could be internalized. This alone made the model popular, and it has spawned a large literature (Ickes, 1996). Romer (1986) follows Arrow's (1962) seminal work on the economics of learning by doing. Arrow (1962) noted from case studies that there was strong evidence that experience and increasing productivity were associated. He argued that a good measure of increase in experience is investment, because "each new machine produced and put into use is capable of changing the environment in which production takes place, so that learning takes place with continuous new stimuli". Arrow (1962) then indexes experience by cumulative investment.

Lucas (1988) develops an endogenous human capital model in which constant returns to scale (CRS) in the inputs that can be accumulated is obtained by arguing that all inputs can be accumulated. Rather than rely on externalities, as in Romer (1986), Lucas introduces human capital, rather than physical labor, in the production function. Agents invest in human capital through their "studies." All inputs of the production function can thus be accumulated. With a CRS production function, where the broad measure of capital includes human *and* physical capital. Growth is then generated by assuming that the incentive to invest in human capital is non-decreasing in human capital. That is, Lucas postulates a production function of human capital which is constant returns to scale in human capital. Hence the marginal product of human capital -- which determines the incentive to spend time studying -- is constant.

Furthermore, Barro (1990) develop an endogenous model with public goods (specifically, infrastructure) where public expenditure is productive. Therefore, it is easy to think of investments in infrastructure that make private production more profitable (Ickes, 1996). Barro (1990) noted that the private return to investment is less than the social, because entrepreneurs don't consider the effect they have on others through investment. The channel is that with higher

investment, and thus income, there is more government spending, which, since it is productive, makes for higher growth. But individual investors do not take into account the effect on growth from their investments (Ickes, 1996).

Still, modeling infrastructure in the context of endogenous growth has been based on a more restrictive production function, generally excluding the indirect impact of infrastructure via TFP. Such a modelling approach, motivated by Barro (1990), introduces government infrastructure expenditures as an argument of the production function, and is justified by reasoning that private inputs (K) are not a close substitute for public inputs. However, his assumption that public expenditures is a flow variable brought a wave of criticism, starting with Futagami et al. (1993) who modified Barro's original model (1990) by considering productive public expenditures as a stock variable, much like private physical capital is.

Generally, if there were empirical support for endogenous growth model, the policy significance would be fundamental. In practical terms, however, it is difficult to distinguish these new growth theory effects from more traditional growth effects. Therefore, in the traditional growth model of the Solow type is amended to include public infrastructure in this paper.

2.1.4. Approach of Modeling Infrastructure on Growth

We can distinguish between two theoretical approaches to modeling the impact of infrastructure on growth (Agenor et al, 2005). The first treats government infrastructure expenditures as a flow variable which directly enters the production function. The second treats public infrastructure as accumulated capital stock, rather than as current flows, and thereby represents infrastructure as a stock variable in the aggregate production function (Dissou & Didic, 2013).

Modelling Infrastructure as a Flow Variable

Using a simple AK endogenous growth theory Barro (1990) modeled infrastructure as a flow variable. In his infrastructure model a production function that incorporates public services (an expenditure flows variable) as an input to private production, and a Ramsey equation that captures the representative consumer's optimization behaviour are the two building blocks.

As we pointed earlier, the production elasticity of public services is the first building block. For most of his analysis, he applied a Cobb-Douglas production function which assumed to exhibit constant returns to scale with respect to the private stock of capital and the flow of public services provided by the government:

$$\boldsymbol{y = A.g^{\alpha}k^{1-\alpha}\,;0 < \alpha < 1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(2.5)}$$

Where y is output per worker which is subject to diminishing returns to k, k is capital per worker of private sector and g is the per capita quantity of government purchases of goods and services. α is the (aggregate) production elasticity of public services; the function also defines the share of public services in total output. Furthermore, let G be aggregate services, then g = G/N is the quantity allocated to each of N producers. Notice that this is not exactly what we usually think of as public services, since it is rival and excludable. We could think of infrastructure such as phone lines or roads to factories.

In this infrastructure model, Barro (1990) makes a theoretical assumption that the government is not engaged in production and does not own capital; rather, it buys a flow of output (e.g. services of highways, sewers, etc.) from the private sector. These services are paid for and made available to households and correspond to the input g. However, this assumption is very weak to consider the economic systems of developing countries (like Ethiopia) where governments highly

participate in production and ownership of capital goods. Moreover, Barro (1990) argues that it is the amount of government purchases per capita that matters since few government services are actually non-rival.

The consumption growth rate equation is the second building block in Barro's model, derived from the utility-maximization problem of the infinite-lived household in a closed economy:

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}(f' - \rho) \quad (2.6)$$

Where: f' is the marginal product of capital, **c** is consumption per person, $\rho > 0$ is the constant rate of time preference, and $\sigma > 0$ constant elasticity of marginal utility

Since income is taxed to provide for public services, Eq. (2.6) is modified as follows [4]

$$\gamma = \frac{\dot{c}}{c} = \frac{1}{\sigma}\left[(1-\tau)\Phi\left(\frac{g}{k}\right)(1-\eta) - \rho\right] \quad (2.7)$$

Equation (2.7) is the growth rate of consumption. Provided that the government sets g and T to grow at the same rate as y, g/k and η, then γ will be constant, as long as tax rate is constant. As a consequence, in the steady state, per capita consumption, per capita output and per capita capital will grow at the same rate, a positive function of the marginal product of capital (Dissou & Didic, 2013).

Investing in infrastructure has two conflicting effects on per capita growth: a positive one, an increase in productive government spending stimulates the marginal product of private capital and thus generates sustained per capita growth. On the other hand, an increase in financing of public infrastructure by taxing income reduces per capita growth. In general, the effect of infrastructure investment is depending on the magnitude of the two effects; that is, the negative

[4] For more detailed derivation see Barro (1990)

effect dominates when government size is large, while the positive effect dominates when government is small.

Maximizing growth, in Barro's (1990) model, (Equation 2.7) with respect to the tax rate τ, the government must set the tax rate equal to the elasticity of the public services g in aggregate production. In the context of the model, this condition not only corresponds to maximum growth, but it also maximizes lifetime utility or welfare. In other words, to maximize the national growth rate and social welfare, the government sets the optimal level of the income tax financing public services as a share of national income to be equal to the contribution of public services to aggregate output in a competitive economy (i.e. the elasticity of the public services g in aggregate production).

The main advantage of modeling infrastructure as a flow variable is that it produces highly tractable models (Fisher and Turnovsky, 1998). Agenor et al (2005) noted that public infrastructure can affect private investment indirectly through its "flow" effect on the price of domestic consumption goods relative to the price of imported goods, that is, the (consumption-based) real exchange rate. Furthermore, by the same token, Agenor (2007) observes that the flow specification generates results that are not qualitatively very different from studies employing the stock specification of infrastructure. However, the stock variable specification may be more appropriate or plausible if someone is interested in modeling the impact of infrastructure on growth; because specifying infrastructure as a flow variable within the production function implies that only newly established roads or buildings raise the level of private production, and that previously accumulated capital does not contribute to this increase (Dissou and Didic, 2013).

According to (Fisher and Turnovsky, 1998) the flow specification open to the criticism that insofar as productive government expenditures are intended to represent public infrastructure,

such as roads and education, it is the accumulated stock, rather than the current flow, that is relevant. Another criticism of the flow specification approach by Fisher and Turnovsky (1998) and (Dissou and Didic, 2013) captures the idea that it may not be realistic to describe government expenditures on infrastructure as a non-rival good like aggregate knowledge.

Modelling Infrastructure as a Stock Variable

Many of the theoretical contributions after Barro (1990) use an endogenous growth framework allowing infrastructure to impact the economy's long-run growth rate such as Futagami et al. (1993), Fischer and Turnovsky (1998), Rioja (1999), Turnovsky (2004), Tamai (2007), Kalaitzidakis and Kalyvitis (2004), Tsoukis and Miller (2003), and Zhao and Kanamori (2007). In many cases, however, the focus is on the stock of infrastructure assets rather than the flow of infrastructure-related expenditure due to the limitations of modelling infrastructure as a flow variable discussed above.

Arrow and Kurz (1970) were the first authors to formulate government expenditure as a form of investment. More recently, Baxter and King (1993) study the macroeconomic implications of increases in the stocks of public goods. They derive the transitional dynamic responses of output, investment, consumption, employment, and interest rates to such policies by calibrating a real business cycle model (Fisher and Turnovsky, 1998).

Following this logic, Futagami et al (1993) extend the Barro (1990) infrastructure model in the endogenous growth model framework with the assumption that government spending does not influence the aggregate production function directly, but only indirectly via the stock of public capital. Despite this, Futagami et al's (1993) modeling strategy of incorporating public infrastructure into an endogenous growth model differs from that of Barro (1990) in that

government services are now accumulated like physical capital. In other words, the stock specification of infrastructure requires the introduction of a government services accumulation equation.

The main finding of the Futagami et al. (1993) study is that Barro's (1990) result about optimal fiscal policy remains valid in the steady-state equilibrium even if government services are proportional to the stock of public capital (rather than capital expenditure flows), but not in the development transition phase. Furthermore, Futagami et al. (1993) find that maximizing the growth rate of the economy is not equivalent to maximizing social welfare.

The previous studies reviewed above assumed that public services are derived from either flow expenditures or the stock of public capital, while Tsoukis and Miller (2003) consider the case where public services are derived from both public capital stocks and expenditure flows. However, according to Tsoukis and Miller (2003) and in line with the findings of Futagami et al. (1993), this rule is too high for welfare maximization. They also introduce private capital adjustment costs into their analysis. Their study suggests that taxation has a negative effect on private returns to capital.

Zhao & Kanamori (2007) have extended the basic Futagami et al. (1993) framework of modeling infrastructure as a stock variable. Zhao & Kanamori (2007) argued that most of the existing endogenous growth models which explicitly account for public infrastructure fail to consider the external effects of this infrastructure on consumption. In other words, the studies reviewed above, as well as many others, fail to account for the positive effect of public services on household utility. Zhao and Kanamori (2007) include the stock of public infrastructure in both the household's objective utility function and the private production function, because they also

observe that the flow specification of infrastructure is inappropriate since "what contributes directly to production and utility is the service flow of public infrastructure produced by capital."

A common feature of the studies reviewed above is their modelling strategies that employ the stock specification of infrastructure has been to assume a constant depreciation rate of public capital. However, Kalaitzidakis and Kalyvitis (2004) modify this assumption by introducing public capital maintenance expenditures. The freshness in Kalaitzidakis and Kalyvitis (2004) is that they allow the depreciation rate to vary with maintenance expenditures. They define public capital maintenance as "the deliberate utilization of all public resources which preserve the operative state of public capital goods". The main finding of Kalaitzidakis and Kalyvitis (2004) is that "the government can improve the growth rate of the economy by reducing (increasing) the share of maintenance expenditure in total expenditure if it is set at a high (low) level" as the tax rate is already set at the steady-state level.

From the above theoretical analysis we can understand that, in contrast to Barro (1990), Futagami et al. (1993) and Tsoukis and Miller (2003), Kalaitzidakis and Kalyvitis (2004) found that the optimal tax rate to maximize long-run economic growth is larger than the production elasticity of public capital when maintenance expenditures are incorporated into the infrastructure-led endogenous growth model.

There seems to be a common tendency within the theoretical literature to ignore the indirect impact of infrastructure via TFP whether the modeling strategy employs a stock or a flow variable approach to measuring infrastructure. In other words, the common approach used to analyze the effects of public capital on output assumes that infrastructure only affects output directly as a production factor (Calderon and Serven, 2014; Dissou and Didic, 2013).

In general, all the theories explained above show the importance of infrastructure investment as one of the important factors to determine economic growth and how it is the indispensable input to boost growth.

2.1.5. Accelerator Theory of Investment

Keynes was the first economist, in his book "The General Theory of Employment, Interest and Money", to call attention to the existence of an independent investment function in the economy in departure from the prevailing notion that all available saving is automatically invested provided an appropriate interest rate exists in the economy (Serven & Solimano, 1989). Keynes' (1936) theory asserts that investment is the result of firms balancing the expected return on new capital—we call it the marginal product of capital; he called the marginal efficiency of capital—with the cost of capital, which depends primarily on the real interest rate (Parker, 2009). In addition, he pointed out any forecast of the returns of investment accruing in the future will be necessarily incomplete and uncertain (Serven & Solimano, 1989). According to Keynes, such intrinsic volatility of private investment would lead investors to their "animal spirits' in making their investment decisions rather than to a rational calculation of an inherently uncertain distant future (Keynes, 1936).

After Keynes, the accelerator theory of investment become popular in the 1950s and early 1960s following its further modifications by Chenery (1952) and Koyck (1954) assume that the desired capital stock at any point in time is a constant multiple of output at that time and widely used even today in practical growth exercise. This is often associated with a Keynesian approach

which is primarily due to its assumption of fixed prices.[5] The origins of the principle go back at least to Carver (1903) analysis (Luintel & Mavrotas, 2005). The name "acceleration principle" seems to have been coined by Clark (1917) and it is a simple model that incorporates the kind of feedback from current output to investment that Keynes saw occurring through the effect of current output on investors' expectations and hence investment (Eklund, 2013).

The accelerator model begins with an assumption that firms' desired capital-output ratio is roughly constant.[6] This implies that the desired capital stock for any period t is proportional to the level of output in t (Blejer & Khan, 1984; Parker, 2009);

$$\boldsymbol{K_t^* = \sigma Y_t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad \mathbf{(2.8)}$$

Where σ (the lower-case Greek letter sigma) is the desired capital-output ratio.

This is simply the well---known accelerator principle where the desired capital stock is assumed to be proportional to output. Investment in any period will therefore depend on the growth in output. Suppose that firms invest in period t in order to bring their capital stocks to the desired level K_{t+1}^* in period $t + 1$. Then, if depreciation is zero for simplicity,

$$\boldsymbol{I_t = K_{t+1}^* - K_t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad \mathbf{(2.9)}$$

But since $K_t = K_t^* = \sigma Y_t$, that means

$$\boldsymbol{I_t = \sigma(Y_{t+1} - Y_t) = \sigma \Delta Y} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad \mathbf{(2.10)}$$

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[5] Assuming fixed prices means that the factor substitution elasticity becomes zero, whereas in Jorgenson's neoclassical theory the factor substitution elasticity is one.

[6] Since we focus on short-run business-cycle fluctuations here, it is reasonable to ignore changes in K/Y that may be associated with long-run advances in technology

Thus, the simplest accelerator model predicts that investment is proportional to the increase in output in the coming period.

In the accelerator model, profitability, expectations and cost of capital considerations play no role in the determination of investment (Serven & Solimano, 1989). Furthermore, it is worthwhile to note that even though the accelerator principle is often coupled with a Keynesian approach, Keynes himself was very skeptical towards approaches like this. First, Keynes was very critical towards formal models of economic behavior. Second, and more fundamentally, Keynes did not believe that investment is determined as adjustment towards equilibrium (Eklund, 2013).[7]

2.2. Review of the Empirical Literatures

2.2.1. The Impact of Public Infrastructure Investment on Private Investment

This section is concerned with the empirical studies on the relationship between public investment on infrastructure and private investment. Thus, this section presented evidences and/or empirical literatures about crowding-in/out effects of public infrastructure investment on private investment.

Using a model that accounts for credit to the private sector and the accelerator effect, Dhumale (2000) revealed that public investment in infrastructure appeared to have a crowding-out effect in oil-exporting countries, and a crowding-in effect in the non-oil-exporting countries.

[7] If expectations are volatile and humans "animal spirited" this leads to constant shifts in the Keynesian investment demand schedule, which makes the notion of investments as determined by a desired capital stock meaningless since the desired stock of capital keeps shifting before equilibrium is reached.

Furthermore, he found out in the case of the non-oil-exporting countries it seems that better infrastructure investment will have greater positive effects on private investment than the comparable negative effects caused by greater non-infrastructure investment. Similarly, Shafik (1992) found that public investment tends to crowd out private investment in Egypt through its effect on credit markets, and to crowd-in through investment in infrastructure.

However, Agenor et al, (2005) criticized the studies of Dhumale (2000) and Shafik (1992) on the following main grounds: first, they seldom make a clear distinction between the flow effect of public investment, and the stock effect of public capital. But this is crucial, given that the transmission channels are substantially different. Second, the treatment of dynamics in these studies is sometimes crude if not inexistent. All those issues are addressed in Agenor et al, (2005) study, which employed a VAR approach to examine the impact of public infrastructure on private capital formation in three countries of the Middle East and North Africa: Egypt, Jordan, and Tunisia. Their impulse response analysis suggests that public infrastructure has both, short-lived, "flow" and "stock" effects on private investment in Egypt, and only a significant "stock" effect in Jordan and Tunisia. On the top of this, Agenor et al, (2005) argued that reducing unproductive public capital expenditure and improving quality must be accompanied by reforms aimed at limiting the investment to infrastructure capital that crowd-in the private sector.

Rioja (2001) investigate the economy-wide impact of public infrastructure investment in the general equilibrium studies on Brazil, Mexico and Peru. He noted that these countries had underinvested in infrastructure during 1970s and 1980s. The simulations he carried out suggested that, in addition to this, devoting additional resources to infrastructure investment have sizable positive effects on private business investment. More high ways and public communication networks encouraged private companies to invest because using these public inputs can increased

productivity of private factors. However, Badawi (2005) revealed that public sector capital investment induces a crowding-out impact on private sector physical capital expansion in Sudan. Hence, such crowding out effect would reduce the potential positive impact of public sector capital spending on growth and prosperity by jeopardizing private sector capital undertakings.

Kandenge (2005) and Rena (2011) tried to analyze the impact of public infrastructure investment on private investment in Namibia. Kandenge (2005) confirmed that public investments in infrastructure raises the profitability of private production and encourage private investment, while non-infrastructure projects in areas where the public sector competes with private firms may have the opposite effect in Namibia. However, Rena (2011) revealed that health and transport infrastructure investment leads to the crowding-out of private investment-resulted from financing unproductive activities. In his result, however, education infrastructure investment has a positive impact on private investment.

Boopen & Khadaroo (2009) employed a neoclassical investment model within an error correction framework to examine the dynamic link between transportation capital and private investment in Mauritius. They argued that transport capital is complementary to private investment and thus consistent with the crowding in hypothesis in both short and long run. However, the neoclassical investment approach has been subject to several criticisms regarding: the consistency, and plausibility of its assumptions: (i) the assumptions of perfect competition and exogenously given output are inconsistent; (ii) the assumption of static expectations is inappropriate, since investment is essentially a forward looking process; (iii) delivery lags are introduced in an ad hoc manner (Serven & Solimano, 1989).

In a recent study, Tchouassi and Ngangue (2014) empirically examined the relationship between private investment and public capital expenditures in a panel of fourteen African countries over

the period 1980-2010. Their findings provided clear evidence that the complementarity effect between private investment and public capital investment is not justified; rather support the idea that private investment is a substitute of public capital and basic infrastructure expenditure.

Despite the earlier outlined empirical arguments, Dissou and Didic (2011) indicate that the crowding-out effects of public infrastructure is sensitive to the mode of financing chosen by the government. Overall, their findings suggest that public investment in infrastructure can support private investment and sustain capital accumulation. The positive impact of public investment on private investment can be explained through the infrastructure financing channels such as public private partnerships and subcontracting which in turn tend to crowd-in private investment (Dissou and Didic, 2011). It is noted in many studies (for instance Corong et al (2012), Zhang et al (2012) and Ahmed et al (2013)) noted that the impact of public infrastructure investment on private investment is sensitive to the modes of financing.

Corong et al (2012) has investigated the role of public infrastructure investment in Philippines through analyzing the two modes of financing public infrastructure: international borrowing and production taxes.[8] They found, under international financing, the expansion of public infrastructure investment leads to the crowding-in effect. The main driver of this effect is international capital inflows which finance increased public investment expenditures. Hence, in the absence of higher production taxes, domestic firms enhance their profitability by producing more capital goods and by accumulating private capital stock. However, when public infrastructure investment is financed by higher production taxes, Corong et al (2012) argue that,

[8] The reason for choosing the production tax is that usually, of the many indirect taxes, this is one of the easiest to implement in developing countries with fewer politically unfavorable implications (given that it is linked with growth in value added). However this tax also has highly distortionary effects on production and consumption (Corong et al, 2012).

there is a slight reduction in private investment results from a crowding-out effect. This crowding-out effect is caused by higher prices of investment goods and the higher production tax rate imposed on firms in order to balance the government budget. Total private investment thus falls. In similar vein, Ahmed et al (2012) argued that the public investments stimulates private investments via improved productivity in China whether it funded by taxation or international borrowing.

Most recently, Ahmed et al (2013) used a dynamic CGE model linked to a microsimulation model to estimate the macro-micro impact of public infrastructure investment in Pakistan under the two modes of financing infrastructure (i.e. production tax and foreign borrowing). Under production tax financing, they found in their simulation the overall investment increased in the long run mainly comes from public infrastructure investment. There are also positive knock-on effects on private investment providing evidence of crowding-in effect. They note that private investment is higher despite a production tax due to complementarities in public and private investment. However, in the short term there is a negative impact on private investment at the disaggregated level and a null effect on the capital stock. On the other hand, when public infrastructure investment financed by foreign borrowing the lower cost of capital facilitates long run expansion of private capital stock. Generally, Ahmed et al (2013) concluded that public infrastructure investments have the same direction of impact whether funded by taxation or international borrowing in the long run but in the very short run, tax financing puts a strain on the industrial sectors and thus reduces private investment in the short run.

With regard to Ethiopia, Shebeshi (1994) in his study entitled with "Determinants of Private Investments" shows that low and poor infrastructural supply and lack of private investment in infrastructure crowds-out private investment in the Ethiopian economy. Furthermore, he

suggested that public infrastructure investment may not encourage private investment if it is financed by public borrowing.

The following empirical studies, which are not separate infrastructure and non-infrastructure government investment for the purpose of analyzing the determinants of private investment, are also has been done in Ethiopia to show the impact of public investment on private investment. Workie (1997) found that public investment did not have a significant effect on private investment. Daniel (2006) also attempts to identify the determinants of private investment in Ethiopia using vector error correction model (VECM). The study confirms that there is a strong positive impact public investment on private investment in the long run but its short run impact is insignificant.

The above discussion suggests that there is no conclusive empirical finding on whether additional public infrastructure investment leads to crowding-out or not private investment. Some results go in favour of crowding-in while others support the crowding-out effect.

2.2.2. The Impact of Public Infrastructure and Private Investment on Economic Growth

In both developed and developing countries much research has been devoted to investigate the potential impact of increased public infrastructure capital and private investment on economic growth. Although there has been a consensus that expansion or contraction in public investment and/or private investment would in principle affect economic growth, the ultimate result of such an effect has been subject to controversy. Some of the empirical studies showed that the marginal productivity of private capital is greater than that of public infrastructure capital and, thus, the contribution of the former to economic growth and development is larger than the latter

(Beddies, 1999; Khan and Kumar, 1997; Khan, 1996; Khan and Reinhart, 1990). On the other hand, some evidence remains to point to a possibly larger contribution of public capital than private capital to economic growth (Ram, 1996; El Makhloufi, 2011). Thus, this section reviewed different empirical studies on the impact of public infrastructure and private investment on economic growth.

Kumo (2012) indicated that, using bivariate vector autoregression (VAR) model with and without a structural break, there is a strong causality between economic infrastructure investment and GDP growth that runs in both directions implying that economic infrastructure investment drives the long term economic growth in South Africa while improved growth feeds back into more public infrastructure investments. He further assessed the pairwise causality test results using autoregressive distributed lag (ARDL) or bounds testing approach for cointegration to assess both the short-and long-run relationships among the variables in question. The bounds test results indicated the presence of steady-state long-run equilibrium relationship between economic growth, economic infrastructure investment, and formal employment.

In time-series study, Nketiah-Amponsah (2006) shows for Ghana that aggregate government expenditures have a negative impact on economic growth. More specifically, he revealed that disaggregated (short-run) health and infrastructure expenditures positively affected growth and education expenditures negatively impacted growth. And, Sahoo and Dash (2009) also show for India that the stock of infrastructure positively contributes to growth with unidirectional causality from infrastructure development to output growth.

Enimola (2010) analyzed empirically the influence of infrastructure investment on economic growth in Nigeria, by employing the vector error correction estimate (VECM). The study found out an increase in the share of expenditures in infrastructure for strategic sectors, particularly

energy and transport, is necessary and productive in Nigeria. By the same token, Okoh and Ebi (2013) examine the effect of interaction of infrastructure investment and institutional quality (corruption and contract enforcement) on economic growth in Nigeria. The findings showed that infrastructure investment has a robust positive influence on economic growth. Corruption has a negative and significant effect while contract enforcement has positive and significant effect on economic growth. However, the interaction between infrastructure investment and institutional quality on economic growth were insignificant. It appears that low levels of contract enforceability and increase corruption render the positive infrastructure investment –economic growth nexus insignificant in Nigeria. As a result, Okoh and Ebi (2013) suggested that success of infrastructure investment may, to a great extent, depend on the prevailing institutional quality (corruption and contract enforceability) in Nigeria.

Keyoda et al (2013) have investigated the impact of public sector investment in transport infrastructure on economic growth of Nigeria, using endogenous growth framework in which transport investment entered into the production function as input. The findings of the study suggested that transportation infrastructure investment is insignificant in determining economic growth in Nigeria-this is resulted from the low level of investment of transport infrastructure within the nation's economy. Thus, he recommended that an increase in public funding and complete overhauling of the transportation system in the country.

Kandenge (2005) analyzed the impact of public and private investment on economic growth in Namibia using the framework of an endogenous growth model. The findings of the study implied that public and private investment impact positively economic growth in the short and long run process. In addition, he confirms that private investment is more effective in the long run then public investment. Another main finding of Kandenge (2005) study confirmed that public

investment on infrastructure raises the productivity of private investment. As a result, public infrastructure investment enables the private investment vigorously plays a catalytic role in the economy. It is through private investment that production is expanded and the generation of new employment opportunities is realized. It creates and increase income for the economy. In turn this generate revenue that governments needs to expand access to health, education and public investment in infrastructure development and services and so assist improve the productive capacity of the economy.

Boopen (2006) analyzed the importance of transport capital to growth for two different data sets namely for a sample of Sub Saharan African (SSA) countries and also for a developing states (SIDS) using both cross sectional and panel data analysis. His investigation highlights the importance of transport capital as an element of these countries development. Furthermore it has been observed that this type of capital might have been more productive than the overall investment in SSA countries but not for the SIDS countries. Furthermore, Sedar, F.P. (2007) also studied the role of infrastructure for economic growth in Cote d'Ivoire under the endogenous growth model framework. The findings showed that public infrastructure spending have a positive productive effect on economic growth of Cote d'Ivoire.

According to Ghura (1997), physical capital accumulation plays important roles in influencing the economic growth of Cameroon. He observed that private and private investment plays crucial role in output expansion. His empirical analysis established a significant causal linkage between private/public investment and economic growth; increases in the private/public investment ratio boost economic growth. He confirmed that, however, the impact of private investment is larger than that of an increase in government investment. In the same vein, Haque (2012) analyzed the impact of public and private investment on economic growth in Bangladesh. He argued that

public and private investments have a positive impact on economic growth in the short and long run process.

To date, in Ethiopia, there have been very few empirical studies focusing on the aggregate impact of public investment on economic growth of the country without analyzing the separate (disaggregate) impact of infrastructure investment from non-infrastructure public investments (for instance Alemayehu and Befekadu (2005), Muhammed (2006), Alemnesh (2012), and Siraj Mustefa (2014)).

Alemayehu and Befekadu (2005) have explored the role of investment as one of the long-run determinants of Ethiopia's growth rate. With regard to the relative contribution of public investment and private investment to economic growth, they confirmed that private investment is a greater contributor than public investment to the country's economic growth; a 10% increase in private investment leads to an approximately 1.5% increase in output, while a similar increase in government investment leads to a 0.95% increase.

Using the framework of a Solow growth model, Muhammed (2006) investigated the impact of private and public investment on the economic growth over the 1970/71-2004/05 period using error correction model (ECM). The empirical analysis revealed that private investment exerts a positive and significant effect on economic growth in Ethiopia both in the short run and long run. Public investment also does significantly and positively affect economic growth, both in the short run and long run. This could be due to the direct effect of the level of stock of government capital has on economic growth. In addition, he revealed that the contribution of public investment is higher than private investment in the short run, but it is smaller in the long run. It may be due to the existing acute shortage of infrastructure in the country.

Similarly, Alemnesh (2012) found that there is bi-directional causality between economic growth, private investment and public investment in Ethiopia. In the short run, the impact of public investment is crowding-out economic growth but in the long run it has complementarity effect. Such short run result may be due to the fact that public spending has long gestation period and the productive outcome of public investment is only visible in the long run and thus, in between consume resources that can be used by private resources. With respect to private investment, real private investment has positive and significant impact on economic growth in Ethiopia, both in the short run and in the long run. And also economic growth has positive long run and short run impact on public and private investment.

Most recently, Siraj (2014) tried to evaluate the inter-relationship between private investment and economic growth both in the long and short run. He argued that there is evidence of uni-directional causality between economic growth and private investment. The findings showed that both private and public sector investment have a positive significant impact on real output/economic growth while in the short run public investment has a negative impact on growth and private investment has a positive impact on growth.

Generally, all the above empirical studies showed that adequate infrastructure can be expensive, but the costs of not delivering housing, transportation, energy, water, sewage, public facilities, and other necessities are also high. Inadequate infrastructure slows and even reverses economic growth, driving unemployment, crime, and urban decay. It can fuel country tensions by widening divisions among ethnic or income groups or between long-time residents and recent immigrants. And it can foster a general malaise that drains a country's vitality and spirit. Furthermore, the dynamic and feedback effects of public infrastructure investments are key reasons for choosing a vector autoregressive (VAR) model framework for the empirical analysis of this study.

CHAPTER THREE

OVERVIEW OF PUBLIC INFRASTRUCTURE INVESTMENT, PRIVATE INVESTMENT, AND ECONOMIC GROWTH IN ETHIOPIA

Based on different government documents and policy papers, this chapter provides a brief overview on the current state of infrastructure and its investment, private investment, and economic growth in Ethiopia as well as their respective policies and strategies.

3.1. Policy Environment and Growth Performance in Ethiopia

During the Imperial (Monarchy) regime, which was the Emperor Haile Selassie I reign from the period 1930 to 1974, the land aristocracy and the majority of peasants (tenants) constitute the major socio-economic agents. Land was the most important resource and source of power that served as institution to exploit the masses by the Monarchy and the Feudal land lords. The economy was predominantly subsistence agrarian (Alemayehu and Befekadu, 2005).

During the early l950s, the imperial regime called for the transformation of the subsistence agrarian economy to an agro-industrial economy. In order to fulfill this objective the country needed to develop infrastructure, expand and improve health, education, communication and other essential services that enable proper utilization of resources and improve living conditions of the population. In order to carry through this new economic policy, the regime framed centrally administered development plans. The First Five-Year Plan (1957-61) had the objective to develop a strong infrastructure, particularly transportation and communications, to connect remote regions; to produce skilled and semi-skilled personnel to facilitate the industrial process so as to reduce Ethiopia's dependence on imports, and to promote commercial agriculture in

order to accelerate agricultural development. During the First Five-Year Plan, the Gross National Product (GNP) increased at a 3.2 percent annual rate as opposed to the projected figure of 3.7 percent, and growth in economic sectors such as agriculture, manufacturing, and mining failed to meet the national plan's targets. Furthermore, exports import grew at a rate of 3.5 and 6.4 percent per annum, respectively (Tadesse, 2011).

The Second Five-Year Plan (1962-67) had the objective of diversification of production, introduction of modern processing methods, and expansion of the economy's productive capacity to increase the country's growth rate (Second Five Year Development Plan-SFDP, 1962). During this planning period the real GDP increased at 4.25% which is a good performance on the basis of the plan. Ministry of Planning was established and prepared the Third Five-Year Plan (1968-73) that pursued to facilitate Ethiopia's economic well-being by raising manufacturing and agro-industrial performance. This Plan was ambitious in both regards and ended up with serious under implementation (Tesfaye, 1992). During this planning period, the Gross Domestic Product (GNP) increased at a 3.32 percent annual rate.[9]

However, the development planning efforts of the imperial regime failed to achieve its prime objective, i.e. the transformation of subsistence agrarian economy, and improve the living standards of the masses. This is mainly due to lack of administrative and technical capabilities to implement the plan (Tadesse, 2011; Tesfaye, 1992).

On 12 September 1974, the socialist (Derg) regime removed the emperor from power and Ethiopia was declared a socialist state on December 1974. Which means the government installed a socialist economy system where market forces were deliberately repressed (Berhanu,

[9] Note that the numerical figures stated in this chapter without citation are computed from MOFED data set to support the theoretical discussions of different authors.

2001). This regime largely characterized by a complete nationalization measures and intense conflict, which highlighted the gloomy growth performance (Alemayehu, 2011). During this regime, the Ethiopian economy registered miserable growth. According to Alemayehu (2001), growth decelerated to 2.3 percent (-0.4 percent in per capita terms) between 1974/75 and 1989/90. He argued that this poor growth record is because of its dependence on volatile agricultural sector and negative shocks from political instability, and inappropriate institutions.

We can frame the Derg regime's growth performance in to different phases. In the first phase (1974/75-1977/78) the real GDP grew on average by 0.55 percent annual rate. According to Ofcansky and Berry (1991), this sluggish economic growth is mainly due to nationalization measures and unstable political climate (war with Somalia). Thus, the huge amounts of the country's resources were shifted for military budget. This phase is followed by a period of recovery of the Ethiopian economy from the period 1978/79 to 1979/80, where the real GDP increased at a 4.8 percent annual rate. This is attributed to government's new effort through cooperation campaign (known as 'Zemacha') and security conditions improved as internal and external threats weakened.

However, in the third phase (1980/81-1984/85) the economy reversed glumly, where the economy registered 0.9 growth rate on average below zero in real GDP. These were periods where manufacturing and agriculture output fall dramatically. The main factor accounted for this gloomy development is the fact that country was hit by severe drought and famine, and establishment of large military establishment which absorb 40 to 50 percent of government's expenditure (see Ofcansky and Berry, 1991; and Berhanu, 2001). The final phase is the period 1985/86−90/91. In this phase, the economy showed amazing recovery during the period 1985/86 and 1986/87, where real GDP grew at a rate of 11.95 percent on average. In the last years of the

Derg regime (over the period 1987/88-1990/91) the economy collapsed again. During these period the real GDP was increasing at an average annual rate of 0.7 percent. This is due to the lingering effects of the 1984−85 drought (Ofcansky and Berry, 1991).

In 1991, the EPRDF removed the military regime through military action and issued New Economic Policy in November 1991 by openly adopting a market-oriented economic policy. The new regime began to carry out liberalization under the World Bank (WB) and International Monetary Fund (IMF) policy prescriptions in a typical Structural Adjustment Program (SAP) packages. This policy promoted domestic private sector and opened the door to foreign investors, except in the financial industry (Alemayehu, 2001). The Ethiopian Privatization Agency (EPA) was also established and privatization program started in 1994 so as to give the private sector a room to play a significant role in the country's development than the Derg regime did.

The core objective of the EPRDF regime is poverty reduction. To accelerate the reduction of poverty in the most effective way, the government chosen growth strategy, named Agricultural Development Led Industrialization (ADLI) (SDPR, 2002). The primary objective of ADLI is to make a strong interdependence between agriculture and industry by increasing farmer's productivity, expanding private commercial farms, and reconstructing the manufacturing sector. ADLI is seen as a long-term strategy to achieve faster growth and economic development by making use of technologies that are labour using, but land augmenting, such as fertilizer and improved seeds and other cultural practices (Tadesse, 2011).

In the first decade of the EPRDF regime, from the period 1991/92 to 2000/01, the economy bounced back to good growth track, except the year 1998- primarily due to the severe drought and conflict with Eritrea. In this decade the real GDP and per capita GDP grew at an average annual rate of 4.8 percent and 1.9 percent, respectively. The economy would have registered

above this growth rate if the country did not have war with Eritrean in 1998, where the real GDP and per capita GDP grew at a rate of 1.4 percent and 4.3 percent below zero, respectively.

The next two consecutive years (year 2001/02 and 2002/03) again the Ethiopia economy has deteriorated. In the period 2001/02 the real GDP grew at a rate of 1.6 percent, but in the year 2002/03 the real GDP increased at a rate of 2.1 percent below zero. The actual reason for this slothful economic growth is that the economy has been adversely affected by the drought that severely hit Ethiopia in 2001/02 and 2002/03 – the worst since 1984/85. This was accompanied by a sharp decline in agriculture production (Getahun, 2004). This shows how the overall economic growth of Ethiopia has been highly associated with the performance of the agriculture sector, which is highly dependent on natural rain. According to Alemayehu (2001), good macro performance will not be sustained if the country continues to depend on rain fed agriculture sector. Furthermore, he showed that dependence on rain-fed agriculture had negative multiplier effect on production levels in subsequent years if there is a shock (drought) in one period because the drought not only deprived peasants current income but also his wealth (for example farmers may be forced to sell oxen), leading to a decline in output in the next agricultural season.

From the period 2003/04 to 2009/10, with no doubt, the economic growth was quite impressive. Real GDP and per capita GDP grew nimbly at an average annual rate of 11.3 percent and 8.3 percent respectively for the last seven consecutive years, which is the highest among the non-oil producing economies of Africa. However, following the recovery commencing in 2003/04, growth has been very much sustained and complemented by strong performance in the construction, manufacturing, trade and tourism, banking and insurance, and real estate sectors/sub-sectors. The construction sector has been spurred by the much needed public sector

investment in infrastructure (roads, rural infrastructure development including food security, telecom, power, irrigation, etc.) and private sector expansion as well.

The Government of Ethiopia's current five-year development plan (2010/11-2014/15), the Growth and Transformation Plan (GTP), is geared towards fostering broad-based development in a sustainable manner to achieve the Millennium Development Goals (MDGs). The GTP envisions a major leap in terms of not only economic structure and income levels but also the levels of social indicators. During the first year of GTP implementation (2010/11), the country has registered 11.4 percent real GDP growth rate surpassing the GTP target of 11 percent. Particularly, the agriculture and industry sectors have registered growth rates above their targets set for the year. Clearly, more effective implementation of prudent macroeconomic and sectoral policies has contributed to this faster and broad-based growth (MoFED, 2012).

During the second year (2011/12) of GTP implementation, real GDP grew by 8.8 percent. In 2012/13, the GDP grew by 9.7 percent in real terms. Though the 9.7 percent growth performance registered in 2012/13 is below the 11.3 percent target set for the fiscal year under review, it was achieved under difficult domestic and global environment. Furthermore, the 2012/13 low real GDP growth was achieved due to the fall in prices of Ethiopia's major export commodities such coffee and gold while prices of its major import items such as fuel continued to be high. On the other hand, the 2012/13 economic growth was high compared to the sub Saharan average performance of around 5 percent. The performance was also above the 7 percent growth requirement set to achieve the Millennium Development Goals (MDGs). In general, Ethiopia's economic performance in 2012/13 was widely regarded as one of the fastest growth rates in the world by different international financial institutions (MoFED, 2014). Moreover, the country's Real GDP expanded by 10.3 percent in 2013/14 ((World Economic Outlook Update, July 2014).

3.2. Policy Environment and Performance of Private and Public Investment in Ethiopia

The imperial regime characterized by a low level of infrastructure development along with negligible participation of the private sector. By the late 1950s, a network of roads and the Ethiopian airlines as well as the beginnings of banks and the generation of electric power were set in motion by the imperial government. Furthermore, the government was also taking steps to encourage private sector development by introducing legislation (Notice No. 10, 1950) in 1950. This legislation focused on encouraging the absorption of private foreign capital.

The above legislation were consolidated in 1963 as the investment decree and ultimately issued as a proclamation in 1966. This proclamation allows private investors to invest in all sectors of the economy. In addition to this, it provides an attractive incentive structures such as import and export tax exemptions, income tax holidays, and foreign investors were also allowed to acquire land. Because of the continued effort to encourage the participation of private investments, the rate of private investment participation averaged approximately 8% of real GDP, while public investment accounted for 1% (Muhammed, 2006).

During the Derg regime, the economy was guided by central planning, and economic policies were advised in such a way that the public sector was favored at the cost of the private sector (Alemayehu, 2011). The Derg regime nationalization policy started by proclamation No. 26/1975 (the nationalization proclamation). As a result, the military government nationalized a large number of domestic and foreign production, distribution and service rendering private enterprises. Such act of nationalization significantly decreased participation of the private capital

and especially the foreign investors to foster the economic development of the country (Berhanu, 2001).

Moreover, the military regime limited the participation of the private investors to a few lines of activities and imposed capital ceilings of private investors to Birr 500,000 (proclamation No. 76/1975). And the government levied progressive tax on the income and profit of individual business that completely discouraged the participation of the private sector. Latter in 1989, the government allowed domestic private investment participation in the form of joint-venture agreement and the provision for majority shareholding by the state (Tadesse, 2011). The restrictive policy of the Derg regime has frozen the private sector development. The average growth rate of private investment to real GDP during the period 1974/75-1990/91 was 8.2% while the average growth rate of public investment to real GDP was 23%.

Unlike the Derg regime, the economic policies of the EPRDF regime limited the role of the state in the economy and promote the active participation of the private sectors through various economic reforms. To rehabilitate and revitalize the economic performance the Transitional Government of Ethiopia (TGE) issued the proclamation that encourages private sector development. The proclamation encouraged the private sector to invest in most sectors except some areas, which are exclusively reserved for the government. It prohibited sectors like defense industries, large-scale air, and marine transport service and import of petroleum and armaments for the government (proclamation No. 15/1992). As a result of the above proclamation, the private investment share of real GDP reached 3.6% for the period 1991/92-1995/96 with the growth rate of 25% on average.

In 1996, the newly revised proclamation No. 37/1996 has just been put in to practice by improving some of the shortcomings of proclamation No. 15/1992. The new proclamation

guaranteed to domestic investors with an investment capital of less than Birr 250,000 channeled to sectors of priority. It also extends duty free exemptions to services such as hotel, tourism, health and educational services. The EPRDF government also legislate two proclamations [proclamation No. 280/2002 and its reenactment proclamation No. 373/2003) to provide more areas for private sector participation and to enhance transparency and efficiency of service provision. Accordingly, the share of private investment to real GDP reached an average of 10.3% for the period 1996/97-2013/14 with 17.9% growth rate on average.

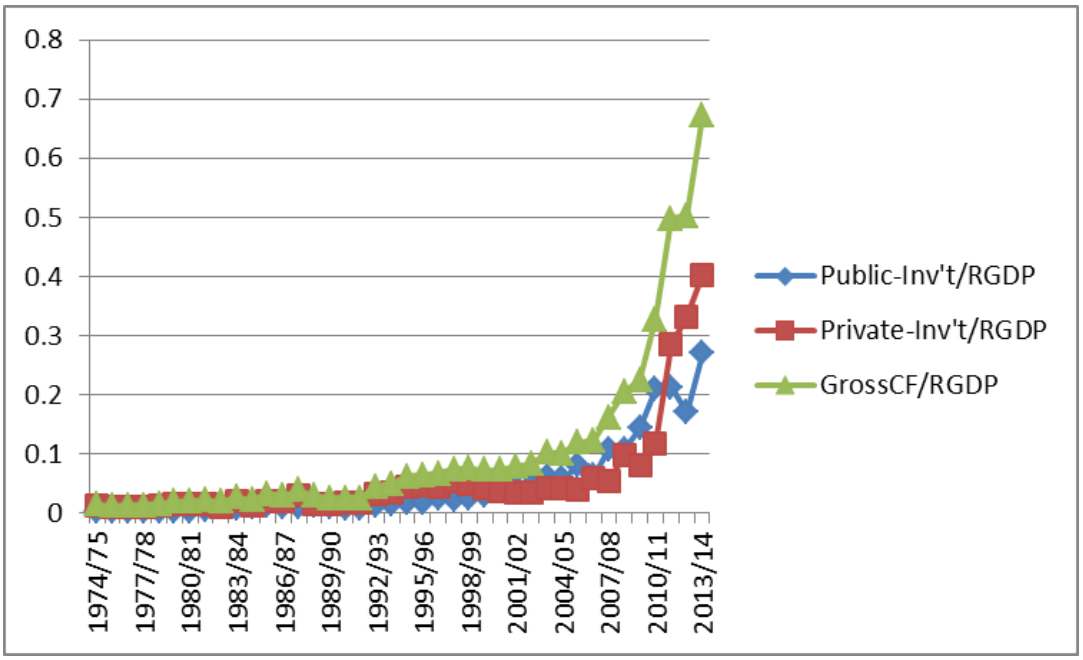


Figure 3.1: Public and private investment to real GDP ratio

In line with the above figure 3.1, we can conclude that the development of private investment is more related with the policy environment. However, compared to the country's requirement, investment is still very low in Ethiopia.

3.3. State of Infrastructure in Ethiopia

The government of Ethiopia has been engaged in extensive investment in infrastructure development as infrastructure provides a backbone that sets an economy on the path towards sustained economic growth. The provision of basic and efficient infrastructure in transport, communications, education, health and utilities such as electricity provides an enabling environment for the private sector which then takes the lead in the growth process. Ethiopian's infrastructure has improved significantly over the past three decades. While Ethiopia has invested in public assets, poor governance (poor accountability, monitoring, stakeholder participation, etc.) continues to plague these assets (Foster and Morella, 2011; World Bank, 2010). According to the overall competitiveness index in the 2011-2012 and 2012-2013 reported in the Global Competitiveness Reports, Ethiopia ranked 119th among 142 countries. It also ranked 120th among 144 economies in terms of infrastructure (WEF, 2011; WEF, 2012). Furthermore, the 2013-2014 Global Competitiveness Reports showed that Ethiopia requires significant improvements in the areas of infrastructure due to the less competitive position (124th out of 148 countries) of the infrastructure sector (WEF, 2013). Infrastructure in Ethiopia is traditionally financed through the public sector, much of which is actually leveraged through foreign aid. In addition to these, this sector still underdeveloped due to the less attention that has been given by different regimes of the country. To have the general picture of the current state of infrastructure in Ethiopia each subsectors are discussed below:

Road transport

The development of road transport, which is the dominant mode of freight and passenger transport, is expected to play a vital role in the growth of the economy of Ethiopia. The country

planned to create a network over a wide array of infrastructural facilities so as to improve the accessibility and mobility of agricultural and industrial products (NBE annual report, 2012/13).

Before the formulation of RSDP, the challenges facing the roads sector were immense. The total road network was only 26,550 km, of which over half was in a poor condition. Only 22% of the network at that time was in a good and serviceable condition, finances were scarce and maintenance was all but neglected (ERA, 2009). To address these constraints in the road sector, mainly low road coverage and poor condition of the road network, the Government formulated the Road Sector Development Program (RSDP) in 1997. The RSDP has already been implemented over a period of seventeen years and in four successive phases, RSDP I - Period from July 1997 to June 2002 (5 year plan), RSDP II - Period from July 2002 to June 2007 (5 year plan), RSDP III - Period from July 2007 to June 2010 (3 year plan), RSDP IV - Period from July 2010 to June 2015 (the 5 year plan, of which 4 years elapsed). RSDP has been financed from domestic sources including Government of Ethiopia (GoE) and the Road Fund Office, and foreign sources including Governments and International Financial institution (ERA, 2014).

Over the Seventeen years of the RSDP, physical works have been undertaken on a total of 110,163 km of roads excluding routine maintenance work (see Table 3.1). As a result, the road density per 1000 sq. km has increased from 24 km in 1997 to 90.5 km in 2014. It includes 85 Km Addis- Adama Express Way, the first of its kind in the country, which was completed in 2013/14 (NBE annual report, 2013/14). Also substantial improvement has been registered in the condition of the country's road network. The proportion of road network in good condition increased from 22% in 1997 to 70% in 2014 (NBE annual report, 2013/14). Despite this quite impressive improvement in road sector, the country is still less competitive in terms of its global ranking of quality of roads, in which it ranked 69th out of 148 countries in 2013/14 (WEF, 2013).

Table -3.1: Summary of 17 Years Performance of RSDP

Program	Physical Plan Vs. Accomplishment, km			Finical Plan Vs. Disbursement, in million ETB		
	Plan	**Actual**	**% age**	**Budget**	**Disbursed**	**% age**
Total RSDP I	8908	8709	98	9812.9	7,284.5	74
Total RSDP II	8486	12006	141	15985.9	18,112.8	113
Total RSDP III	20686	19251	93	34643.9	34,957.9	101
RSDP IV (Four years)	90386	70196	78	99871.2	120,501.2	121
Total RSDP (17 years)	**128,466**	**110,163**	**86**	**160,313.9**	**180,856.4**	**113**

Source: Ethiopia Road Authority (ERA), 2014

The total budget for the planned works during the seventeen years of the RSDP amounted to ETB 160.3 billion (USD 11.1 billion). And, the total amount disbursed in these period is ETB 180.9 billion (USD 12.2 billion). Around 79% of the RSDP financing over the last seventeen years came from internal sources (GoE, the Road Fund and the Community). The remaining 21% was pooled from the development partners (ERA, 2014). The share of the Government of Ethiopia was the highest (69.4%), followed by the Road Fund (7.7%), the IDA (7.3%) and the EU (4.5%) (See table -3.2). Thus, as a result of road sector investment, the total road network of the country and its condition has improved even if the rate of change was slow at the beginning of RSDP (NBE report 2013/14; ERA, 2014).

Table-3.2: Financing Pattern of RSDP (in million ETB)

Phase of RSDP	Financing from Local Sources		Financing from External Sources		Total
	Amount	Percentage	Amount	Percentage	
RSDP I	4,433.7	61	2,850.9	39	7,284.5
RSDP II	12,110.2	67	6,002.6	33	18,112.8
RSDP III	26,068.4	75	8,889.4	25	34,957.9
RSDP IV	99,873.7	83	20,627.5	17	120,501.2
Total	**142,486.1**	**79**	**38,370.3**	**21**	**180,856.4**

Source: Ethiopia Road Authority (ERA), 2014

Rail transport

One of the priorities in the development of economic infrastructure is developing railway network. Rail transport started about the time of the industrial revolution and it has been serving the world over 200 years. The first railway line in Ethiopia is the Ethio-Djibouti railway line, which was established in the regime of Emperor Menelik II. The total distance covered by the line was 781Km, of which the 681 Km stretch lies within Ethiopian territory (Temesgen, 2007).

Railway transport is a cost effective and time saving mode of transportation which helps to transport products and inputs in bulk. Accordingly, greater emphasis has been given to Railway network development/construction in GTP period (2010/11-2014/15). During the GTP period, a

total 2,395 Km railway line construction is planned to be constructed. In the first two consecutive fiscal years of GTP, construction of the railroads has not yet been started due to delays in detail study, planning, and design activities (MoFED, 2013).

In 2012/13, priority was given to the construction of the Addis Ababa-Djibouti national railway line and the Addis Ababa Light Rail Transit. Accordingly, 22% and 20% of the total construction works of the Addis Ababa/Sebeta-Mieso (317KM) and Mieso-Dewanle (339KM) projects have been accomplished respectively. Feasibility studies and other pre-construction preparatory works of the Awash–Woldiya/Hara Gebeya (389KM), Woldiya-Hara Gebeya-Mekele (268KM), Woldiya/Hara Gebeya-Semera-Asaiyta (229KM) and the Asaiyta-Tajura (210KM) railway projects have been undertaken. Likewise preparatory works of Addis Ababa/Sebeta-Ijaji-Jimma-Bedele and Mojo-Hawasa-Boditi-Woito railway projects are in progress (MoFED, 2014).

Aviation

Ethiopia's aviation history goes back to 1929 when the first aero plane landed in the capital of Ethiopia, i.e. Addis Ababa, by a French pilot Andre Milet. This was 26 years after the first attempted flight by the Wright brothers and two years after the famous flight across the Atlantic by Captain Lind burg (Hailegabriel, 2011).

From 1926-1936 new domestic routes were opened to Gefersa, Bishoftu, Janmeda and Akaki, and the country had also acquired twenty airplanes until the occupation of Italy. In 1944 Ethiopia was one of the few African nations to sign the convention of the International Civil Aviation Organization and the government of Ethiopia taken another major forward step in aviation by founding the Civil Aviation Authority. One year later in 1945 Ethiopian Airlines (EAL) was founded, with an initial investment of ETB 2.5 million, with six - second world surplus DC - 3/c

– 47 Airplanes. The company was financed by the Ethiopian government but managed by (Trans World Airlines) TWA.

In 1982, EAL became the first African carrier in ordering the Boeing 767, as well as the first airline to order the Boeing 767-200ER. In 1990, Ethiopia became the first passenger airline in taking delivery of the Boeing 757 freighter, receiving the first of five Boeing 757-200s a year later. In the late 2000s, the airline announced it would be the customer of the Boeing 787 Dreamliner. In July 2011, Ethiopian was named Africa's most profitable airline for the year 2010 by Air Transport World for the third time in a row (EAL, 2012).

During the GTP period, the main focus of the aviation subsector is to expand and improve the quality of air transport service. In 2010/11, the available seat km and available ton increased from 15 billion and 3.2 billion in 2009/10 to 18.8 billion and 3.9 billion, respectively. With regard to expanding air transportation services, the numbers of international and domestic flight destinations were increased from 58 to 63 and 16 to 17, respectively (MoFED, 2012). During the second fiscal year of GTP period (2011/12), the available seat in km increased to 22.1 billion and the available ton km increased to 4.6 billion. In the same year, the international flight destinations increased to 66 and regarding domestic flight destination, there was no opened new destination even if the construction of Semera airport completed (MoFED, 2013).

During the 2012/13 GTP period, the available seat in km was 25.755 billion and the available ton in km was 5.224 billion. With respect to expanding the market, the international destinations increased to 73, while no new domestic destinations became operational during the year. With regarding to the participation of private investors in the aviation sector, 13 operators were registered in the budget year. The plan to increase the private operators in the aviation sector was not as planned because of the delay in the ratification of the air transport policy (MoFED, 2014).

As of May 2014, the carrier served 79 international and 18 domestic destinations, with 48 passenger destinations in Africa, 11 in Europe and the Americans, and 21 in the Middle East and Asia; the airline also operates a cargo network of 24 destinations (EAL, 2014). As a result, according to the overall competitiveness index in the "2013-2014 Global Competitiveness Report" Ethiopia ranked 42th among 148 countries in terms of the Quality of air transport infrastructure and 57th in terms of Available airline seat km/week (WEF, 2013).

To sum up, Ethiopian air transport sector can be described as Ethiopia's ambassador at large serving to link Ethiopia with the rest of the world. Its status both within Africa and around the world has been growing from time to time, and it has assumed a special status among African countries as the airline to be relied upon, as has been expressed at various forums. However, the local service the airline provides is not as reputable as its international flights. Although there have emerged some private aviation companies operating of late, the range of the services they provide is very much limited. According to some experts, among the reasons for the limited domestic services both the Ethiopian airlines and the private operators provide are: the small number of planes; the low buying power of the people; the relative shortness of the runways at the available airports.

Energy

Electric power was introduced to Ethiopia in the late 19th century during the regime of Emperor Menelik II. The first diesel generator was introduced to the place in 1898. And, the first hydro-power plant was constructed in 1912 at Akaki River to supply power to small factories in Addis Ababa (EEPCo, 2014).

Ethiopia has untapped potential for hydro (water) electric power, geothermal and wind energy generation. As a result, the country has an estimated potential to generate 45,000 MW from hydro-power, 10,000 MW from geothermal, 1.3 million MW from wind farm (NBE annual report, 2013/14). Despite such huge energy potentials, currently the country's generating capacity only 2177 MW of electric power (MoFED, 2014).

In the recent years the country is plagued by power shortage. To narrow the gap between power supply and demand, and hence avoid losses, the government of Ethiopia is engaged in implementing an ambitious investment plans in last five years of GTP (2010/11-2014/15) period; including the Grand Renaissances hydroelectric power project, which can generate 6000 MW of power with the estimated cost of 80 billion birr (MoFED, 2010). The national energy generation capacity has also increased from 2000MW in 2009/10 to 2075.1 MW in 2010/11 (MoFED, 2012). By generating 128.5 MW additional powers in 2011/12, the national energy generation capacity has increased in to 2177 MW in 2011/12 (MoFED, 2013). However, during the 2012/13 GTP period, the national energy generation capacity didn't show any change. In spite of this, the construction of the Grand Renaissances hydroelectric power project has made progress and its total construction work reached 23.89 percent in 2012/13 (MoFED, 2014).

According to the Ethiopian Electric Power Corporation, the energy production of the country for the last six years (from 2008 to 2012) was 3,531.70 GWh, 3,727.78 GWh, 3,981.07 GWh, 4,980 GWh, and 6,289.58 GWh, respectively. Furthermore, in 2013/14 the actual energy production performance was 8,701 GWh (NBE annual report, 2013/14). Over all the projected power generation through hydro could reach up to more than 7,000 MW and this, augmented by other renewable and non-renewable sources, is expected to bring the level of energy production of the country up to 10,000 MW by the end of GTP period (MoFED, 2010).

Despite such huge energy potentials and improvements in the generation capacity of the country, the challenge in electricity accessibility is acute problem for Ethiopia; which currently has the world's second-largest rural population without access to electricity (almost 70 million) (IEA, 2014). In addition, according to the overall competitiveness index Ethiopia also ranked relatively low (115th of 148 countries) in the "2013-14 Global Competitiveness Report" in terms of the quality of electricity supply (WEF, 2013).

Telecommunication services

The introduction of telecommunication in Ethiopia dates back to 1894, seventeen years after the invention of telephone technology in the world. It was Minilik II, the King of Ethiopia, who introduced telephone technology to the country around 1894, with the installation of 477km long telephone and telegram lines from Harar to Addis Ababa. Ethiopian Telecommunications Corporation (ETC) is the oldest public telecommunications operator in Africa (Potluri, 2010). It is the second largest state owned enterprise next to the Ethiopian Airlines and the sole telecom service provider in the country (Worku, 2005).

Unfortunately, ETC's development was interrupted by the Italian aggression (from 1935-1940). As a result, the entire telecommunication infrastructure destroyed by the war against Italian. After the end of the war, Ethiopia reorganized the telephone, telegraph and postal services in 1941. Under the proclamation no.131/52 the Imperial Board of Telecommunications (IBTE) established in 1952, which became the Ethiopian Telecommunication Authority under the Derge regime in 1981. During the long run period of the military regime, the sector had managed only to have 160,000 subscribers. Under the current ruling government, the Ethiopian

Telecommunication Agency (ETA) established in 1996, and during the same year, the council of ministers set up the Ethiopian Telecommunications Corporation (ETC) (Worku, 2005).

By the end of 1998/99 fiscal year, the number of fixed telephone subscribers and internet subscribers increased to 194494 and 2163, respectively. In the same year, ETC started to give the mobile telephone service, and the numbers of subscribers were 6,740 at the end of the year (NBE Report of 2008/09). During 2003 fiscal year, Ethiopia's investment in the telecommunication sector has seen a substantial increase. Capital investment jumped from US$ 29.1 million in 2002 to US$ 128 million in 2003. The capital budget doubled in 2004 to US$ 300 million and rose to about US$ 500 million in 2005 (Adam, 2007). As a result, according to NBE 2008/09 report, the number of fixed telephone subscribers, internet subscribers, and mobile telephone subscribers increased quite impressively from 404790, 9534 and 51,234 to 484368, 12155, and 155534, respectively.

The Ethiopia telecommunication sector has been substantial growth from a very low base over the last five years of PASDEP period (2005/06-2009/10) as a result of a massive investment. For the 2005/06 fiscal year, ETC had an investment budget of ETB 5.4 billion (USD 644 million) for the expansion of its infrastructure, including the rollout of 250,000 new fixed lines. The switching network has been 98% digital since 2004. In August 2006, ETC signed a USD 4.9 million contract with Huawei Technologies for the upgrade of 260 switches, to be completed by October 2006 (Baron, 2010). In the same year, ETC reached an agreement with China's ZTE worth US$1.5 billion through vendor financing (Adam, 2007). Accordingly, the number of fixed telephone, internet and mobile subscribers grew up to 1 million, 0.187 million and 6.52 million, respectively (MoFED, 2010).

During the GTP period, the government of Ethiopia gave a huge policy and investment emphasis to the development of telecommunication infrastructure in the country (MoFED, 2010). In 2010/11 fiscal year, the Ethiopian Telecommunication has been re-organized and replaced by Ethio-telecom. After the re-organization, the number of mobile subscribers and telecom density for mobile lines increased to 10.7 million and 12.85 percent in 2010/11. Similarly, the number of subscribers for fixed line and internet were absolutely declined to 0.854 million and 0.129 million respectively, compared from the previous year (MoFED, 2012). As a result, a report released by the International Telecommunications Union (ITU) indicated, Ethiopia, which ranked 80th in 2011 in telecom expansion.

The number of subscribers has reached 18.28 million in 2011/12. Out of which 805, 000 are fixed telephone line subscribers, 17.26 million are mobile telephone subscribers and 221,000 internet service subscribers (MoFED, 2013). In 2012/13 fiscal year, in all telecom services, the number of subscribers reached 28.98 million. Out of which 23.76 million are mobile telephone subscribers, 4.43 million are internet and data subscribers and 0.79 million are fixed line subscribers. Despite the above statistical figure network quality continues to be a major challenge of the sector (MoFED, 2014).

In 2013, Ethio Telecom signed a USD 1.6 billion agreement with china's vendors Huawei and ZTE to expand its mobile service capacity to 50 million subscribers and introduce 4G broadband network in the capital Addis Ababa. The deal will also see the rollout of 3G service across the rest of the country. In 2013/14, according to NBE report of 2013/14, the number of mobile and internet subscribers reached 28.3 million and 6.2 million, respectively. Similarly, the number of fixed line subscribers slightly increased to 813,410. However, the report in information and communication technology development index (IDI) on October 24, 2014 shows that Ethiopia

stands 162nd out of 166 surveyed countries, based on mobile phone and internet use (ITU, 2014). In 2014, Ethio-telecom signed an agreement with Ericsson, the project is the part of the USD 1.6 million expansion project awarded for Huawei and ZTE last year.

To sum up, telecom sector in Ethiopia is among the sectors where the state allocates a large amount of budget within thids decade alone, the country has invested over USD 15 million (10 percent of the GDP) to the ICT. Despite repeated announcements from Ethiopian Telecommunication reported in the media about huge infrastructure investment in information communication technology (ICT) and expanding service, Ethiopia remains at the bottom of the table in Africa in ICT.

Education Sector

The purpose of development is to create an enabling environment for people to enjoy long, healthy and creative lives, and that is why we say the real wealth of a nation is its people. However, this simple but powerful truth is too often forgotten. Many reports stress on the need to invest in people, an investment in the future of each of us, our children and the nation as a whole. The importance of educating people to ensure a country's continuous competitiveness and sustainable development is, therefore, unquestionable (Teshome, 2004).

Modern education in Ethiopia has a history of 100 years (MoE, 2011). In Ethiopia, the education sector in general and the basic education sub-sector in particular is characterized by low access, efficiency, quality and an equitable distribution of educational opportunities. Realizing this fact, the current Government of the Federal Democratic Republic of Ethiopia has adopted an Educational and Training Policy (ETP) along with its sector strategy in 1994. To realize the goal of the education and training policy, a program action, the Education Sector Development

Programme (ESDP) was launched in 1997/98. The ESDP has already been implemented over the past 17 years and in four successive phases, as follows: ESDP I - Period from 1997/98 to 2001/02 (5 year plan), ESDP II - Period from 2000/01 to 2004/05 (5 year plan), ESDP III - Period from 2005/06 to 2009/10 (5 year plan) in line with PASDEP, and ESDP IV - Period from 2010/11 to 2014/15 (5 year plan, 4 years elapsed) in line with GTP (MoE, 2010).

According to the NBE report of 2009/10, the number of primary schools (Grades 1-8) moved up from 12,471 in 2002/03 to 26,951 in 2009/10, corresponding to an average annual growth rate of 14.5 percent. With regard to secondary schools (Grades 9-12), the total number of schools reached 1,335 exhibiting a 171.9 percent growth since 2002/03. In addition, the number of Technical and Vocational Education and Training (TVET) institutions increased in to 814 in 2009/10 against 153 in eight years ago (MoE, 2010). However, higher education in Ethiopia has relatively short history of some 60 years only, but during the past ten years it has undergone both major quantitive and qualitative change. According to the NBE report of 2009/10, the number of public universities reached 22 in 2008/09 against 11 in 2005/06.

Education sector is one of the key focus areas of GTP and MDG. As a result, the number of primary schools has increased from 28,349 in 2010/11 to 29, 507 in 2011/12 and further to 30,495 in 2012/13. These show that a total of 3,544 primary schools were constructed over the last three years. As a result, primary gross enrolment rate increased from 93.4 percent in 2009/10 to 95.1 percent in 2012/13, while net enrolment rate increased from 82.1 percent in 2009/10 to 85.9 percent in 2012/13. With regard to secondary education, the number of schools increased from 1517 in 2010/11 to 1710 in 2011/12 and further to 1912 in 2012/13. These indicate that a total of 577 secondary schools were constructed over the first three GTP years. Gross enrolment in secondary school First Cycle (9-10) and preparatory (11-12) reached 1,540,525 and 358,493 in

2012/13 respectively. Concerning technical and vocational training, the number of students in 2010/11 was 371,347. This figure, however, has declined to 335,058 in 2011/12 and further to 238,884 in 2012/13 (MoFED, 2014).

With regard to higher education both in public and private institutions, undergraduate enrolment rate has increased from 447,693 in 2010/11 to 494,110 in 2011/12 and further to 553,849 in 2012/13. Similarly, the post graduate program intake capacity increased from 14,272 in 2009/10 to 31,304 in 2012/13. Furthermore, the number of public universities has increased to 32 (MoFED, 2014). Despite this improvement, still the country is hampering by the low quality of education system. According to the overall competitiveness index in the 2013-2014 Global Competitiveness Report Ethiopia ranked 108th among 148 countries in terms of the quality of the educational system (WEF, 2013).

Table-3.3: Recent education sector data

Period	Indicators			
	Number of primary schools	Number of secondary schools	Number of TVET centers	Universities
2002/03	12471	491	153	NA
2003/04	13181	595	158	NA
2004/05	16513	706	199	NA
2005/06	19412	835	264	NA
2006/07	20660	952	388	21
2007/08	23354	1,087	458	22
2008/09	25212	1185	458	22

2009/10	26951	1351	448	22
2010/11	28349	1392	505	26
2011/12	29482	1710	505	32
2012/13	30534	1912	437	32

Source: Ministry of education

To sum up, the education sector has witnessed a great leap forward over the past years in terms of coverage. However, so many scholars and researchers questioned the quality of the education sector in Ethiopia over the past several years, particularly in the regime of present government, EPRDF.

Health Sector

Ethiopia experiences extremely poor health status relative to other Sub-Saharan Africa mainly attributed to communicable infectious diseases and nutritional deficiencies. Shortage and high turnover of human resource and inadequacy of essential drugs and supplies have also contributed to the burden. However, there has been encouraging improvements in the coverage and utilization of the health services over the periods of implementation of four consecutive phases of comprehensive Health Sector Development Plans (HSDPs), starting from 1997/98. The HSDP has already been implemented in four successive phases, as follows: HSDP I - Period from 1997/98 to 2001/02 (5 year plan), HSDP II - Period from 2002/03 to 2004/05 (3 year plan), HSDP III - Period from 2005/06 to 2009/10 (5 year plan) in line with PASDEP, and HSDP IV - Period from 2010/11 to 2014/15 (5 year plan, 4 years elapsed) in line with GTP (FMoH, 2005).

During the HSDP I and HSDP II period, encouraging improvements recorded. In terms of health infrastructure, the improvements have been the construction of additional 3, 135 new Health

Posts reaching 2899 in 2003/04 from an insubstantial of 76 Health Posts in 1996/97. The number of Health Centers and Hospitals also increased from 243 in 1996/97 to 519 in 2003/04 and from 87 in 1996/97 to 126 in 2003/04, respectively. In addition, the increase in the number of health workers has been most remarkable. There have been 2800 trained and deployed health extension workers with 7138 already enrolled for training in 2004/05 (FMoH, 2010).

During the third phase of the HSDP III, the total of 33819 health extension workers were trained and deployed surpassing HSDP III target. Besides, the total number of health posts has increased from the baseline of 6191 in 2004/05 to 14416 in 2009/10. Moreover, the number of health centers reached 2689 in 2009/10 and the number of hospitals also went up to 195 at the end of HSDP III period. In addition, the construction of 21 blood banks in six regions is on progress with 95 percent of the construction completed in 2009. In addition, an increasing number of indigenous and international NGOs are currently involved in various aspects of service delivery, and there are 277 private clinics not for profit and 1788 private clinics for profit in the country. The total numbers of hospital beds were 13922, which mean that there is one bed for a population of about 5300. This figure is about five times lower than the Sub-Saharan African average (FMoH, 2010).

During the first year of GTP period (2010/11), the number of health extension workers that are deployed in rural kebeles and urban has reached 34,382 and 3916 respectively. In relation to improving health infrastructure, 903 new health posts were constructed, increasing the cumulative total to 15095 Health Posts. In the same year, 518 Health Centers were newly constructed. This increased the total number of health centers to 2660. A total of 516 Health Centers were still under construction, therefore the cumulative total of health centers constructed and under construction reached 3176 at the end of 2010/11 (FMoH, 2012; MoFED, 2012).

The health infrastructure development also grew over the last three consecutive years of HSDP IV. Accordingly, the number of health posts has increased from 15668 in 2011/12 to 16048 in 2012/13 and to 16251 in 2013/14. The number of health centers has increased from 2999 in 2011/12 to 3100 in 2012/13 and to 3335 in 2013/14. As a result, primary health care service coverage reached 93.4 percent in 2012/13. According to the service provision assessment, the total available public hospitals were 156 in 2013/14, and out of these 150 were functional. On the other hand, 123 hospitals were under construction. In 2013/14 the percentage share of the public health budget allocation from the total budget reached 10.3 percent. With regarding to Donor's contribution, a total of USD 558.33 million was committed and a total of USD 612.87 million was disbursed (MoFED, 2014; FMoH, 2015).

CHAPTER FOUR

MODEL SPECIFICATION, VARIABLE DEFINITION AND ESTIMATION TECHNIQUE

The empirical framework of this study consists of two models. The first model tests whether private business investment is encouraged or deterred by additional public infrastructure investment in Ethiopia. The second model tests the relative significance of public infrastructure investment and private investment to the economic growth of Ethiopia.

The empirical framework focused on the two broad categories of public infrastructure investments and each infrastructure investment categories included the major infrastructures which are the pillars for the Ethiopian economy. The first category is economic (physical) public infrastructure which includes three subsectors; namely energy, transport and communication. The second category is social public infrastructure which includes two subsectors: education and health. Thus, the study considers five public infrastructure investment categories.

4.1. Model Specification for the Public Infrastructure Investment and Private Investment Relation

The first empirical frame work of this study is focused on modeling the impact of public infrastructure investment on private investment. The question is, does public infrastructure investment crowd-in or crowd-out private investment? The common approaches used for modeling the determinants of private investment are the accelerator model, the Tobin - q model and the user cost model (Alemayehu, 2002). Among the investment theories, the flexible accelerator model appears to be popular in applied work as it takes account of the institutional

and structural characteristics of developing countries (Quattara, 2004; Jorgenson, 1967). Therefore, this study applied a flexible accelerator investment model, which begins by assuming that the desired capital stock (K_t^*) is proportional to the level of expected output (Q^e) (Blejer and Kahn, 1984; Ramirez, 1994):

$$\boldsymbol{K_t^* = \alpha Q^e} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (\mathbf{4.1})$$

Where α = capital output ratio

When driving the investment function keeping "α" constant, the desired investment (I_t^*) can be given by:

$$\left.\begin{aligned} \boldsymbol{I_t^*} &= \boldsymbol{K_t^* - K_{t-1}^* + \delta K_{t-1}^*} \\ \boldsymbol{I_t^*} &= \boldsymbol{K_t^* - (1-\delta) K_{t-1}^*} \\ \boldsymbol{I_t^*} &= \boldsymbol{[1-(1-\delta)L] K_t^*} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (\mathbf{4.2})$$

Where "*L*" is the lag operator thus $\boldsymbol{LK_t^* = K_{t-1}^*}$ and $\boldsymbol{\delta}$ is the rate of depreciation**.**

Due to the time need to build and install capital, there is a lapse between the time of investment decision made and the time period investment is actually materialized. Thus, using partial adjustment for the time lag we can derive the investment function as follows:

$$\boldsymbol{[I_t - I_{t-1}] = b[I_t^* - I_{t-1}]} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (\mathbf{4.3})$$

Where " b" is the speed of adjustment; $0 \leq \mathrm{b} \leq 1$

If $b = 1,\ \mathrm{I_t^*} = \mathrm{I_t} \rightarrow$ meaning complete adjustment.

If $b = 0, I_t = \mathrm{I_{t-1}} \rightarrow$ meaning no adjustment.

We can rewrite equation (4.3) as:

$$\boldsymbol{b = \frac{1}{[I_t^* - I_{t-1}]}[I_t - I_{t-1}]} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (\mathbf{4.4})$$

The response of private investment to the gap between desired and actual investment, as measured by b, is influenced by different economic factors; such as ***i)*** public infrastructure investment (both physical and social). This may complement or compete with the private investment (see Aschauller, 1989; Ramirez, 1997; Agenor et al, 2005; Han, 2012; Adam & Bevan, 2014). ***ii)*** Cost of capital measured by real interest rate (see Blejer & Khan, 1984; Ghura & Good Win, 2000). ***iii)*** Real GDP (see Ghura & Good Win, 2000; Ang, 2010; Blejer & Khan, 1984; Ramirez, 2000). i***v)*** macroeconomic uncertainty- whose proxy is inflation rate- measured by consumer price index (CPI) (see Hartman, 1972; Abel, 1985; Ang, 2010). Thus, the adjustment coefficient (b) can be specified as:

$$\boldsymbol{b = b_0 + \frac{1}{[I_t^* - I_{t-1}]}\,[b_1RGDP + b_2RPII + b_3RSII + b_4RIR + b_5CPI + b_6REER]} \dots\dots\dots\dots (\mathbf{4.5})$$

Where: $\boldsymbol{RGDP}$**=** Real gross domestic product

$\boldsymbol{RPII}$**=** Real physical public infrastructure investment

$\boldsymbol{RSII}$**=** Real social public infrastructure investment

RIR= Real interest rate

REER= Real effective exchange rate

$\boldsymbol{CPI}$**=** Consumer price index

By substituting equation (4.5) in to (4.3), we obtain the private investment equation

$$\boldsymbol{I_t = b_0I_t^* + b_1RGDP + b_2RPII + b_3RSII + b_4RIR + b_5CPI + b_6REER + (1 - b_0)I_{t-1}} \dots . (\mathbf{4.6})$$

But we define the desired capital stock as

$$\boldsymbol{K_t^* = \alpha Q^e} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (\mathbf{4.7})$$

The desired investment level defined as

$$I_t^* = [1 - (1 - \delta)L]K_t^* \ldots \ldots \ldots \ldots (4.8)$$

Substituting (4.7) in (4.8), and then substitute the result in to (4.6), we can obtain the estimable equation for private investment

$$I_t = b_0[1 - (1 - \delta)L]\alpha Q^e + b_1 RGDP + b_2 RPII + b_3 RSII + b_4 RIR + b_5 CPI + b_6 REER + (1 - b_0)I_{t-1} \ldots \ldots \ldots \ldots (4.9)$$

In line with the objectives of the study and by considering the availability of data the above model is modified for estimation purpose as follows

$$LRPIV_t = \beta_0 + \beta_1 LRGDP_t + \beta_2 LRPII_t + \beta_3 LRSII_t + \beta_4 RIR_t + \beta_5 LCPI_t + \beta_6 REER + \beta_7 LRPIV_{t-1} + \varepsilon_t \ldots \ldots \ldots \ldots (4.10)$$

Where: $\mathbf{t}$ = time

RPIV = Real private investment

$\boldsymbol{\varepsilon_t}$ = Stochastic shock

L = denote the natural logarithm

4.2. Model Specification for the Contribution of Public Infrastructure Investment and Private Investment on Economic Growth

As discussed in the literature review part, in the Solow-Swan growth model capital accumulation is main source of growth (see Jones, 2002; Weil, 2013; and Acemoglu, 2008). This study adopted a Solow-Swan growth model to examine the relative effect of public infrastructure

investments (i.e. physical and social infrastructure investments), and private investment on economic growth in Ethiopia.

The production function in the Solow-Swan growth model frame work is modified to account for the three types of capital stocks: physical/economic public infrastructure capital stock, social public infrastructure capital stock, and the private capital stock. The motivations behind the modification of the standard framework are two. First, the possibility of the differential impacts of private and public capital stocks on economic growth is considered. Most growth models assume that the elasticities of output with respect to private, public and total capital stock are equal. However, Khan and Reinhart (1990) showed the limitation of equating these elasticities because it tells us little about the independent effects of private and public capital on growth. The second motivation for the modification is the existence of differential impacts of the two categories of public infrastructure capital stock: physical and social. Thus, following Ghura (1997) and Beddies (1999), the aggregate production function can be written as:

$$\boldsymbol{Y_t = A_t f\left(K_t^p, K_t^{pi}, K_t^{si}, Z_t\right) = A_t (K_t^p)^{\alpha} (K_t^{pi})^{\beta} (K_t^{si})^{\gamma} (Z_t)^{\theta}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{4.11})$$

Where: Y is the level output; K^p private capital stocks; K^{pi} physical public infrastructure capital stocks; K^{si} social public infrastructure capital stocks; and Z is including other factors affecting growth. The variable A measures the factor of productivity, which is generally assumed to be an exogenous rate of technology, and t is a time index.

The parameters $\alpha, \beta, \gamma, and\ \theta$ denote the elasticities of output with respect to private capital stock, physical and social public infrastructure capital stock, and other factors, respectively. Under conditions of perfect competition, equation (4.11) is characterized by constant returns to

scale, such that $(\alpha + \beta + \gamma + \theta) = 1$. Thus, each individual factor of production faces diminishing returns to scale.

Equation (4.11) can be expressed in terms of the growth rate as follows by taking the total differentials of the equation:

$$\boldsymbol{dY = Y_{K^p} dK^p + Y_{K^{pi}} dK^{pi} + Y_{K^{si}} dK^{si} + Y_Z dZ + Y_A dA} \dots \dots \dots \dots \dots \dots \dots . \dots \dots \dots (\mathbf{4.12})$$

Then divide equation (4.12) by Y, we obtain

$$\boldsymbol{\frac{dY}{Y} = \left[\frac{\partial Y}{\partial K^p} . \frac{K^p}{Y}\right] \frac{dK^p}{K^p} + \left[\frac{\partial Y}{\partial K^{pi}} . \frac{K^{pi}}{Y}\right] \frac{dK^{pi}}{K^{pi}} + \left[\frac{\partial Y}{\partial K^{si}} . \frac{K^{si}}{Y}\right] \frac{dK^{si}}{K^{si}} + \left[\frac{\partial Y}{\partial Z} . \frac{Z}{Y}\right] \frac{dZ}{Z}}$$

$$\boldsymbol{+ \left[\frac{\partial Y}{\partial A} . \frac{A}{Y}\right] \frac{dA}{A}} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \dots \dots \dots \dots . \dots \dots \dots \dots . (\mathbf{4.13})$$

Therefore, rewriting equation (4.11) in terms of the growth rates (with lower case letters denoting growth rates) as:

$$\boldsymbol{y = a + \alpha k^p + \beta k^{pi} + \gamma k^{si} + \theta z} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \dots (\mathbf{4.14})$$

Equation (4.14) represents a long run growth relationship, which can be estimated, provided data for capital stock are available. However, such data are typically unavailable for developing economies including Ethiopia, making it difficult to estimate equation (4.14). Nevertheless, following Ghura (1997), equation (4.14) can be transformed into an estimable form by making some simplifying assumptions regarding capital stock. Following Ghura (1997), consider the following representing the growth of private, physical public infrastructure, and social public infrastructure capital stocks:

$$\boldsymbol{\frac{\Delta K_t^p}{K_{t-1}^p} = \frac{I_t^p}{K_{t-1}^p} - \delta^p} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \dots \dots \dots (\mathbf{4.15})$$

$$\frac{\Delta \boldsymbol{K}_t^{pi}}{\boldsymbol{K}_{t-1}^{pi}} = \frac{\boldsymbol{I}_t^{pi}}{\boldsymbol{K}_{t-1}^{pi}} - \boldsymbol{\delta}^{pi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{4.16})$$

And

$$\frac{\Delta \boldsymbol{K}_t^{si}}{\boldsymbol{K}_{t-1}^{si}} = \frac{\boldsymbol{I}_t^{si}}{\boldsymbol{K}_{t-1}^{si}} - \boldsymbol{\delta}^{si} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{4.17})$$

Where: I_t^p denotes real private investment, I_t^{pi} is real physical public infrastructure investment, and I_t^{si} represents real social public infrastructure investment; and $\delta^p, \delta^{pi}\ and\ \delta^{si}$ are the respective rates of depreciation of private, physical public infrastructure and social public infrastructure capital stocks.

Assuming private, physical public infrastructure and social public infrastructure capital stocks are a constant share of real GDP, that is (Ghura, 1997):

$$\boldsymbol{K}^p = \boldsymbol{\varphi}_p \boldsymbol{Y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{4.18})$$

$$\boldsymbol{K}^{pi} = \boldsymbol{\varphi}_{pi} \boldsymbol{Y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{4.19})$$

$$\boldsymbol{K}^{si} = \boldsymbol{\varphi}_{si} \boldsymbol{Y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{4.20})$$

Where $\varphi_p, \varphi_{pi} and\ \varphi_{si}$ are the respective fixed coefficients for private, physical public infrastructure, and social public infrastructure capital. Now equation (4.14) can be rewrite as follows:

$$\boldsymbol{y} = \boldsymbol{a}' + \boldsymbol{\alpha}' \left[\frac{\boldsymbol{I}_t^p}{\boldsymbol{Y}_{t-1}}\right] + \boldsymbol{\beta}' \left[\frac{\boldsymbol{I}_t^{pi}}{\boldsymbol{Y}_{t-1}}\right] + \boldsymbol{\gamma}' \left[\frac{\boldsymbol{I}_t^{si}}{\boldsymbol{Y}_{t-1}}\right] + \boldsymbol{\theta z} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{4.21})$$

Where: $a' = \left(a - \alpha\delta^p - \beta\delta^{pi} - \gamma\delta^{si}\right),\quad \alpha' = \frac{\alpha}{\varphi_p},\ \beta' = \frac{\beta}{\varphi_{pi}},\ and\ \gamma' = \frac{\gamma}{\varphi_{si}}$

Equation (4.21) can be estimated with available data for Ethiopia. By including other explanatory variables to meet the basic objective of the study, we can rewrite equation (4.21) for estimation purposes as follows:

$$\boldsymbol{LRGDP_t = \beta_0 + \beta_1 LRPIV_t + \beta_2 LRPII_t + \beta_3 LRSII_t + \beta_4 LLAB_t}$$
$$\boldsymbol{+\beta_5 LEXP_t + \varepsilon_t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \boldsymbol{(4.22)}$$

Where: **RGDP=** Real gross domestic product

RPIV= Real private investment

RPII= Real physical public infrastructure investment

RSII= Real social public infrastructure investment

LAB= Active labour force

EXP= Total value of export

$\boldsymbol{\varepsilon_t}$ = Stochastic shock

L = denote the natural logarithm

4.3. Data and Its Sources

The data used in this study were obtained from different sources. The annual time series data on GDP, private investment, physical and social public infrastructure investment, interest rate, real effective exchange rate, foreign direct investment, and total value of export are from the National Bank of Ethiopia (NBE), from Ministry of Finance and Economic Development (MoFED) and from Ethiopian Investment Agency (EIA). Consumer price index is from Central Statistical Agency (CSA). The population and the participation data is collected from CSA.

4.4. Description of Variables

Real physical public infrastructure investment (RPII) is proxied by government energy, transportation and communication infrastructure capital formation deflated by the GDP deflator. At the theoretical level, the impact of physical public infrastructure investment is ambiguous. It may have a positive or negative effect on private investment depending on which one out weights i.e. the crowding in/out effect of it. However, it is expected to have a positive impact on private investment and economic growth, according to the infrastructure hypothesis.

Real social public infrastructure investment (RSII) is proxied by government education and health infrastructure capital formation deflated by the GDP deflator. Similarly, its impact is ambiguous like RPII. However, according to the infrastructure hypothesis, it is expected to have a positive impact on private investment and economic growth.

Real private investment (RPIV) is proxied by private capital formation deflated by GDP deflator. It is expected to have a positive impact on economic growth.

The real gross domestic product (RGDP) is the gross domestic product deflated by GDP deflator, is used as a proxy for economic growth. The real GDP is expected to have a positive impact on private investment as its growth would increase demand for the private investor's product.

The change in consumer price index (CPI) is used as a measure of inflation. Inflation makes nominal values uncertain, so investment planning becomes difficult. Therefore, individuals may be reluctant to enter in to contracts and over time will inhibit investment which will affect economic growth. The sign of the effects of inflation on private investment is thus to be negative.

Real interest rate (RIR) is the lending interest rate, which is calculated according to the Fisher (1991) equation, by subtracting the inflation rate from the lending nominal interest rate. It is expected to show the real cost of undertaking an investment activity. One would expect that as the cost of acquiring capital (e.g. interest rate) increases, potential investors would withdraw from their projects. Therefore, we would expect the effect of real interest rate on private investment to be negative.

Real effective exchange rate (REER) is an average of the bilateral RERs (real exchange rates) between the country and each of its trading partners, weighted by the respective trade shares of each partner. It may have a positive or negative effect on private investment depending on which one out weights i.e. the crowding in/out effect of it.

Export (EXP) is the total value of export. The more the country exports the higher the growth of output. Thus, export expected to have a positive impact on the growth of the economy.

Active labour force (LAB) is calculated as the product of the total population and the labour force participation rate. The higher the employment rate, the higher the growth of output. The expected sign of active labour force on growth can't be predetermined since labor force participation rate includes also unemployed labour force too.

4.5. Econometric Approach

4.5.1. Stationarity and Unit Root Test

Generally, most of the economic time series are not stationary, thus it is necessary to explore the time series properties of the data before estimating a macroeconomic time-series model of this study. Using non-stationary time series data in econometric models produces unreliable and

spurious results (Granger & Newbold, 1986). In order to avoid the problem of spurious regression, in this study, the time-series properties of the variables is investigated using the standard Augmented Dickey-Fuller (ADF) and the Phillips-Peron unit root tests.

4.5.2. Vector Autoregressive (VAR) Modelling and Co-integration Analysis

In fact, the dynamic and feedback effect of public infrastructure and private investment are key reasons for choosing a VAR framework for empirical analysis. Use of the cointegrated modeling approach helps to avoid spurious regression problems. Furthermore, vector error correction models (VECMs) distinguish clearly between long and short run impacts, providing a suitable tool for policy analysis. In other words, VAR provides an important framework for analyzing both short and long run relationships through an equilibrium correction model and facilitates dynamic simulation of variables using "Impulse response analysis" (Harris & Sollis, 2003; Badawi, 2005). Thus, this study employed a co-integrated vector autoregressive modelling approach to account for potential endogeneity and non-stationarity problems for the two models separately. The approach in this study follows the methodology developed and used by Johansen (1988, 1991), and Johansen and Juselius (1990).

The test of cointegration is carried out using the Johansen co-integration approach (1991) using the trace and the maximum eigenvalue test statistics. Weak exogeneity test is also conducted using Granger Causality/Block Exogeneity Wald Test for identification of the cointegration relationships.

In this study, different post-estimation diagnostic tests were performed to guarantee that the residuals from the model have a Gaussian distribution. Such as: residual vector serial correlation LM test, residual vector normality test, and residual vector heteroscedasticity test. Furthermore,

the diagnostic test results used as indicators of the validity of employing impulse-response functions and variance-decomposition analyses. Thus, following Shin et al (2006), to track the time path of private investment to shocks from public infrastructure investment and from other variables, and the time path of GDP (economic growth) to shocks from public infrastructure investment, private investment and from other variables impulse response function is employed. Similarly, the study also employed the variance decomposition to examine the degree to which one variable influences the other (Shin et al, 2006).

CHAPTER FIVE

EMPIRICAL ANALYSIS AND FINDINGS

5.1. Time Series Property of the Data

5.1.1. Unit Root Tests

Before estimating equation (4.10) and (4.22),[10] the time series properties of the underlying data are examined. Testing for stationarity of our time series ensures that the variables used in the regressions are not subject to spurious correlation/ regressions. In order to avoid the problem of spurious correlations (to obtain consistent and reliable results) in the regression analysis, the time series of the variables used in the regression analysis are investigated using the standard Augmented Dickey-Fuller (ADF) and the Phillips-Perron unit root tests under two alternative hypothesis.

The time series behaviour of each series using the ADF test is presented in table (5.1). The ADF test results shows that all the critical values are less than the ADF test statistics; therefore we can reject the null hypothesis of having a unit root problem. Running ADF tests for change in variables indicates that all variables are integrated of order one (I (1)), i.e. they need to be differenced once to attain stationarity. Therefore, we can conclude that all the variables become stationary at their first difference.

[10]Note that, in this study, the two models (i.e. private investment model-equation (4.10) and the growth model-equation (4.22)) are estimated separately using Co-integrating VAR approach since the variables included in each models are different.

Table 5.1: Unit Root Test Result Using Augmented Dickey-Fuller Test

Variables	Test statistic under different assumptions			Order of Integration
	Intercept	Trend and Intercept	No Trend, No Intercept	
LRPII	0.761459	-1.596635	5.054065	I(1)
D(LRPII)	-4.531162*	-4.574527	-3.214647	
LRSII	1.339825	-1.619488	5.368263	I(1)
D(LRSII)	-4.779982*	-5.046573	-2.627238	
LRPIV	0.627953	-2.468750	2.645976	I(1)
D(LRPIV)	-4.470996*	-4.550032	-3.958478	
LRGDP	3.457005	0.326118	2.068814	I(1)
D(LRGDP)	-4.646694*	-6.286537	-1.083533	
RIR	-1.945182	-1.929186	-1.940674	I(1)
D(RIR)	-8.715536	-8.717160	-8.850504*	
LCPI	0.476286	-1.975434	5.577718	I(1)
D(LCPI)	-4.202155*	-4.225741	-1.276625	
LREER	-1.047148	-1.874922	-0.413278	I(1)
D(LREER)	-4.985700*	-4.915816	-5.030313	
LLAB	1.341916	-1.934609	2.107777	I(1)
D(LLAB)	-2.472315**	-3.693989	0.058046	
LEXP	0.798358	-1.217850	2.803981	I(1)
D(LEXP)	-5.403653*	-5.651065	-4.756188	

Note: *D shows the variable is differenced once. MacKinnon (1996) critical values ADF unit root test statistics are used here. *shows significant at 1 percent and ** shows significant at 5 percent*

The Phillips- Perron test for unit root also used to check stationarity behaviour of the time series data of the study, and gives a result that is consistent with the results of the ADF test (See appendix 1).

5.2. Econometric Analysis of the Private Investment Model

5.2.1. Co-integration Test Result

Optimal Lag Length Selection Criteria

Since the Johansen co-integration tests are sensitive to the lag length use in the VAR model, the sequential modified Likelihood Ratio test statistics (LR), the Final Prediction Error (FPE), the Akaiki Information Criterion (AIC), the Schwarz Information Criterion (SIC)], and the Hannan-Quinn Information Criterion (HQ) statistics are employed to determine the optimal lag length used in this study. As tabulated in table (5.2), the FPE, AIC and HQ criteria indicate that the appropriate lag length is three while SIC and LR criteria indicate it is, rather, one. The private investment model, therefore, used the first lags of the variables due to insufficient number of observation.

To complement the result of the SIC and LR criteria and in order to make sure that the lags with significant information content are not excluded from the VAR system Wald Lag-Exclusion Test were conducted (see table 5.3), and the Wald tests show that the first lags (chosen as an optimal) of all variables are individually and jointly significant in the VAR system. This result implied that the use of the first lags of the variables in the private investment model is valid.

Table-5.2: Optimal Lag Order Selection Criteria for the private investment model

Lag	Log-likelihood	LR	FPE	AIC	SIC	HQ
0	-90.52159	NA	4.59e-07	5.271437	5.576206	5.378882
1	259.5733	548.7974*	4.12e-14	-11.00396	-8.565817*	-10.14440
2	314.9400	65.84144	3.93e-14	-11.34811	-6.776584	-9.736431
3	390.7882	61.49854	2.30e-14*	-12.79936*	-6.094460	-10.43557*

Note: * indicates lag order selected by the criterion

Table-5.3: VAR Wald Lag-Exclusion Test for the private investment model

Lags	LRPIV	LRGDP	LRPII	LRSII	RIR	LREER	LCPI	Joint
Lag 1	727.815 [0.0000]	6606.229 [0.0000]	3962.732 [0.0000]	5497.104 [0.0000]	35.373 [9.51e-06]	334.2252 [0.0000]	4107.681 [0.0000]	117670.6 [0.0000]
df	7	7	7	7	7	7	7	49

Note: The numbers are Chi-squared test statistics for lag exclusion; the numbers in parentheses are p-values.

The Johansen Co-integration Test Results

The above stationarity test showed that all of the variables are stationary at first difference, warranting the test of Johansen co-integration. The Johansen co-integration method was used to determine the number of co-integrated vectors for any give number of non-stationary variables of the same order.

The Johansen's cointegration rank test was performed using the trace statistics and the maximum eigenvalue test, mainly using trace statistics. Moreover, it is also generally acknowledged that

the results of Johansen co-integration test may be sensitive to the deterministic trend assumptions. Therefore, in order to carry out the test, an assumption regarding the trend underlying data is made. For the private investment model co-integration test we used case two deterministic trend assumption of test (i.e. if none of the series appear to have a trend) since none of the series appear to exhibit a linear trend in the private investment model (Based on Eviews 8 Users Guide II, page 851).

As presented in table (5.4), the cointegration testing of the real private investment model (equation) based on the methodology developed by Johansen (1991) indicate that there are four co-integrating equations at a significance level of 5% (outcome based on trace test). The trace test fails to reject the null of at most four cointegrating equations in the system. Therefore, there is four cointegrated vector in the real private investment model. This result can be complemented by the fact that the characteristic polynomial of the model has three roots with modulus equal to unity (see appendix-2). The number of variables in the private investment model is seven; existence of three roots with unit modulus indicates that the adjustment coefficients for three potential cointegration equations are statistically zero, leaving only four potential cointegrating relationships.[11]

[11] For further clarification see Harris (1995).

Table-5.4: Johansen Cointegration Test of the Private Investment model (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value (5%)
None *	0.883884	205.8556	134.6780
At most 1 *	0.658816	124.0354	103.8473
At most 2 *	0.505440	83.17274	76.97277
At most 3 *	0.461465	56.41748	54.07904
At most 4	0.339458	32.89920	35.19275
At most 5	0.300537	17.14079	20.26184
At most 6	0.089382	3.557998	9.164546

Note: * denotes rejection of the hypothesis at the 0.05 level

However, the maximum eigenvalue test result of the private investment model is different from the trace test result (see appendix-3A for the maximum eigenvalue test result, which indicates the existence of one cointegrating equations at the 0.05 level). In this case, we should take the trace test as a conclusive result. In fact, trace test has more power and the desired asymptotic properties.[12]Generally, it is safe to conclude that there exists a long-run relationship among the variables in the private investment model. Moreover, weak exogeneity test was conducted using Granger Causality/Block exogeneity Wald test for identifying the cointegrating equations/relationships. As tabulated in table (5.5). the test indicate that LRPIV (log real private investment) is endogenous in the estimated real private investment model since the probability value is highly significant enabling us to easily reject the null hypothesis of weak exogeneity at 5% level of significance.

[12] For more details see Luintel & Khan (1999).

Table-5.5: Granger Causality/Block Exogeneity Wald Test results for private investment model

Dependent variable: LRPIV			
Excluded	Chi-sq	df	Prob.
LRGDP	3.669589	1	0.0554
LRPII	0.147310	1	0.7011
LRSII	0.743286	1	0.3886
RIR	0.567170	1	0.4514
LREER	1.306185	1	0.2531
LCPI	10.24218	1	0.0014
All	19.61591	6	0.0032

5.2.2. Diagnostic Tests

To guarantee the estimation results and inferences are trustworthy, in this study, different diagnostic tests are undertaken (see appendix-4). These tests are serial correlation, heteroscedasticity and normality tests. The VEC Residual Serial Correlation Lagrange multiplier (LM) test accepts the null hypothesis of no serial correlation up to order one. The LM test indicates that the residuals of the estimated error correction model do not suffer from autocorrelation. And, to check whether the residuals are normally distributed the Jarque-Bera Normality test was performed. As shown in appendix-4 the Jarque-Bera test of normality fails to reject the null hypothesis of normal distribution at the 5% significance level but not at 10% significance level. In principle, it always better to be accept the null hypothesis of normal distribution at 10% probability value; that means the probability value should be close to one . However, still we can accept the

null hypothesis of normal distribution at 5% since it has the probability value of 0.0893 which is greater than 0.05.[13]

Finally, the VEC residual heteroskedasticity test performed to test for a range of specifications of heteroskedasticity in the residuals of private investment equation. The test fails to reject the null hypothesis of homoskedasticity (see appendix 4). Therefore, the estimated error correction model passes all diagnostic tests, and implied that the validity and robustness of the estimated results.

5.2.3. Vector Error Correction Model (VECM) of the Private Investment Model

Once the variables included in the Vector Autoregressive (VAR) model found to be cointegrated, we can use Vector Error Correction Model (VECM). Indeed, VECM is a special type of restricted VAR, is introduced to correct a disequilibrium that may shock the whole system. The VECM model consist the dynamics of both short run and long run adjustments. The VECM also allow as finding out the causal factors that affect our variables.[14]

Long-Run Dynamics of the Private Investment Model

The result of ADF and Johansen cointegration tests supported the existence of long-run equilibrium relationships among the private investment model variables. Hence, the next step is estimate the VECM model of the private investment model. As discussed in the cointegration test, the Johansen trace statistics indicated that four cointegrating vectors, however the objective of this section is examining the impact of public infrastructure investment on private investment.

[13] See Eviews 8 User Guide I, page 359-360, for further details about Jarque-Bera test

[14] But if we found that the variables are not cointegrated, we will restrict our analysis to the Unrestricted VAR model.

The result of the single long-run relationship after estimating the unrestricted cointegrating vector with *ad-hoc* normalization on LRPIV is (with t-value in parenthesis):

$$\boldsymbol{LRPIV - 3.49LRGDP - 0.74LRPII + 1.84LRSII + 0.03RIR + 0.82LREER + 0.41LCPI}$$

$$(-7.21118) \quad (-2.65050) \quad (3.99840) \quad (1.54478) \quad (3.92432) \quad (2.11629)$$

$$\boldsymbol{+14.62 = ECM_{1t}}$$

The above long-run equilibrium equation show that, citrus paribus, physical public infrastructure investment, and economic growth (real GDP) have a significant positive long-run impacts on private investment while social public infrastructure investment, real effective exchange rate, and consumer price index remain to have significant negative impacts on real private investment. In the long-run lending interest rate seem to have negative but insignificant impact on private investment.

The main empirical finding of this study is that, the long-run crowding-in impacts of physical public infrastructure investment on private investment. That is, a one percentage point increase in real physical public infrastructure investment stimulates private investment by 0.74 percentage points in the long run. This result implied that the impact of crowding-in categories of public sector investment has been large enough to offset any crowding-out effects in the long-run. And, thus it is consistent with the "crowding-in" hypothesis. Such crowd-in/complementarity effects of physical public infrastructure investment occur in Ethiopia could be through its positive impact on private sector productivity. By raising the marginal productivity of private inputs (both labour and capital), it raises the perceived rate of return on, and increases the demand for, physical capital by the private sector.[15] A similar simulative effect on private capital formation may occur due to physical public

[15] Greater availability of public capital in infrastructure could in principle also reduce the demand for private inputs, at a given level of output (net substitution effect). But if inputs are gross complements (as is the case in general), higher availability of public capital will always increase the marginal productivity of private inputs. Moreover,

infrastructure investment in Ethiopia by lowering the production costs that private firms may incur. For instance, a better transportation network may reduce expenses associated with the construction of a new factory or the transportation of heavy equipments. This result is in accordance with a substantial share of the previous literatures, mainly based on public investment, and particularly to those of Aschuer (1989), Ahmed & Miller (2000), Pereira (2000), Kandenge (2005), and Boopen and Khadaroo (2009) who found important crowding-in effect of the public investment components on private investment.

From the above long-run equation results, economic growth (real GDP) also exerts significant positive impact on private investment in Ethiopia. That is a one percentage increase in real GDP will lead to a 3.49 percentage increase in real private investment. Theoretically, this result is realistic since the accelerator theory makes investment a linear proportion of changes in output.[16] Muhamed (2006) and Alemnesh (2012) have found a similar result of real GDP having a positive impact on private investment in Ethiopia. The impact of consumer price index (CPI) is consistent to those of the literature and suggests crowding-out effects (for instance see Muhamed (2006) for Ethiopia). Which means that a one percentage-point increase in CPI will displaces the real private capital formation by 0.41 percentage points in the long run. Moreover, this also a measure of macroeconomic uncertainty and the negative sign means that uncertainty has been deterring private investment in the long-run.

The long-run impact of social public infrastructure investment on private investment is found to be negative and statistically significant, which means that a one percentage-point increase in social

public and private physical capitals are likely to have a high degree of complementarity, that is, a small elasticity of (net) substitution.

[16] Solimano et al (1989) revealed that the accelerator theory is the numerical value of the relationship between the increases in investment resulting from an increases output.

public infrastructure investment displaces private investment by 1.84 percentage points in the long-run. Thus, it is consistent with the "crowding-out" hypothesis. This result is quite realistic in the case of Ethiopia since both public and private social infrastructure sectors (i.e. education and health) provide/produce substitute services (net substitution effect). That means, in the long run, the expansion of public education and health sectors in Ethiopia may exert a stiff competition on private investment in service market. And, large percentage of the Ethiopia's population is found in the low income category and/or agrarian so they will choose the public sectors since the public sector charges lower price and give a higher education scholarship chance under future payable cost sharing payment.

In addition to this, similar crowding out effect may occur in Ethiopia due to the fact that public infrastructure under taken by heavily subsidized and inefficient state-owned enterprises in health, and education, have often reduced the possibilities for private investment. Moreover, the financing of public capital expenditures through external indebtedness, and the repression of the public financial system, has crowded out the private sector from profitable investment opportunities. Similar crowding-out effects may occur due to the fact that the government of Ethiopian financed the public sector through an increase in distortionary tax systems - which may increase incentives for private agents to evade taxation, or reduce the expected net rate of return to private capital, and therefore the propensity to investment. In other words, the private sector perception of the method of deficit finance has a bearing on other sorts of crowding-out.

Furthermore, with regard to the relationship between social public infrastructure investment and private investment, this finding is consistent with studies in Africa, mainly based on public investment, by Shafik (1992), Ahmed & Miller (2000), Rena (2011), and Badawi (2005) who found that a significant substitutable/crowding-out relationship between public infrastructure

investment and private investment in the long run. Similarly, more recently Tchouassi and Ngangue (2014) support the idea that private investment is a substitute of public capital and basic infrastructure expenditure in Africa.

Finally, the long run impact of real effective exchange rate on private investment is found to be negative and statistically significant, which means that a one percentage increase in real effective exchange rate crowding-out private investment by 0.82 percentage points in the long-run. Such crowding out effect is due to the fact that real appreciation undermines competitiveness, widens current account deficit, and increases the vulnerability to a financial crisis in developing countries, Ethiopian is not far from this fact.[17] Significant appreciation can also led to a sudden drying up of capital flows, causing an abrupt adjustment of the current account. Beyond its negative effect on investment, significant real appreciation could thus create major problems for macroeconomic management. The appreciation of real effective exchange rate, mainly, may also able to discourage domestic private investment participation. In general, the above result implied that, in Ethiopia, the crowding-out effect of REER has been large enough to offset any crowding-in effects on private investment in the long run.

Short-Run Dynamics of the Private Investment Model

Once the existence of long-run relationship checked and the appropriate parameters are determined, the next step is estimating the coefficients of the short term dynamics of the investment model. In order to capture the short-run dynamics of the model error correction mechanism was applied. The full result of the VECM is presented in Appendix-5. In table (5.6), the estimated VECM provide the

[17] Appreciation of REER (i.e. decrease in exchange rate) makes domestically produced goods relatively expensive for foreigners. Hence, citrus paribus, an appreciation of domestic currency decreases the trade balance of the country and discourage domestic private investment.

correction terms that reflect influences of deviation of the relationship among the variables from long-run equilibrium and short-run parameters. In this study, we have four error correction terms in the real private investment model due to the existence of four cointegrating vectors in the Johansen cointegration test and the interrelationship of the variables in the VECM.[18] The coefficients of ECM1 (-1), ECM2 (-1), ECM3 (-1), and ECM4 (-1) showed the speed of adjustment of disequilibrium in the period of study. This implied that all the six variables are adjusted to the four error correction terms in the VECM since the cointegrated equations are four.

As the first error correction term (ECM1 (-1)) were significant with negative sign, hence the results of VECM depicted that the adjustments in LRPIV is due to the first error correction term (ECM1). This result implied that there is a reasonable adjustment towards the long run steady state. The coefficient of the first error correction term is significant which implied that LRPIV adjusted by 32.3 percent in one year to the long run equilibrium. The result showed that it took more than approximately three years ($^{1}/_{0.323} = 3.09$) to eliminate the disequilibrium which is to make a full adjustment towards its long-run equilibrium.

[18] Since the Johansen (1988, 1991) procedure allows testing for the presence of more than one cointegration vector and permits to estimate the model without priority restricting the variables as endogenous and exogenous, the number of error correction terms in each model is equivalent to the number of cointegrating vectors. However, if we use the single equation based Engel-Granger two step procedure we will have a single error correction term in each model (i.e. the weighted average error correction term).

Table-5.6: Short Run Coefficients When LRPIV is a dependent variable

Dependent Variable: LRPIV

Variables	Coefficient	Std. Error	t-Statistics	Prob.
D(LRGDP(-1))	0.752067	0.371241	2.025820	0.0528***
D(LRPII(-1))	0.594078	0.299666	1.982464	0.0577***
D(LRSII(-1))	-0.133503	0.333606	-0.400181	0.6922
D(RIR(-1))	-0.003486	0.002240	-1.556401	0.1313
D(LREER(-1))	-0.279186	0.156585	-1.782974	0.0858***
D(LCPI(-1))	0.679120	1.056654	0.642708	0.5258
ECM1(-1)	-0.323111	0.146329	-2.208109	0.0359**
ECM2(-1)	0.114153	0.282946	0.403444	0.6898
ECM3(-1)	-0.263712	0.194632	-1.354924	0.1867
ECM4(-1)	0.088029	0.268530	0.327818	0.7456

Note: **, **, ***shows significant at 1%, 5%, and 10% respectively*

The short run dynamics results in the above table (5.6) appear to suggest that the short-run determinants of private investment in Ethiopia are found to be economic growth (real GDP), physical public infrastructure investment and real effective exchange rate. That is, economic growth and physical public infrastructure investment have a "crowding-in/complementary effect" on private capital formation in Ethiopia while real effective exchange rate (REER) has a crowding-out effect on private investment in the short-run.

The short-run impact of physical public infrastructure investment on private capital formation is found to be positive and statistically significant both in the short run and long-run. That is, a one percentage –point increase in physical public infrastructure investment stimulates private

investment by 0.59 percentage points in the short-run; the positive sign of physical public infrastructure investment is the implication of a "Crowding-in/complementarity" effect on private capital formation in the short run. In the short run, physical public capital in infrastructure may affect private capital formation indirectly, through changes in output and relative prices. As noted earlier, public capital in infrastructure may raise the marginal productivity of all factor inputs (capital and labor), thereby lowering marginal production costs and increasing the level of private production in the short-run. In turn, this scale effect on output may lead, through the standard accelerator effect, to higher private investment—thereby raising production capacity over time and making the growth effect more persistent. Another indirect channel is that the expansion of, by nature, physical public infrastructure investments demands large amount of raw materials/inputs which are produced by the private sector, this demand may encourage the private investors to expand their production capacity.

In the short-run, economic growth (real GDP) reported to have its expected theoretical sign and significance. As it can be seen from the short run error correction result, an output (real GDP) induced a significant crowding-in effect is observed and is typical of its accelerator characteristics. Which means a percentage change in economic growth will lead to a 0.75 percentage increase in real private investment in the short-run. The relatively large crowding-in effect is consistent to some studies of investment in developing countries (for instance Blejer & Khan (1984), Greene & Villanueva (1991), Serven & Solimano (1993)).

Furthermore, the short-run coefficient of the real effective exchange rate (REER) is found to be negative and significant in Ethiopia. That is, a one-percentage point increase in real effective exchange rate will displace the real private investment by 0.27 percentage points in the short-run. As discussed previously, the appreciation of real effective exchange rate will discourage the

domestic private investment, and it may also lead to stiff competition in the domestic market since domestically produced goods relatively expensive for foreigners due to the real appreciation. This implied that, in Ethiopia, the crowding-out effect of REER has been large enough to offset any crowding-in effects on private investment in the short-run.

Finally, the short-run impact of social public infrastructure investment on private investment is found to be inconclusive (it is negative but not statistically significant) over the period 1974/75-2013/14. In part, this may due to the fact that social public infrastructure investment has a long gestation period to give a return, especially education sector.

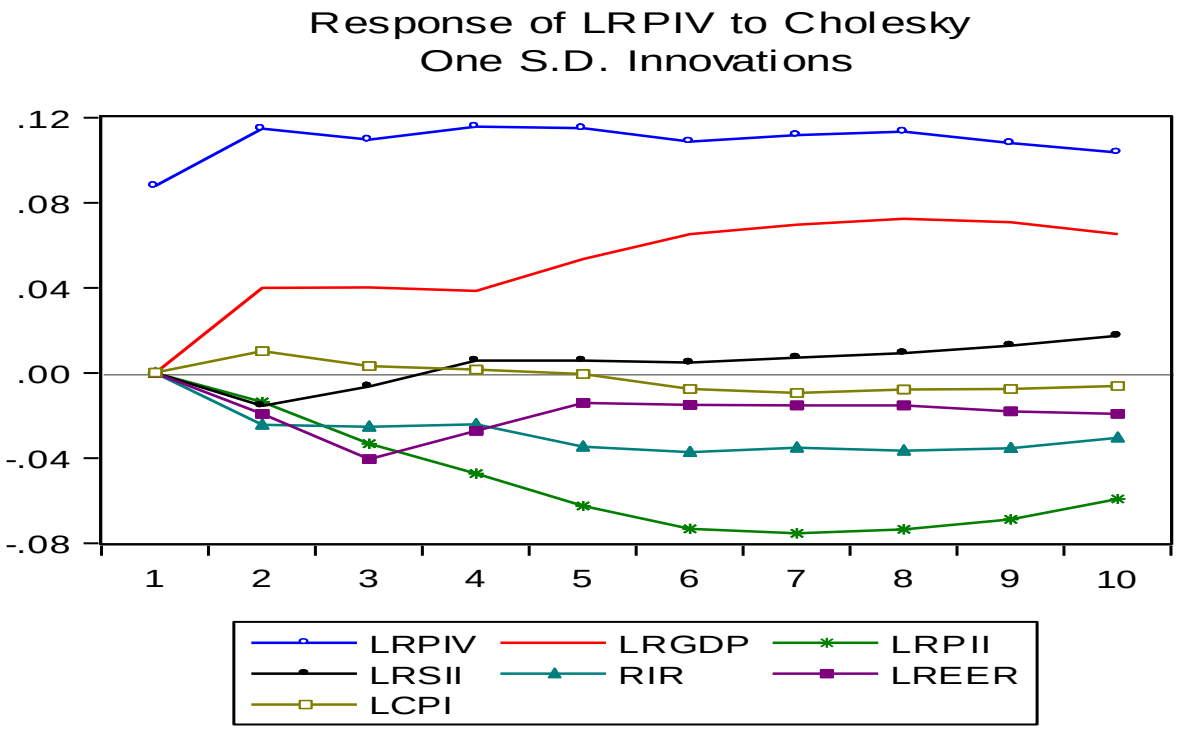
5.2.4. Impulse Response Function and Variance Decomposition Analysis

To make the results of this study more concrete, the researcher have tried to investigate the dynamic relationship among the variables through decomposing the variance of LRPIV and showing the impulse responses of LRPIV to shocks in public infrastructure investment and other variables.

Impulse Response Function

An impulse response function traces the response of the endogenous variable in the system to a shock in one variable. In other words, impulse response functions measure the importance of next period shocks for future values of a time series. Thus, in this study, to track the time path of private investment to shock from public infrastructure investment and from other variables the impulse response function employed. Figure (5.1) shows the response of real private investment to the shocks from other variables.

Figure 5.1: Impulse response of LRPIV to shock from other variables



From the above figure (5.1), a positive shock occurring on real physical public infrastructure investment has a negative impact on real private capital formation. Which means the effect of one standard deviation shock of physical public infrastructure investment on real private investment is negative in the short run over the whole period. This result is not consistent with the result we have got in the VECM analysis. However, such-crowding-out effects may occur due to the fact that in the short run the involvement of the government sector in production distribution activities of social public infrastructure may lead to a competition with the private sector in factor markets of labour, funds, and intermediate goods.

On the other hand, the effect of one standard deviation shock of social public infrastructure investment on real private investment is positive. Similarly, this impulse response result is not

consistent with the result we have got in the VECM. In addition to this, the effect of one standard deviation shock of real GDP on private capital formation is positive.[19]

Variance Decomposition Analysis

The extent to which exogenous changes (or innovations) in physical and social public infrastructure investment and other variables in the VECM model have affected the behavior of private capital formation can be also gauged by computing the proportion of the variance of the forecast error for the private capital that can be attributed to variations in each variable at different forecast horizons. The full decomposition of the variation in real private investment is presented in appendix-(7) for the first 40 periods alongside with the Monte Carlo standard errors.

Table-5.7: Variance Decomposition Analysis of LRPIV

Period	S.E.	LRPIV	LRGDP	LRPII	LRSII	RIR	LREER	LCPI
1	0.0879	100.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.2027	80.134	7.8121	3.1457	0.6895	3.0182	4.9247	0.2757
9	0.4209	61.129	15.163	16.187	0.3807	4.6612	2.2628	0.2163
17	0.5298	58.253	14.318	15.735	2.6716	3.9061	4.4740	0.6419
21	0.6301	42.702	12.772	27.828	3.6994	4.2241	6.7239	2.0516
25	0.8079	26.141	13.721	40.763	3.4811	5.0072	7.5767	3.3104
28	0.9586	18.575	14.866	46.523	3.0771	5.4318	7.6733	3.8534
32	1.1398	13.146	16.031	50.494	2.6392	5.7315	7.6978	4.2606
33	1.1784	12.305	16.235	51.085	2.5575	5.7717	7.7146	4.3310
36	1.2757	10.536	16.659	52.289	2.3724	5.8366	7.8054	4.4997
40	1.3655	9.3347	16.869	53.059	2.2354	5.8372	8.0047	4.6601

[19] The full impulse response function is presented in Appendix-6.

The results show that (in table 5.7) the real physical infrastructure investment is responsible for explaining 16.2% of the variation of real private investment (RPIV) after nine time periods, this percentage reaches 40.8% after twenty five time periods and goes up to 53.1% after forty time periods. On the other hand, variations of the social public infrastructure investment (RSII) were found to explain about 0.4% of the forecast error of RPIV after nine time periods, and 3.3% after twenty five time periods. It seems that the real physical public infrastructure investment has a greater impact, compared to the real social public infrastructure investment, on the private capital formation in the long run. In addition, the result further showed that a huge variation in real private investment explained by real GDP next to real physical public infrastructure investment both in the long run and short run. And, the impact of real private investment on itself is dying out over time. Over all, therefore, the variance decompositions suggest that physical public infrastructure investment account the highest fraction of the variance of private investment in Ethiopia.

5.3. Econometric Analysis of the Growth (Real GDP) Model

5.3.1. Co-integration Test Result

Optimal Lag Length Selection Criteria

The determination of optimal lag length in the VAR system is a crucial issue since the cointegration rank and resulting outputs are sensitive to the dynamic structure of the system. In this study, standard lag length selection criteria are used to select the number of lags of the VAR: the sequential modified likelihood ratio (LR) test, the Akaike information Criterion (AIC), the Final Prediction Error (FPE), the Hannan-Quinn Information Criterion (HQ), and the Schwarz Information Criterion (SIC). As presented in table (5.8), all these criteria select one lags except

AIC. However, in order to make sure that lags with significant information content are not excluded from the VAR system of the growth model, Wald Lag- Exclusion Tests are performed. Wald tests (in table 5.9) show that one lags are jointly significant for all the equations in the VAR system. The VAR was, therefore, estimated with one lags.

Table-5.8: Optimal Lag Order Selection Criteria for the Growth (real GDP) model

Lag	Log-likelihood	LR	FPE	AIC	SIC	HQ
0	61.81778	NA	1.97e-09	-3.017177	-2.755947	-2.925081
1	408.5008	562.1886*	1.03e-16*	-19.81085	-17.98224*	-19.16618*
2	446.1068	48.78624	1.11e-16	-19.89767	-16.50168	-18.70042
3	484.4046	37.26269	1.55e-16	-20.02187*	-15.05850	-18.27205

Note: * indicates lag order selected by the criterion

Table-5.9: VAR Wald Lag-Exclusion Test for the growth model

Lags	LRGDP	LRPIV	LRPII	LRSII	LLAB	LEXP	Joint
Lag 1	5546.389 [0.0000]	835.2494 [0.0000]	4179.314 [0.0000]	5090.176 [0.0000]	917288.5 [0.0000]	1519.543 [0.0000]	1112591. [0.0000]
df	6	6	6	6	6	6	36

Note: The numbers are Chi-squared test statistics for lag exclusion; the numbers in parentheses are p-values.

The Johansen Co-integration Test Results

Since the included variables in real GDP model are I (1), the verification of the existence of a long run equilibrium relationship between the model variables is examined using Johansen co-

integration approach. On the basis of the results of Trace test statistics in table (5.10), the Johansen procedure test results for cointegration with one lags in the system indicates that there are three cointegrating relationships. The trace test statistics fail to reject the null of at most three cointegrating equations in the system. This suggests that there exist precisely three co-integrating vector in the estimated growth model.

Table-5.10: Unrestricted Co-integration Rank Test of growth model (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value (5%)
None *	0.724855	137.0420	103.8473
At most 1 *	0.547012	88.00462	76.97277
At most 2*	0.453629	57.91284	54.07904
At most 3	0.374775	34.94344	35.19275
At most 4	0.263387	17.09700	20.26184
At most 5	0.134310	5.480700	9.164546

Note: * denotes rejection of the hypothesis at the 0.05 level

Occasionally, the number of cointegrating relationships implied by trace test and maximum eigenvalue test are different (see appendix-3B for the maximum eigenvalue test result, which indicates the existence of 1 cointegrating equations at the 0.05 level). Since the trace statistics is more robust than the maximum eigenvalue statistics in testing for co-integration, the existence of three cointegrating relationships is accepted. This result can be also perfected by the fact that the characteristic polynomial of the model has three roots with modulus equal to unity (see appendix 8). The number of variables in the growth (real GDP) model is six; existence of three roots with unit modulus indicates that the adjustment coefficients for three potential cointegration equations

are statistically zero, leaving only three potential cointegrating relationships. Hence, we can conclude that there is a long-run relationship between the variables which is explained by a linear combination of I (1) variables since there are three cointegrating equations.

Furthermore, in order to identify the potential cointegrating equations/relationships, in this study, weak exogeneity test is conducted using VEC Granger Causality/Block Exogeneity Wald test.

Table-5.11: VEC Granger Causality/Block Exogeneity Wald Test for growth (Real GDP) model

Dependent variable: D(LRGDP)			
Excluded	Chi-sq	df	Prob.
LRPIV	2.836083	1	0.0922
LRPII	8.049470	1	0.0046
LRSII	0.520127	1	0.4708
LLAB	3.840007	1	0.0500
LEXP	3.033542	1	0.0816
All	14.55367	5	0.0124

The weak exogeneity test (in the above table 5.11) indicate that LRGDP (log real GDP) is endogenous in the estimated real GDP (growth) model since the null hypothesis of weak exogeneity is rejected at 5% level of significance. Therefore, the Real GDP series can be a long-run cointegrating equation. In addition, the rejection of the null hypothesis that real output (GDP) is weakly exogenous indicates that the existence of a significant long-run stationarity feedback to real GDP.

5.3.2. Diagnostic Tests

The estimated Vector Error Correction model passes all the diagnostic tests conducted in this study (see Appendix-9). The Serial Correlation Lagrange multiplier (LM) test fails to reject the null hypothesis of no serial correlation up to order one. This result indicates that the residuals of the estimated error correction model do not suffer from any type autocorrelation. The normality of the residuals is checked by Jarque-Bera tests. As shown in appendix-9, the Jarque-Bera test of normality fails to reject the null hypothesis of normal distribution at the 1% significance level but not at the 5% or 10% significance level.[20] However, since normality is an asymptotic or large sample property, it may be expected that the residual normality could asymptotically be improved if the sample size could be increased. Unfortunately, the sample size could not be increased because of the investment data. This may suggest that there could be small sample size problem in the data that has probably reduced the power of this test. Finally, the VEC residuals heteroskedasticity test performed. The test fails to reject the null hypothesis of no heteroskedasticity. This result indicates that the residuals of the model are found to be homoscedastic.

5.3.3. Vector Error Correction Model (VECM) of the Real GDP (Growth) Model

The presence of cointegration between variables in the cointegration test result suggests that the presences of a long term relationship among the variables. Then, the VEC model can be applied. The VECM model is estimated, in this study, to examine the short run dynamic relationship

[20] The normality of the residuals is increases when the probability value is close to one (i.e. at 10% level of significance). But we can accept the normality of the residuals at 1% or 5% level of significance (see Eviews 8 User Guide I, page 359-360).

between the variables and long-run equilibrium; the appropriate optimal lag-length (lag one) used which is selected through different criterion previously. Furthermore, the VEC model is convenient for the simultaneous analysis of long-run equilibrium relationships between variables as well as for their adjustment to deviations from these equilibria in the short-run.

Long-Run Relationship in the Growth (Real GDP) Model

As discussed in the cointegration test result previously, the Johansen trace statistics indicated that the presence of three cointegrating vectors/equations. However, the objective of this section is analyzing the relative impact of public infrastructure and private investment on the economic growth of Ethiopia. Therefore, we estimated the unrestricted cointegrating vector with *ad-hoc* normalization on LRGDP.

After normalization the first cointegrating vector on LRGDP normalized cointegrating coefficients were estimated as below:

$$\boldsymbol{LRGDP - 0.19LRPIV - 0.63LRPII + 1.47LRSII - 0.73LLAB - 0.75LEXP - 7.59 = ECM_{1t}}$$

$$\boldsymbol{(0.96388)\quad (3.79527)\quad (6.24979)\quad (2.44628)\quad (10.25483)}$$

Following the Johansen approach (1991), the above normalized cointegrating equation shows that, in the long run, there is a clear and reliable positive impact of private investment, physical public infrastructure investment, active labour force, and export on economic growth in Ethiopia. However, social public infrastructure investments seem to have a negative relationship with economic growth in Ethiopia.

The long run impact of real physical public infrastructure investment on economic growth is found to be positive and statistically significant in Ethiopia. That is, a one percentage –point

increase in real physical public infrastructure investment will raise the real GDP by 0.63 percentage points in the long-run. In Ethiopia, the possibility that physical public infrastructure investments enhance economic growth directly through its contribution of new capital on nation's production process as capital enters directly in the country's production function. On the other way, the physical public infrastructure investment may stimulate economic growth indirectly by increasing the efficiency of private investments through creating a better infrastructure, increasing the amount of capital competing in the economy, facilitating the flow of goods and services, decreasing the cost of transportation, and cost of acquiring private investments. Another indirect positive effect may come through increasing the amount of capital per worker, thus increasing workers' productivity. Furthermore, this finding is consistent with studies in Africa by Ghura (1997), Kandenge (2005), Boopen (2006), Nketiah-Amponsah (2006), Enimola (2010), Kumo (2012), Ebi (2013), Keyoda et al (2013); they revealed that public infrastructure investments have a positive and statistically significant impact on economic growth.

The most surprising result in this study is that the real social public infrastructure investment has a negative and significant impact on the real GDP of Ethiopia. Which is a one percentage point increase in real social public infrastructure investment decrease real GDP by 1.47 percentage points in the long run –this is resulted from the huge crowding-out impact of social public infrastructure investment on private investment. Such crowding-out effect has divert the favourable effect of social public infrastructure investment on the economic growth of Ethiopia in to unfavorable one by jeopardizing private sector capital undertakings. The social public infrastructure investment effect on growth should logically follow the direction of its effect on private investment in the long-run. In addition to this, the negative impact of social physical

infrastructure on economic growth is may be due to the fact that the quality of education and health sector in Ethiopia is very low- since the recent trend shows that the government of Ethiopia is showing a strong commitment to expand the number of education institutes in the country (focused on coverage) rather than quality. This reason, indeed, supported by the recent global competitiveness report of 2013/14 by WEF (2013), Ethiopia ranked 113th from 148 countries in terms of health and primary education.

The above result implied that the negative effect of an increase in social public infrastructure investment spending outweigh the positive effect on the economic growth of Ethiopia. Furthermore, Badawi (2005) also showed that the crowding-out effect of public capital expansion has weakened favourable positive effect that public sector's investment has exerted on growth by jeopardizing private sector capital undertakings in Sudan.

With respect to private investment, real private investment has a positive (but insignificant) impact on real GDP in Ethiopia, in the long-run. Which is a percentage change in real private investment is associated with a 0.19 percentage change increase in real GDP. This result is consistent with the result we get in the private investment model, which is the huge crowding out impact of social public infrastructure investment on private investment in the long-run. Such crowding out impact of public infrastructure investment weakened the favourable positive impact of private investment. Moreover, active labour force and export have a positive significant impact on the economic growth of Ethiopia in the long run as expected.

Short-Run Dynamics of the Real GDP (Growth) Model

In this study, the VECM was applied to capture the short-run dynamics of the model. The full VECM result is presented in Appendix-10. The results in table (5.12) below appear to show that

real physical public infrastructure investment, active labour force and export have significant impacts on real output (real GDP) of Ethiopia in the short-run. Social public infrastructure and private investment, however, doesn't have a strong impact on short-run economic growth.

The short-run coefficient of physical public infrastructure investment indicates a negative and significant effect on economic growth, while it has shown significant positive impact in the long run in Ethiopia. That is, a one percentage point increase in physical public infrastructure investment decreases economic growth by 0.36 percentage points in the short-run- this is resulted from the inflationary impact of physical public infrastructure investment in the short-run, especially in the LDCs, because it has a long gestation period to give a return. Such inflationary impacts may distort private investment productivity directly or indirectly, and/then it may distract the economy through reducing the saving level and increasing the cost of production. This result is consistent with the findings of Badawi (2005) in Sudan, showed that public sector investment appears with a significantly negative short-term effect on economic growth.

Table-5.12: Short Run Coefficients When LRGDP is a dependent variable

Dependent Variable: LRGDP

Variables	Coefficient	Std. Error	t-Statistics	Prob.
D(LRPIV(-1))	0.296416	0.176012	1.684067	0.1029
D(LRPII(-1))	-0.363135	0.127992	-2.837159	0.0082*
D(LRSII(-1))	0.113253	0.157034	0.721198	0.4766
D(LLAB(-1)	6.145079	3.135895	1.959594	0.0597***
D(LEXP(-1))	-0.058883	0.033808	-1.741707	0.0922***
ECM1(-1)	-0.588939	0.112971	-5.213211	0.0000*
ECM2(-1)	-0.408715	0.088670	-4.609397	0.0001*
ECM3(-1)	0.199010	0.046266	4.301417	0.0002*

Note: **, **, and *** shows significant at 1%, 5%, and 10% respectively.*

The short run impact of social public infrastructure investment on economic growth in Ethiopia is inconclusive (positive but insignificant). The findings of the study suggested that in the short-run social public infrastructure investment is insignificant in determining economic growth in Ethiopia. This result is quite realistic since social public infrastructure investment has a long gestation period to give a return, especially education sector, and due to unfavorable investment environment in the country. Similarly, the above short-run dynamic results also suggested that private investment have inconclusive (positive but insignificant) effect on economic growth of Ethiopia. Moreover, such variables as labour force and export are found to have a significant role in the short run economic growth.

The above table (5.12) indicates that the VECM of this study have three error correction terms since we found three cointegrating long run equations in the Johansen cointegration test

previously.[21] The coefficients of ECM1 (-1), ECM2 (-1), and ECM3 (-1) showed the speed of adjustment of disequilibrium in the period of study. This means that all the five explanatory variables of the model adjusted to the long run by the three error-correction terms.

Since the coefficient of the first error correction term (ECM1) has negative significant sign and large adjustment coefficient, which indicates that there is a movement back to the equilibrium relationship, and there is a long-run equilibrium relationship among the variables, and the speed of adjustment of any disequilibrium towards long-run equilibrium state is 58.9 percent. The result showed that it took less than approximately two years ($^{1}/_{0.589} = 1.7$) to eliminate the disequilibrium which is to make a full adjustment towards its long-run equilibrium.

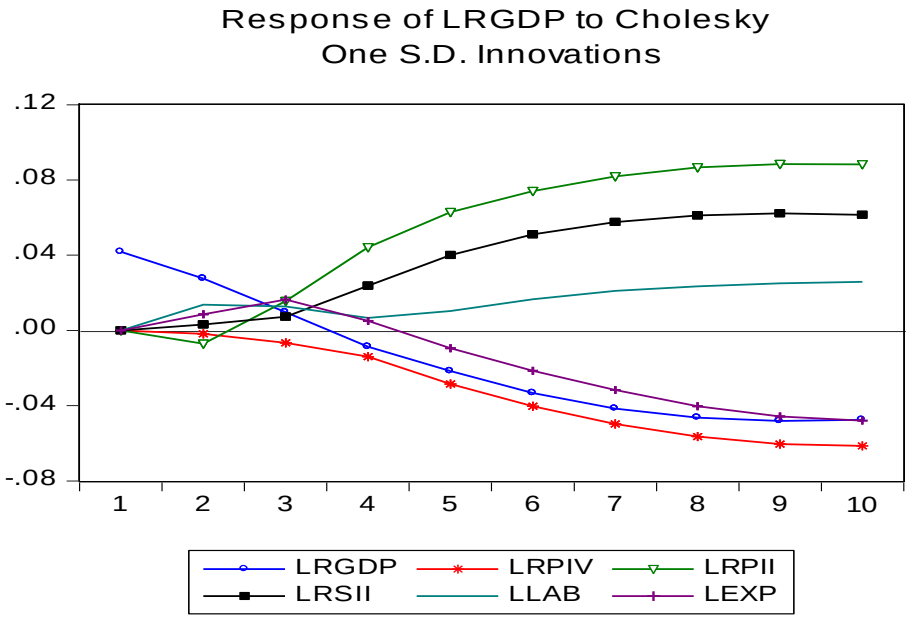
5.3.4. Impulse Response Function and Variance Decomposition Analysis

Impulse Response Function

Impulse response function represents the time profile of the effect of a shock to one variable on the future values of all exogenous variables. Thus, in this study, to track the time path of Real GDP to shock from public infrastructure investment, private investment and from other variables impulse response function employed. Figure (5.2) below shows the impulse response function result. This function can produce the time path of dependent variable (LRGDP), in the system of equation developed within the VECM framework, to shocks from all the explanatory variables.

[21] For further detail on why the real GDP model has three error correction terms see the previous short run dynamics foot not (18) of real private investment model.

Figure 5.2: Impulse response of LRGDP to shock from other variables



From the above figure (5.2), it is very clear that a positive shock occurring on both types of public infrastructure investments (i.e. Physical & social) has a positive impact on real output, which means that an increase in the public infrastructure investment level raises the level of economic growth in Ethiopia. This result is consistent with the simulative impact of social public infrastructure investments on growth result of the short-run dynamic model but not consistent with the result of the physical public infrastructure investment. On the other hand, the effect of one standard deviation shock of real private investment on real GDP is negative-this is due to the huge crowding out impact of physical public infrastructure investment. Furthermore, the real GDP response to a positive shock in labour force is positive; while the initial response of real GDP to a positive shock in export is positive and dies out over time.[22]

[22] The full impulse response function is presented in Appendix-11

Variance Decomposition Analysis

The variance decomposition provided further evidence of relationships among the variables under investigation. The variance decomposition showed the proportion of the forecast error of one variable due to the other variables. Therefore, the variance decomposition makes possible to determine the relative importance of each variable in creating fluctuations in other variables (Ratanapakorn and Sharma, 2007). Table (5.13) reports the decomposition of variance of the variable LRGDP for various time periods, they are showing that there are significant role played by the shocks in most of macroeconomics variables in accounting for the fluctuations in the economic growth of Ethiopia.

Table-5.13: Variance Decomposition Analysis of LRGDP

Period	S.E.	LRGDP	LRPIV	LRPII	LRSII	LLAB	LEXP
3	0.0608	70.484	1.2424	7.8974	1.7114	9.4442	9.2207
5	0.1166	23.132	7.7378	45.679	16.414	3.6819	3.3552
6	0.1586	16.898	10.637	46.491	19.248	3.0875	3.6383
8	0.2442	13.649	13.976	43.494	19.962	2.9665	5.9526
13	0.3954	11.575	16.358	40.748	18.973	3.2773	9.0749
17	0.4685	10.465	15.707	42.123	18.993	3.7402	8.9715
22	0.5487	9.4239	14.249	44.377	19.238	4.4109	8.2998
26	0.6098	8.7339	13.049	46.080	19.395	4.9797	7.7609
31	0.6821	7.9503	11.589	48.123	19.536	5.7207	7.0804
35	0.7379	7.3702	10.477	49.677	19.608	6.3296	6.5381
36	0.7517	7.2311	10.209	50.051	19.621	6.4831	6.4049
40	0.8065	6.6958	9.1859	51.486	19.646	7.0998	5.8857

Table (5.13) above, show that real physical infrastructure investment is responsible for explaining 46.5% of the variation of LRGDP after six time periods, this percentage reaches

44.4% after twenty two time periods and goes up to 51.5% after forty time periods. On the other hand, variations of the social public infrastructure investment (LRSII) were found to explain about 19.2% of the forecast error of LRGDP after six time periods, and 19.6% after forty time periods. And the variation in real private investment was increase until period twenty and after this period its contribution starts to decline. The above variance decomposition result shows that the real physical public infrastructure investment has a greater impact, compared to the real social public infrastructure investment, on the economic growth of Ethiopia. These results support the above result of the long-run equation of real output. In addition, the result further showed that a small variation in real output explained by labour force and export. [23]

[23] The full decomposition of the variation in real output is presented in appendix -12 for the first 40 periods alongside with the Monte Carlo standard errors.

CHAPTER SIX

CONCLUSIONS AND POLICY IMPLICATIONS

6.1. Conclusions

To accomplish the objective of this study, i.e. to test the relationship between private and public investment as well as their relative contribution to the economic growth of Ethiopia, the vector error correction modelling approach has been employed to the Ethiopian data for the period 1974/75 to 2013/14.

The major contribution of this study is that, unlike other researchers who consider public infrastructure investment at an aggregate level, this study looks the separate impacts of the two categories of public infrastructure investment: physical and social infrastructure using a cointegrating approach. The two models were estimated using VECM by taking the disaggregate data. The first specification focused on the impact of public infrastructure investment (both physical and social public infrastructure investments) on private investment. The second specification examines the contribution of private investment and public infrastructure investment on economic growth of Ethiopia. The major findings of the study are summarized as follows:

Physical public infrastructure investment has a crowding-in effect on private investment both in the short-run and long-run. Such crowding-in effect may be through its positive impact on private sector productivity. By lowering production costs that private firms may incur and raising the expected rate of return, physical capital in infrastructure may have a strong positive impact on private investment.

On the other hand, social public infrastructure investment has a crowding-out effect on private investment in the long-run while its impact in the short –run is inconclusive (negative but insignificant). The long-run result may be due to the fact that since both public and private social infrastructure sectors (i.e. health and education) provide/produce substitute services the expansion of public education and health sectors in Ethiopia may exerts a stiff competition on private investment. Moreover, the financing of public capital expenditures through external indebtedness and distortionary taxes may displace the private sector investment from the profitable investment opportunities. This implying that the crowding-out impact of social public infrastructure investment has been large enough to offset any crowding-in effects. Furthermore, the impulse response function indicates that the short run fluctuations in real private investment are attributable significantly to shock to itself, real GDP and physical infrastructure investment. Similarly, the variance decomposition suggested that much of the variation in private investment explained by the variation in itself, physical pubic infrastructure investment and real GDP.

The contribution of physical public infrastructure investment to the real GDP is positive and significant in the long run while it has a negative and significant contribution in the short run. Such long run result may be through the physical public investment contribution of new capital on nation's production process as a capital and through increasing the efficiency of private investment. And, the short-run result is due to the fact that the productive outcome of physical public infrastructure investment needs a long gestation period.

In the long run, social infrastructure investment exerts negative and significant effect on real GDP –this may be resulted from the huge crowding-out impact on private investment. However, its impact in the short run is inconclusive (positive but insignificant). This may be occurring

because social public infrastructure investments have a long gestation period, especially education.

On the other hand, the contribution private investment to growth is inconclusive (positive but insignificant) both in the short run and long run-this may be due to the substitute effect of the social public infrastructure investment and the unfavorable investment environment in the country. Moreover, the variance decomposition analysis of real GDP model indicates that private investment, physical and social infrastructure investments are responsible for most of the variations in the economic growth of Ethiopia.

6.2. Implications

The empirical results of this study have useful policy implications not only for Ethiopia but also for least developing countries (LDCs) in general. Given the relative significance and importance of physical public infrastructure investment in stimulating economic growth and private investment in the long-run this study has the following policy implications:

First, social public infrastructure investment has been one of the prime sources of the long-run crowding-out effect on private investment. Therefore, in order to curb this substitutable effect, it is essential the government of Ethiopia to redefine the role of the public sector as a catalyst, rather than a provider, of the majority of infrastructure. This will ensure greater involvement of the private sector in the infrastructure investment, in turn this involvement will introduce commercial disciple in the service delivery thereby improving efficiency, quality and coverage of services, lowering costs and reducing the burden on public budget.

Indeed, the privatization programme that the government of Ethiopia has launched in the early 1990s seems to be a step in the direction to boost private investment in the country; however it

fails to trigger enough capital commitments by private investors. The Ethiopian government thus needs to adopt a better framework for privatization programme and needs to withdraw from economic activities that can be well filled by private sectors.

The ***second*** policy message of this study is in line with the negative impact of social public infrastructure investment on economic growth in the long run. The recent trend shows that the government of Ethiopia is showing a strong commitment to expand the number of education institutes in the country (focused on coverage), similar for health sector. Indeed, such a boost in social public infrastructure investment will not be enough to generate a tangible effect on long-run growth if not accompanied by increase in the quality of the investment. Therefore, to tackle this problem the government of Ethiopia should take supplementary reform to improve the existing social infrastructure quality than engaging in new investment, especially in the education sector.

Thirdly, public infrastructure investment structure needs to be optimized. Empirical test results show that the sign (direction) of effects of public infrastructure investment on economic growth differs across the different categories of public infrastructure sectors in Ethiopia. Public infrastructure investment in transportation, energy and communication sectors has a positive contribution to growth, while public infrastructure investment in education and health sectors has negative impact in the long run. Therefore, the Ethiopian government should invest more in bottleneck sectors such as low quality education and health sectors, and so on. But it doesn't mean that it should expand social infrastructure on the expense of physical infrastructure sectors.

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Appendices

Appendix-1: Unit Root Test Result Using Phillips-Perron Test

Variables	Test statistic under different assumptions			Order of Integration
	Intercept	Trend and Intercept	No Trend, No Intercept	
LRPII	0.548370	-1.879821	4.136275	I(1)
D(LRPII)	-4.508626*	-4.577432	-3.187303	
LRSII	1.195363	-1.619488	5.368263	I(1)
D(LRSII)	-4.779982*	-5.033240	-3.298490	
LRPIV	0.277565	-1.928220	2.240588	I(1)
D(LRPIV)	-4.466503*	-4.552111	-4.031302	
LRGDP	4.528201	-0.231176	4.420046	I(1)
D(LRGDP)	-4.604471*	-5.828687	-3.324962	
RIR	-4.053291	-3.997537	-4.098831	I(1)
D(RIR)	-9.142942	-9.129989	-9.294767*	
LCPI	0.103618	-1.494792	4.065115	I(1)
D(LCPI)	-4.183113*	-4.173716	-2.858963	
LLAB	0.922645	-1.367835	24.59744	I(1)
D(LLAB)	-2.673332***	-2.798854	0.112930	
LEXP	0.878530	-1.330514	2.733724	I(1)
D(LEXP)	-5.410405	-5.745098	-4.756188	
LREER	-1.161643	-2.017004	-0.404509	I(1)
D(LREER)	-4.899177*	-4.821075	-4.941755	

Note: *D shows the variable is differenced once. MacKinnon (1996) critical values ADF unit root test statistics are used here. *, **, ***shows significant at 1%, 5%, and 10%.*

Appendix-2: Roots of Characteristic Polynomial of private investment model

Roots of Characteristic Polynomial

Endogenous variables: LRPIV LRGDP LRPII LRSII RIR LREER LCPI

Lag specification: 1 1

Root	Modulus
1.000000	1.000000
1.000000	1.000000
1.000000	1.000000
0.954082 - 0.134488i	0.963514
0.954082 + 0.134488i	0.963514
-0.276740 - 0.673669i	0.728295
-0.276740 + 0.673669i	0.728295
0.286083 - 0.585061i	0.651261
0.286083 + 0.585061i	0.651261
0.515180 - 0.330104i	0.611865
0.515180 + 0.330104i	0.611865
0.487678	0.487678
-0.274065	0.274065
-0.057934	0.057934

VEC specification imposes 3 unit root(s).

Appendix-3A: Unrestricted Co-integration Rank Test of the Private Investment model (Maximum Eigenvalue Test)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value (5%)
None *	0.883884	81.82018	47.07897
At most 1	0.658816	40.86267	40.95680
At most 2	0.505440	26.75526	34.80587
At most 3	0.461465	23.51827	28.58808
At most 4	0.339458	15.75842	22.29962
At most 5	0.300537	13.58279	15.89210

Note: * denotes rejection of the hypothesis at the 0.05 level

Appendix-3B: Unrestricted Co-integration Rank Test of the Growth Model (Maximum Eigenvalue Test)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value (5%)
None*	0.724855	49.03739	40.95680
At most 1	0.547012	30.09179	34.80587
At most 2	0.453629	22.96940	28.58808
At most 3	0.374775	17.84644	22.29962
At most 4	0.263387	11.61631	15.89210
At most 5	0.134310	5.480700	9.164546

Note: * denotes rejection of the hypothesis at the 0.05 level

Appendix-4: Diagnostic Test Results of Real Private Investment Model

Diagnostic Tests	Statistics		P-value
VEC Residual Serial Correlation LM Tests	Lags	Chi-sq	0.3347
	1	52.65161	
Jarque-Bera Normality test	Joint	21.50935	0.0893
VEC residual heteroskedasticity test	619.5987		0.4517

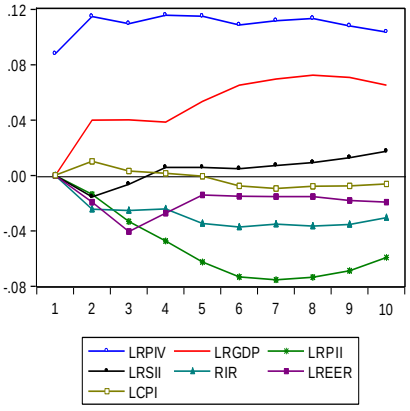
Appendix-5: The VECM result of Real Private Investment Model

Error Correction:	D(LRPIV)	D(LRGDP)	D(LRPII)	D(LRSII)	D(RIR)	D(LREER)	D(LCPI)
CointEq1	-0.323111	-0.107909	-0.013753	-0.103128	19.39456	2.97E-05	-0.177909
	(0.14633)	(0.06927)	(0.18692)	(0.16377)	(11.2822)	(0.23909)	(0.10043)
	[-2.20811]	[-1.55781]	[-0.07357]	[-0.62970]	[1.71903]	[0.00012]	[-1.77156]
CointEq2	0.114153	-0.487957	-0.267999	-0.058605	-59.88002	0.954591	0.552830
	(0.28295)	(0.13394)	(0.36144)	(0.31668)	(21.8157)	(0.46231)	(0.19419)
	[0.40344]	[-3.64302]	[-0.74148]	[-0.18506]	[-2.74482]	[2.06484]	[2.84692]
CointEq3	-0.263712	0.003027	-0.084534	0.271854	-8.188103	0.121906	0.065212
	(0.19463)	(0.09214)	(0.24862)	(0.21784)	(15.0065)	(0.31801)	(0.13358)
	[-1.35492]	[0.03286]	[-0.34001]	[1.24798]	[-0.54564]	[0.38334]	[0.48820]
CointEq4	0.088029	0.267327	0.338787	-0.227844	21.29854	-0.641589	-0.250624
	(0.26853)	(0.12712)	(0.34302)	(0.30054)	(20.7042)	(0.43875)	(0.18429)
	[0.32782]	[2.10298]	[0.98766]	[-0.75811]	[1.02871]	[-1.46230]	[-1.35993]
D(LRPIV(-1))	-0.032083	0.111801	0.098180	0.123662	24.91353	-0.495921	-0.327124
	(0.34158)	(0.16170)	(0.43633)	(0.38230)	(26.3361)	(0.55810)	(0.23442)
	[-0.09393]	[0.69142]	[0.22501]	[0.32347]	[0.94598]	[-0.88858]	[-1.39544]
D(LRGDP(-1))	0.752067	0.244137	0.043899	0.166737	39.11430	0.147548	-0.422441
	(0.37124)	(0.17574)	(0.47422)	(0.41550)	(28.6233)	(0.60657)	(0.25478)
	[2.02582]	[1.38920]	[0.09257]	[0.40129]	[1.36652]	[0.24325]	[-1.65805]
D(LRPII(-1))	0.594078	0.017090	0.499451	0.000660	27.33133	0.044618	-0.284186
	(0.29967)	(0.14186)	(0.38279)	(0.33539)	(23.1048)	(0.48963)	(0.20566)
	[1.98246]	[0.12047]	[1.30475]	[0.00197]	[1.18293]	[0.09113]	[-1.38182]
D(LRSII(-1))	-0.133503	0.068999	-0.124727	0.293002	6.643594	-0.037559	0.029892
	(0.33361)	(0.15792)	(0.42615)	(0.37338)	(25.7216)	(0.54508)	(0.22895)
	[-0.40018]	[0.43691]	[-0.29268]	[0.78474]	[0.25829]	[-0.06891]	[0.13056]
D(RIR(-1))	-0.003486	-0.000625	-0.002525	-0.001762	-0.073643	-0.004166	0.001138
	(0.00224)	(0.00106)	(0.00286)	(0.00251)	(0.17268)	(0.00366)	(0.00154)
	[-1.55640]	[-0.58963]	[-0.88246]	[-0.70290]	[-0.42647]	[-1.13838]	[0.74015]
D(LREER(-1))	-0.279186	-0.146912	-0.298815	-0.152815	-6.863704	0.462741	0.047763
	(0.15658)	(0.07412)	(0.20002)	(0.17525)	(12.0730)	(0.25584)	(0.10746)
	[-1.78297]	[-1.98194]	[-1.49391]	[-0.87197]	[-0.56852]	[1.80868]	[0.44445]
D(LCPI(-1))	0.679120	0.518353	2.158247	1.930202	187.5447	-2.854807	-1.809066
	(1.05665)	(0.50021)	(1.34977)	(1.18262)	(81.4700)	(1.72647)	(0.72518)
	[0.64271]	[1.03628]	[1.59897]	[1.63213]	[2.30201]	[-1.65355]	[-2.49465]

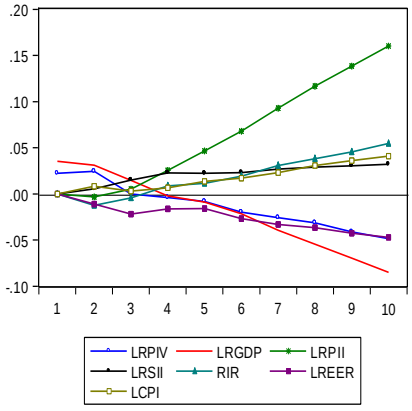
Note: *Standard errors in ( ) & t-statistics in [ ]*

Appendix 6: Impulse Response function of real private investment model

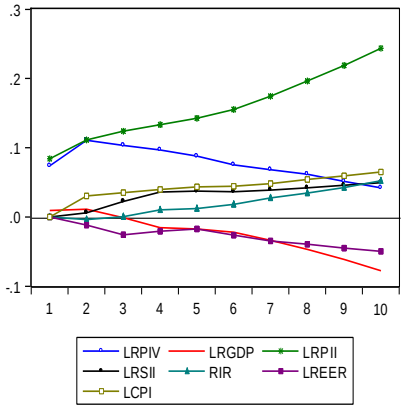
Response of LRPIV to Cholesky
One S.D. Innovations



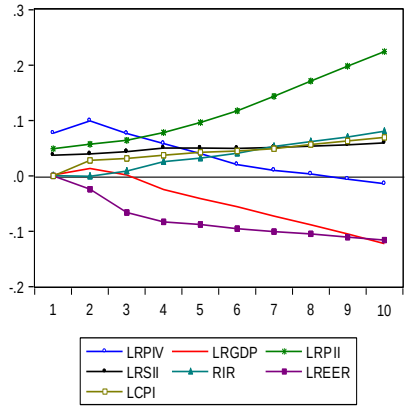
Response of LRGDP to Cholesky
One S.D. Innovations



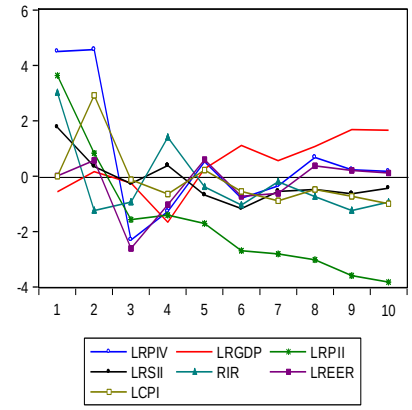
Response of LRPII to Cholesky
One S.D. Innovations



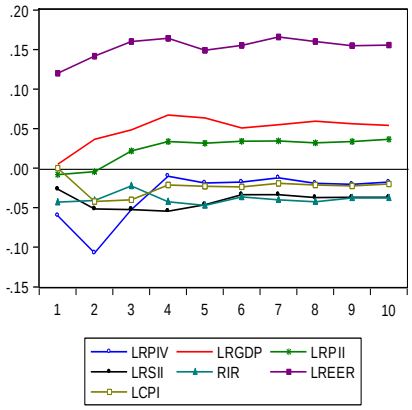
Response of LRSII to Cholesky
One S.D. Innovations



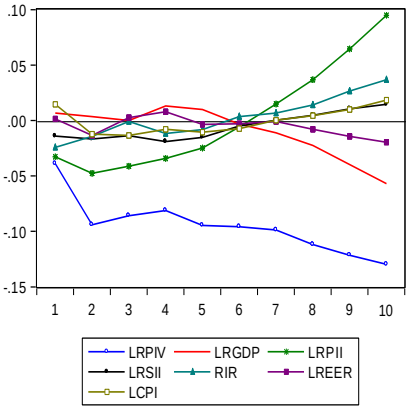
Response of RIR to Cholesky
One S.D. Innovations



Response of LREER to Cholesky
One S.D. Innovations



Response of LCPI to Cholesky
One S.D. Innovations



Appendix 7: Variance Decomposition Analysis of LRPIV

Period	S.E.	LRPIV	LRGDP	LRPII	LRSII	RIR	LREER	LCPI
1	0.087874	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.154898	87.11152	6.647081	0.782156	1.005430	2.474721	1.549287	0.429807
3	0.202686	80.13418	7.812126	3.145656	0.689473	3.018165	4.924724	0.275679
4	0.244017	77.72877	7.886524	5.935337	0.531244	3.069642	4.653893	0.194596
5	0.284566	73.48966	9.328753	9.194092	0.432229	3.742297	3.669325	0.143645
6	0.322644	68.50227	11.31945	12.33010	0.358386	4.246034	3.076026	0.167736
7	0.358747	65.08638	12.91501	14.39411	0.328858	4.397846	2.672231	0.205563
8	0.392321	62.75955	14.20489	15.55237	0.331296	4.551237	2.389109	0.211551
9	0.420852	61.12857	15.16316	16.18721	0.380716	4.661220	2.262834	0.216289
10	0.444127	60.32492	15.76963	16.31671	0.495598	4.659768	2.219415	0.213960
11	0.462979	60.12262	16.15313	16.02051	0.658197	4.612210	2.232211	0.201130
12	0.477681	60.25774	16.33805	15.47446	0.865408	4.528891	2.346473	0.188986
13	0.489059	60.58431	16.28417	14.83399	1.134282	4.403061	2.572085	0.188098
14	0.498459	60.85704	16.00897	14.29976	1.463744	4.256717	2.897411	0.216359
15	0.507277	60.75260	15.55318	14.11697	1.842495	4.110304	3.332875	0.291569
16	0.517166	59.96495	14.96497	14.52961	2.255622	3.985806	3.870179	0.428860
17	0.529822	58.25346	14.31827	15.73466	2.671634	3.906068	4.474001	0.641898
18	0.546648	55.50923	13.70343	17.81062	3.051240	3.887444	5.107799	0.930239
19	0.568702	51.81061	13.20742	20.67846	3.361514	3.939616	5.724484	1.277893
20	0.596530	47.42097	12.89020	24.11724	3.579880	4.057598	6.272999	1.661111
21	0.630096	42.70167	12.77151	27.82785	3.699409	4.224054	6.723930	2.051572
22	0.668917	38.00073	12.83637	31.52104	3.729653	4.419411	7.069170	2.423628
23	0.712178	33.58377	13.04656	34.97995	3.689497	4.624517	7.314417	2.761296
24	0.758855	29.60957	13.35556	38.07715	3.600162	4.823595	7.476671	3.057290
25	0.807857	26.14089	13.72118	40.76255	3.481086	5.007208	7.576691	3.310403
26	0.858124	23.17479	14.10978	43.04031	3.347613	5.170627	7.632990	3.523896
27	0.908669	20.67156	14.49679	44.94489	3.210577	5.312003	7.661123	3.703056
28	0.958622	18.57515	14.86612	46.52317	3.077097	5.431772	7.673292	3.853393
29	1.007248	16.82633	15.20811	47.82428	2.951500	5.531571	7.678087	3.980128
30	1.053947	15.36975	15.51742	48.89409	2.836106	5.613376	7.681392	4.087862
31	1.098250	14.15684	15.79176	49.77266	2.731929	5.679309	7.687160	4.180347
32	1.139817	13.14644	16.03079	50.49376	2.639161	5.731456	7.697792	4.260600
33	1.178423	12.30451	16.23536	51.08535	2.557487	5.771686	7.714595	4.331020
34	1.213947	11.60320	16.40701	51.57021	2.486305	5.801666	7.738160	4.393460
35	1.246363	11.01986	16.54774	51.96677	2.424865	5.822876	7.768543	4.449337
36	1.275720	10.53612	16.65980	52.28997	2.372352	5.836605	7.805424	4.499734
37	1.302133	10.13701	16.74551	52.55185	2.327936	5.843976	7.848242	4.545467
38	1.325768	9.810254	16.80732	52.76222	2.290807	5.845977	7.896280	4.587146
39	1.346830	9.545676	16.84763	52.92907	2.260189	5.843472	7.948724	4.625232
40	1.365548	9.334738	16.86887	53.05902	2.235356	5.837223	8.004720	4.660076

Appendix-8: Roots of Characteristic Polynomial of growth model

Roots of Characteristic Polynomial

Endogenous variables: LRGDP LRPIV LRPII LRSII LLAB LEXP

Lag specification: 1 1

Root	Modulus
1.000490	1.000490
1.000000	1.000000
1.000000 - 1.39e-15i	1.000000
1.000000 + 1.39e-15i	1.000000
0.730396 - 0.309705i	0.793344
0.730396 + 0.309705i	0.793344
0.383211 - 0.388061i	0.545383
0.383211 + 0.388061i	0.545383
-0.027223 - 0.487031i	0.487791
-0.027223 + 0.487031i	0.487791
-0.449177	0.449177
0.432853	0.432853

VEC specification imposes 3 unit root(s).

Appendix-9: Diagnostic Test Results of Real GDP model

Diagnostic Tests	Statistics		P-value
VEC Residual Serial Correlation LM Tests	Lags	Chi-sq	0.4964
	1	35.41173	
Jarque-Bera Normality test	Joint	21.96419	0.0379
VEC residual heteroskedasticity test	388.3554		0.3455

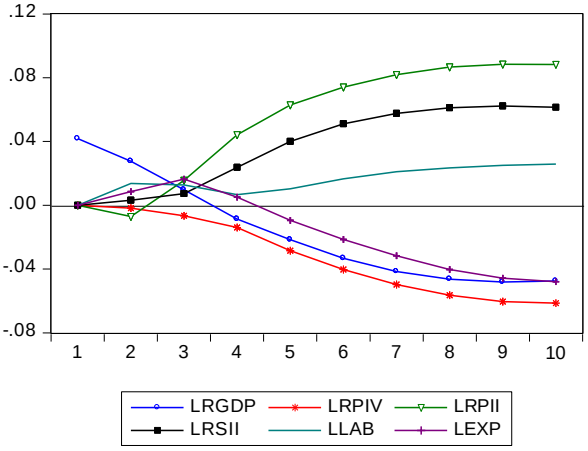
Appendix-10: The VECM result of Growth (Real GDP) Model

Error Correction:	D(LRGDP)	D(LRPIV)	D(LRPII)	D(LRSII)	D(LLAB)	D(LEXP)
CointEq1	-0.588939	-0.499072	-0.553881	-0.512096	0.001919	-0.080914
	(0.11297)	(0.21157)	(0.27714)	(0.22405)	(0.00592)	(0.68451)
	[-5.21321]	[-2.35895]	[-1.99853]	[-2.28559]	[0.32428]	[-0.11821]
CointEq2	-0.408715	-0.022603	-0.219676	-0.259899	0.007012	-1.222022
	(0.08867)	(0.16606)	(0.21753)	(0.17586)	(0.00465)	(0.53727)
	[-4.60940]	[-0.13612]	[-1.00987]	[-1.47788]	[1.50956]	[-2.27450]
CointEq3	0.199010	0.272708	0.239201	0.199184	0.001414	-0.363590
	(0.04627)	(0.08664)	(0.11350)	(0.09176)	(0.00242)	(0.28034)
	[4.30142]	[3.14742]	[2.10746]	[2.17071]	[0.58342]	[-1.29697]
D(LRGDP(-1))	0.292840	1.079482	0.443676	0.671527	0.001528	-0.352822
	(0.17198)	(0.32207)	(0.42190)	(0.34108)	(0.00901)	(1.04205)
	[1.70279]	[3.35170]	[1.05161]	[1.96882]	[0.16954]	[-0.33858]
D(LRPIV(-1))	0.296416	0.026352	-0.023535	-0.052401	-0.001148	1.547763
	(0.17601)	(0.32963)	(0.43180)	(0.34908)	(0.00922)	(1.06650)
	[1.68407]	[0.07995]	[-0.05450]	[-0.15011]	[-0.12453]	[1.45126]
D(LRPII(-1))	-0.363135	-0.403097	-0.133743	-0.549173	0.007557	-1.188224
	(0.12799)	(0.23970)	(0.31400)	(0.25385)	(0.00671)	(0.77554)
	[-2.83716]	[-1.68169]	[-0.42594]	[-2.16340]	[1.12704]	[-1.53213]
D(LRSII(-1))	0.113253	0.132631	0.378400	0.717702	-0.006816	0.976364
	(0.15703)	(0.29408)	(0.38524)	(0.31144)	(0.00823)	(0.95150)
	[0.72120]	[0.45100]	[0.98224]	[2.30443]	[-0.82856]	[1.02613]
D(LLAB(-1))	6.145079	16.62908	14.95108	23.22793	0.450082	10.97875
	(3.13589)	(5.87274)	(7.69310)	(6.21941)	(0.16429)	(19.0011)
	[1.95959]	[2.83157]	[1.94344]	[3.73475]	[2.73964]	[0.57780]
D(LEXP(-1))	-0.058883	-0.131208	-0.104652	-0.052102	-0.000795	0.220183
	(0.03381)	(0.06331)	(0.08294)	(0.06705)	(0.00177)	(0.20485)
	[-1.74171]	[-2.07236]	[-1.26180]	[-0.77706]	[-0.44894]	[1.07486]

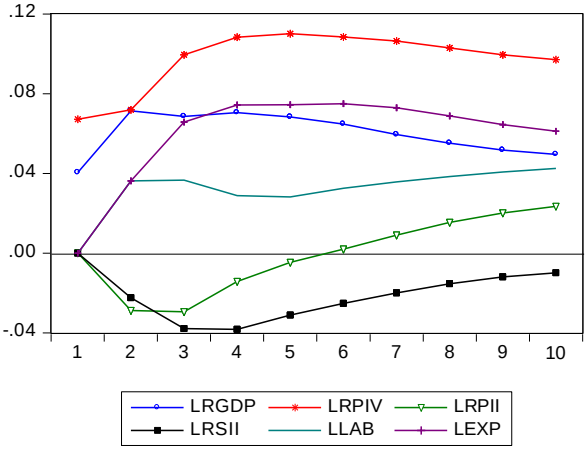
Note: *Standard errors in ( ) & t-statistics in [ ]*

Appendix 11: Impulse Response function of growth model

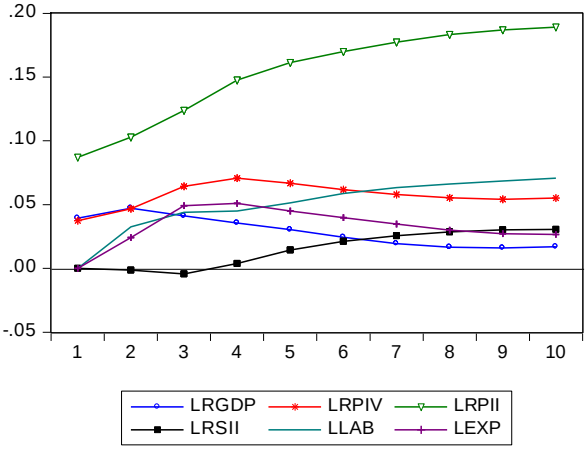
Response of LRGDP to Cholesky
One S.D. Innovations



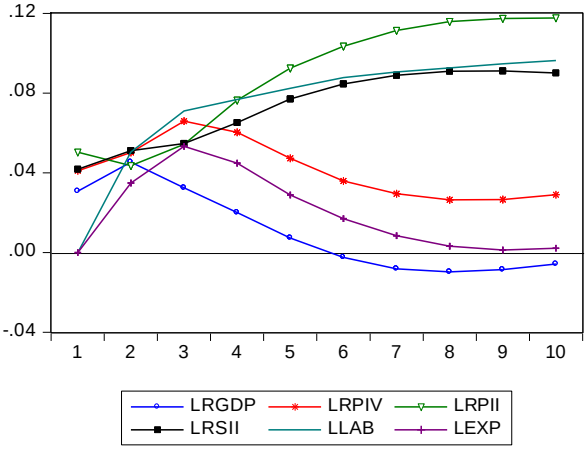
Response of LRPIV to Cholesky
One S.D. Innovations



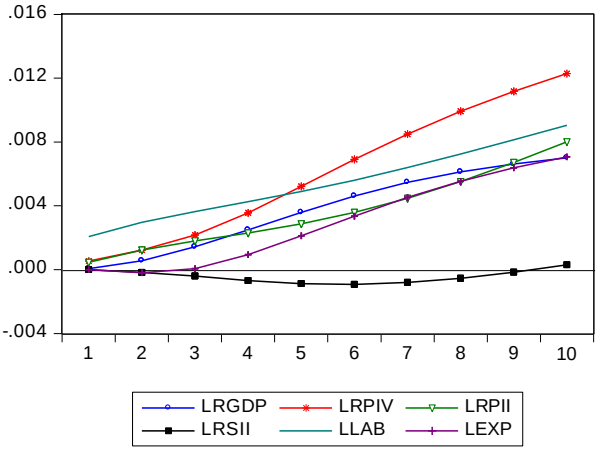
Response of LRPII to Cholesky
One S.D. Innovations



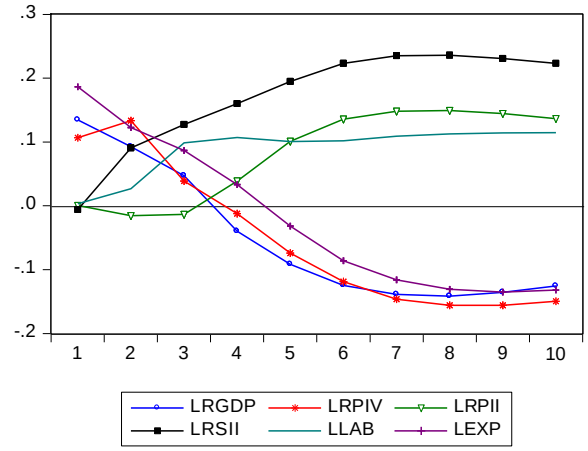
Response of LRSII to Cholesky
One S.D. Innovations



Response of LLAB to Cholesky
One S.D. Innovations



Response of LEXP to Cholesky
One S.D. Innovations



Appendix 12: Variance Decomposition Analysis of LRGDP

Period	S.E.	LRGDP	LRPIV	LRPII	LRSII	LLAB	LEXP
1	0.041843	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.053309	88.52363	0.107692	1.748705	0.358933	6.656166	2.604876
3	0.060835	70.48381	1.242440	7.897393	1.711446	9.444247	9.220668
4	0.081028	40.86051	3.677531	34.31589	9.562387	6.005393	5.578289
5	0.116640	23.13220	7.737789	45.67863	16.41421	3.681940	3.355223
6	0.158646	16.89752	10.63733	46.49089	19.24842	3.087518	3.638321
7	0.202121	14.64295	12.59807	45.08894	19.98224	2.981523	4.706282
8	0.244204	13.64902	13.97603	43.49423	19.96172	2.966451	5.952552
9	0.282870	13.06321	14.97699	42.19934	19.71098	2.992341	7.057138
10	0.317123	12.62900	15.65740	41.33068	19.43667	3.041142	7.905109
11	0.346911	12.25161	16.07676	40.85565	19.21383	3.105414	8.496735
12	0.372740	11.90242	16.29190	40.68878	19.06134	3.184340	8.871224
13	0.395369	11.57508	16.35175	40.74821	18.97277	3.277267	9.074924
14	0.415604	11.26869	16.29507	40.96749	18.93433	3.381718	9.152696
15	0.434170	10.98239	16.15320	41.29438	18.93220	3.495006	9.142830
16	0.451645	10.71506	15.95084	41.68915	18.95480	3.615023	9.075129
17	0.468451	10.46542	15.70704	42.12284	18.99303	3.740191	8.971479
18	0.484867	10.23197	15.43617	42.57523	19.04001	3.869303	8.847318
19	0.501053	10.01300	15.14878	43.03294	19.09081	4.001461	8.713007
20	0.517086	9.806632	14.85230	43.48802	19.14203	4.136034	8.574983
21	0.532984	9.610883	14.55159	43.93657	19.19160	4.272605	8.436749
22	0.548734	9.423854	14.24958	44.37746	19.23842	4.410922	8.299760
23	0.564313	9.243859	13.94785	44.81114	19.28210	4.550849	8.164203
24	0.579698	9.069518	13.64713	45.23877	19.32265	4.692317	8.029621
25	0.594877	8.899784	13.34771	45.66156	19.36029	4.835286	7.895370
26	0.609848	8.733915	13.04975	46.08046	19.39527	4.979708	7.760897
27	0.624620	8.571415	12.75339	46.49599	19.42783	5.125521	7.625856
28	0.639207	8.411967	12.45885	46.90830	19.45811	5.272640	7.490139
29	0.653632	8.255374	12.16642	47.31721	19.48621	5.420961	7.353829
30	0.667915	8.101509	11.87646	47.72238	19.51214	5.570368	7.217145
31	0.682079	7.950279	11.58935	48.12336	19.53590	5.720742	7.080371
32	0.696141	7.801609	11.30549	48.51969	19.55744	5.871962	6.943813
33	0.710119	7.655425	11.02521	48.91097	19.57672	6.023913	6.807757
34	0.724026	7.511655	10.74886	49.29683	19.59371	6.176487	6.672459
35	0.737873	7.370222	10.47670	49.67700	19.60837	6.329583	6.538126
36	0.751669	7.231056	10.20898	50.05125	19.62068	6.483107	6.404927
37	0.765422	7.094087	9.945888	50.41942	19.63063	6.636972	6.272994
38	0.779140	6.959253	9.687590	50.78139	19.63824	6.791093	6.142433
39	0.792828	6.826498	9.434218	51.13706	19.64351	6.945391	6.013327
40	0.806492	6.695776	9.185883	51.48635	19.64646	7.099789	5.885746

Appendix-13: Perpetual inventory method

In this paper, the capital stock series is constructed using the perpetual inventory method by assuming a depreciation rate of 5 percent and using the time series on physical and social public infrastructure investment, and private investment.

$$\boldsymbol{K_t = K_{t-1} + I_t - D_t}$$

$$\boldsymbol{K_t = K_{t-1} + I_t - \delta K_{t-1}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (\mathbf{1})$$

Where K_t is the total capital stock is in period t, K_{t-1} is the initial level of capital stock, δ is the rate of depreciation, and I_t is the total investment in period t. However, it is difficult to compute equation (1) because we don't know the value of $\boldsymbol{K_{t-1}}$(the initial capital stock). We get the initial capital stock through the following process of capital output ratio (ICOR):

$$\boldsymbol{ICOR = \frac{K_{t-1}}{Y_{t-1}}}$$

$$\boldsymbol{K_{t-1} = ICOR * Y_{t-1}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (\mathbf{2})$$

Where $\boldsymbol{Y_{t-1}}$ is the initial output level. Still we don't know about ICOR, to do this we use the concept of Harrod-Domar:

$$\boldsymbol{\frac{I_t/Y_t}{ICOR} = g + \delta}$$

Therefore,

$$\boldsymbol{ICOR = \frac{I_t/Y_t}{g + \delta}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (\mathbf{3})$$

Using equation (3) we can compute the initial level of capital, and once we have the initial level of capital we can generate the capital stock series by using perpetual inventory method, i.e. equation (1).[24]

[24] For further detail see Beddies (1999).