School of Graduate Studies

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Impact of Road Infrastructure Development for Economic Growth in Ethiopia

By

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A Master thesis submitted in partial fulfillment of the requirements for the award of the School of Graduate Studies Department of Economics Master of Science in Developmental Economics:

Declaration by Student

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Biography

I was born for my father Ato Assefa Fekadu and my mother W/ro Mulu Bekele in the Oromiya Regional Ethiopia at 1988 G.C. I was attended elementary school at Ziway Elementary School from 1993 to 2001, Junior and Comprehensive secondary school at Ziway senior secondary school from 2002 to 2005. In 2005, I was joined Gonder University and graduated in August 2008 with a Bachelor of Science Degree in statistics. After graduation, I was employed finance economic development and primary court office from 2009 to 2016 in Butajira town .In 2017; I had also worked in a rehabilitation project office for displaced farmers due to development in Addis Abeba. I was joined the school of graduate Studies at Wolikite University to continue his studies for the Master of Degree in Developmental Economics after taking six months remedial courses in developmental economics in June 2018.

Abstract

This paper examined impact of road infrastructure development on economic growth in Ethiopia. The general specification of the model is an augmented Solow Growth model. Such a model is basically a VAR. The logarithmic form of this production function of Solow growth model allows including road network and good values of export or import in national currency per total road length variables which impact for growth of GDP. Vector auto regressive model (VAR) *use analyzes the secondary data for the long run relationship between road infrastructure development and economic growth in Ethiopia. The study is making use of time series data for the period 1975 to 2017. The data used is from secondary data sources such as central statistics agency, World Bank, IMF, MOFED, and African Development Bank (ADB). The objective of the study is the impact of the road infrastructure development for economic in Ethiopia. The result shows that road infrastructure development for asphalt road, gravel road, road density per 1000 km^2 and export of goods values per total road length in national currency have a positive impact with economic growth in the long run. And also in the same result that total road length per 1000 persons (labour force) and importing goods values per total road length in national currency shows a negative impact on economic growth in the long run. Based on the findings, it was suggested that the government should come up with sustainable and implementable road infrastructure development for economic growth. Maintenance Road Sector Development Program (RSDP) that will ensure good access road network in Ethiopia. Also, economic growth in Ethiopia depended on the level of good and accessible road network is increasing transportation and facilitates for exporting goods (economic activity).*

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Acronyms

ACBF	African Capacity Building Foundation
ADB	African Development Bank
ADF	Dickey Fuller
ADI	Africa Development Indictors
AIC	Akaike Information Criterion
AU	African Union
CRS	Constant Returns Scale
CSA	Central Statistical Authority
ERA	Ethiopian Road Authority
EDRI	Ethiopian Development Research Institute
EGR	Ethiopia's Great Run
EPDRF	Ethiopia people democracy republic federation
EX	The values of export goods in national currency per total road
FPE	Final Prediction Error
GMM	Generalized Method of Moments
GTP	Growth and Transformation Plan
HQIC	Hannan-Quinn information criterion
IM	The values of Import goods in national currency per total road
NB	National Bank
NBE	National Back of Ethiopia
NDP	National Domestic Products
MOFED	Minster of financial Economic Development

PP	Philips-Perron
PSNP	Productive Safety Net Projects
RSDP	Road Sector Development Program
RA	Road asphalt
RDL	Road density per 1000 km^2
RDP	Road density per 1000 person
RG	Road gravel
SBIC	Schwarez's Bayesian information criterion
SSA	Sub-Sahara Africa
SVAR	Structural Vector Autoregressive model
SVAR	Using structural vector autoregressive
USD	Unit State Dollar
VAR	Vector Auto regression
VECM	Vector Error Correction Model

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

A Road transport is important sector of economic activity, especially in developing country, where it plays an essential role in marketing agricultural products. African governments have been addressing the low density and poor condition of their road networks. Sub-Saharan Africa's road network comprises strategic trading corridors of not more than 10,000 kilometers that carries about $200 billion of trade annually. (ACBF, 2016)

The road access rate is only 34 percent, compared with 50 percent in other parts of the developing world, while transport costs are 100 percent higher (AU, 2014). Road density in Ethiopia is among the lowest in Africa and other developing countries, with an estimated 21 km of road per 1000 square km and 1.25 km per 1000 population and the road network in Ethiopia consist of 116127 km of trunk, major link and regional roads (ERA, 2017)

A well-developed road transport sector in developing countries is assumed to fuel up the growth process through a variety of activities of the development endeavors of a nation. Among these, creation of market access opportunities for agricultural products is the major one. The issue of market access is more relevant for a country like Ethiopia where rural population accounts for about 85% of the national population who are engaged in production for both the domestic and international market. (ERA, 2017)

Moreover, road transport facilities play a role in both the production and consumption decisions of every household in their day-to-day activities. Besides, road transport facilities are essential for expanding education, health service provision, trade facilitation both within the country and the export or import market, and better public as well as private service provisions, including banking and insurance services, to the destitute and marginalized rural dweller. Likewise, roads serve as key infrastructural units, which provide linkages to other modes of transportation like railways, shipping, and airways. (ERA, 2017)

Thus, road infrastructure investment is important to study the trends in the levels and composition of government expenditures in the road transport sector, and assess the impact of these changes over time. It is even more important to analyze the contribution of such expenditure in the overall growth aspiration of the nation. The study is also provide important information for more efficient targeting and use of limited financial resources of the country in designing an efficient and effective road transport system and developing the road transport policy of the nation. Added to this, making such an investigation contributes to the stock of knowledge regarding the road transport sector. Moyaki (2015)

A previous study economic development reveals that many economists are of agreement that physical economic infrastructures are core for accelerating economic growth in any economy. Of these infrastructures, road infrastructure is crucial in increasing connectivity, reducing cost of production through reduced transport costs among others. Boopen (2006) asserts that provision of vital linkages between spatially separated facilities enables social contact and interaction possible as well as providing access to agricultural products, education, Health, and other services that brings about civilization. In addition, it is noteworthy that these efforts are not only geared towards construction of international trunk roads but also national, urban and the rural roads in efforts of increasing connectivity. (Moyaki, 2015)

In addition, the road transport sector is essential for developing countries for the reason that provision of other advanced means of transportation is expensive. For instance, Fan and Rao (2004), citing numerous studies, indicated that public spending in rural infrastructure is one of the most powerful instruments that governments can use to promote economic growth and poverty reduction and among these services road transport sector is considered as the crucial one.

In general, this paper reviews that impact of road infrastructure development for economic growth in Ethiopia. It also analyze the stock of achievements and the performance of the road network, the impacts of different types of road on the economic growth and identify the links that exist between road network developments and economic growth.

1.2 Problem Statement

The lack of sufficient and reliable road infrastructure services is said to be holding back private investment in the economy. The current study therefore seeks to investigate impact of road infrastructure development in influencing the growth of the Ethiopia economy. The study also attempts to investigate the stock of road transport in Ethiopia and its impact on economic growth. To this end, the study reviewed the scattered knowledge in the area and uses a number of tools in analyzing its impact on overall and sectoral economic growth. (Chogugudza et al, 201l)

Previous studies, for instance, Fan et al. (2002), Fan et al. (2000), Canninga et al. (2000), Canning et al. (2004) used the standard Cobb-Douglas type production function to analyze the impact of infrastructure on the overall GDP growth, which it is assumed to be a measure of overall economic growth. Fan et al. (2005) indicated that there is strong link between road development, economic growth, and poverty reduction. Dorosh et al. (2009) analyzed the importance of road connectivity to agricultural productivity and the impact of road network on sector GDP in Africa (Fan et al, 2004). The findings indicate that lower return from having high density is exhibited to be low for West Africa. Whereas, longer travel time decreases total crop production, and reducing travel time significantly increases adoption of high-input/high yield technology in East Africa. The findings showed the importance of increased road connectivity in East Africa. Data analysis is evident highly responsive to the government expenditure on the road infrastructure and increases GDP per capita in Kenya. (Moyaki, 2010)

A cording to Worku (2011) was finding that government expenditure patterns and have changed dramatically over the last few years in Ethiopia. Thus, he was also important to study the trends in the levels and composition of government expenditures in the road transport sector, and assess the impact of these changes over time. He is even more important to analyze the contribution of such expenditure government road network investment in the growth economic aspiration of the nation. The study was also provide important information for more efficient targeting and use of limited financial resources of the country in designing an efficient and effective road transport system and developing the road transport policy of the nation (EDRI, 2011).

Following the aforementioned studies is utilizing similar specifications to see road network class by Worku (2011). But, in this study paper is different to exam roads network infrastructure use methodology analysis, current empirical data, export and import goods value in national currency for total road length for economic growth in Ethiopia. In addition that the previous study was total road network has 2010/11 total road length 53997 km significant growth spurring impact. When the road network is, asphalt road length is 82995 km also has a positive sectoral impact, but gravel road length is 14136 km fail to significantly affect both overall and sectoral GDP growth, including agricultural GDP. In the current study the main gaps road network has 2010/17 gravel road length is 15373 km; asphalt road length is 14379 km including export good values per total road length in national currency also has a positive impact economic growth. But, total road length 116127 km including road density per 1000 person or lobar force and import goods value per total road length in national currency is negative impact in economic growth.

1.3 Research Questions

1) How does the stock road network affect the performance of economic in Ethiopia?
2) How does examine the impacts of different types of road network on the economic growth?
3) How does identify the links that exist of developments on the economic growth in Ethiopia?

1.4 Objectives of the study

The aim of the study is analyze the impact of the road infrastructure development for economic in Ethiopia. The study has following specific objectives:
1) To analyze the stock road network affect the performance of economic in Ethiopia,
2) To examine the impacts of different types of road network on the economic growth, and
3) To identify the links that exists of road network developments on the economic growth.

1.5 Significance of the study

Road transport network is importance for increasing connectivity, which in turn promotes regional trade, efficient resource allocation by increasing the mobility of agricultural and factors of production from the surplus areas to the deficit areas as well as the reduced cost of production.

In addition, this research paper was the data analysis efficient road network is importance for reducing poverty by increasing economic growth. With this insight, this study will be of importance in three folds: First, the study can be helpful in informing policy formulation and implementation with regard to investing in road infrastructure. This is because; it could be easier to justify the economic viability of investment in road infrastructure if the impacts of the road infrastructure on economic growth are certain. The mega projects in terms of construction of new roads, by passes as well as maintenance of the existing ones can be economically viable if their impacts are certain. Policies and decisions to do with gap financing where the project is economically viable, but fall short of financial viability thereby leading to private sector shying away from financing them. It can only be made if the economic contribute of road infrastructure projects are known in certainty.

Secondly, the study can be helpful in evaluation of the projects before financing it. Sometimes a difference in the financial viability and economic viability is crucial when it comes to the financing of mega infrastructural projects mainly by the development banks. Therefore, the study can shed some lights on the economic viability of road infrastructure in Ethiopia by giving an insight into the multiplier effects of investing in road infrastructure. Construction and maintenance of roads is not an easy investment. It requires a huge amount of expenditure with foreign currency.

Lastly, this huge amount of money is not affordable only by the government of Ethiopia from internal sources. Hence, the government of Ethiopia finances road construction and maintenance through loans and aid from other countries and organizations in addition to domestic finance. In recent periods, the lion share of finance is the government of Ethiopia followed by International

Development Association. The other following financers are European Union and African Development Bank. (Worku, 2011)

1.6 Scope and Limitations of the study

The study is found out impact of road infrastructure development and the economic growth rate over time in Ethiopia. Therefore, the study did not capture investment in other economic infrastructures that are core in economic growth. The period under review was 1975 -2017 thus enhancing the ability of the study to capture all the road infrastructure investment by different government regimes.

To analyze the stock of achievements in the road transport sector of Ethiopia, time series data are used for the econometric analysis. The major data source regarding most of road related variables is obtained from the Ethiopian Road Authority (ERA). Other relevant variables are collected from government authorities such as the Ministry of Finance and Economic Development (MOFED), and the Central Statistical Authority. In addition, whenever necessary, African Development Indicators and other relevant publications are also used in the data compilation process.

In order to achieve the stated objectives, various empirical methodologies are utilized. In analyzing the trends in the road transport sector over the last few decades, both descriptive statistics and econometric methods are employed. Time series analysis is used to investigate the impact in the road transport sector over the previous years on economic growth. Descriptive analysis is deployed to capture the link between the road transport sector and performance indicators, like road density, road network, road financing, and road accesses. The study also attempts to investigate the stock of road transport in Ethiopia and its impact on economic growth. To this end, the study reviewed the scattered knowledge in the area and uses a number of tools in analyzing its impact on economic growth.

The limitation of the study is that it is difficult to deal with the socio-economic impact of the sector. Analyzing the socio-economic impact requires a baseline survey on the status of the society before and after provision of road infrastructure. This task would require a significant

stock of data, time, and financial resource. It also requires a long-term plan, which is designed in parallel with a new road project intervention. Upcoming studies might deal with this issue to see its impact on socioeconomic development.

1.7 Organization of the study

The thesis is organized in six parts. The first part introduces the background of the study, problem statement, research questions, and objectives of the study, significance of the study, and scope and limitations of the study. Theoretical literature, empirical literature and conceptual framework are in the second part. The third part discusses road sector development program and economic growth in Ethiopia. The fourth part discusses methodology used to undertake this study. Results are Empirical Analysis and Findings in the fifths part. The last part presents conclusion and Recommendation.

CHAPTER TWO

LITERATURE REVIEW

2.1. Theoretical Literature

Growth theory in essence seeks to explain determinants of economic growth within a country and reasons for differences in growth rates and per capita incomes across countries. Central to growth theory is the use of the production function in establishing the determinants of growth of national output in an economy. The production function links the amount of output produced in an economy to the inputs of factors of production and state of technical knowledge. The standard neoclassical model states that the level of output depends on just two inputs, labor and capital, and on the available technology. The relationship is commonly specified as a Cobb-Douglas function, named after Charles Cobb and Paul Douglas.(Ethel Chogugudza et al, 2012)

$Q= f (AK, L)$ ---------- (1)

Where Q is the aggregate output, K is capital inputs, L is labour inputs and A denotes the state of technology or technological progress. The conventional neoclassical assumes technological progress is exogenously determined and the law diminishing returns holds When tested empirically, the Cobb-Douglas function yield estimates of the responsiveness of output to a variation in inputs. The relationship can be expressed as follows.

$Y = A f (K, L)$ ---------- (2)

The neoclassical growth model commonly known as the Solow growth model is an extension of the Harrod - Domar (1946) growth model which regard capital stock as the only factor of output production. Solow and Swan (1956) modified the Harrod - Domar Model to include labour as factor of production. The neoclassical model assumes capital is subject to diminishing returns to scale. Where output $Y(t)$ is produced from capital stock $K(t)$ and augmented labour $A(t)L(t)$, the neoclassical model can be summarized as follows.(Ethel Chogugudza et al., 2012)

$Y(t) = f [Kt^{\alpha} (AtLt)]^{\beta}$ ---------- (3)

Where $\alpha + \beta = 1$ depicting constant returns to scale.

According to the neoclassical growth model, in the short-run rate of economic growth is influenced by capital accumulation as determined by the saving and depreciation rates. In the long-run economic growth is exogenously determined by population growth rate and technological progress growth rate. An important prediction of this model is international convergence in output levels: as developing countries are assumed to grow faster than developed countries. Another prediction is that when capital is mobile, advanced economies should invest in developing countries where capital is scarce and the marginal returns to investment are high. (Ethel Chogugudza et al., 2012)

Given the neoclassical growth model notion that long run growth is influenced by technological progress and labour force growth due to population change, shocks in infrastructure stock can only have temporary effects on income in the model. The possibility of infrastructure influencing output in the long run rests on endogenous growth theory which allows increasing or decreasing returns to scale can raise the steady state income per capita. (Sahoo. et al., 2010)

The endogenous growth theory also known as the new growth theory came about as a result of the dissatisfaction with how the exogenous growth theory explained long run economic growth. The endogenous growth model developed by Romer (1986) and Lucas (1988) focused on the role of human capital as a main source of increasing returns and divergence in growth rates between developed and underdeveloped countries. The endogenous growth theory states that investment in human capital; innovation and knowledge are significant contributors to economic growth. In other words economic growth is mainly a result of endogenous and not external factors. The theory also emphasizes the importance of positive externalities and spillover effects as well as policy measures in determining economic growth in the long run (Ethel Chogugudza et al. (2012)).

The simplest endogenous growth model is a straightforward extension of the Solow model as is defined as follows.

$Y = AK^{\alpha}L^{\beta}$ ---------- [4]

Where Y is national output, K is composite measure of capital stock and A is a constant on assumption of constant returns to scale (CRS). The CRS replaces the assumption of diminishing returns to scale in neoclassical growth theory so that investment matters for long run growth and growth is endogenous. (Khaledet al, 2000) The new growth theory, such as the first model in Lucas (1988), endogenizes the technology factor as follows:

$A_t = BH^c 0 < c < 1$---------- [5

Where: H, is the level of human capital stock. If H increases by 1 percent, A, is assumed to increase by c percent. Supposing that labor input is allocated between physical output production and human capital production by *xL*, and (1- x)L, respectively. Then the production function of equation (4) can be re specified as

$Y = B [K^a H^c (x L)^b]$ ---------- *(6)*

In this model, endogenous growth is possible as long as there is continuous investment in human capital even if it keeps being accumulated. Model (6) introduces a critical assumption that there are no diminishing returns in the production of human capital. Endogenous growth model purports that the growth rate of the economy depends positively on the savings/investment rate. Therefore, any public policy measure that increases the savings rate accelerates economic growth permanently. The model implies divergence in international income. (Ethel Chogugudza et al, 2012)

If two economies start out with different initial stocks of capital, then the absolute gap gets larger as time proceeds. If two economies have different savings rates and hence different growth rate, the ratio of international income level explodes (collapses). Some of the early proponents of endogenous growth theory also include Kenneth Arrow (1962), HirohumiUzawa (1965), Miguel Sidrauki (1967), Paul M. Romer (1986), Robert Emerson Lucas (1988), Rebelo (1991) and En.Wikipedia.org/wiki/ Endogenous growth theory.

Conclusion that both endogenous and exogenous growth theories do not explicitly specify the impact of road infrastructure capital in the production process, whether it represent an additional input factor in the production function or influence the technology with which other inputs are combined. The impact of road infrastructure is implied on the premise of the underlying assumptions of the growth theories. The road of infrastructure investments features temporary

growth effects in the presence of diminishing returns to capital under exogenous theory, while under the endogenous theory they improve the efficiency of all other input factors and hence long-run productivity growth. (Ethel Chogugudza et al, 2012)

2.2 Empirical Literature

The review of the empirical studies is impact of road infrastructure development for economic growth. The evidences of research on the subject matter of this study are mixed across countries, time series data and methodologies, with some of the findings having positive impact, while others find little or no significant growth effect of road network investment for economic growth. Various estimation methodologies linking road network investment to economic growth using time series data and measures of road network expansion have been adopted over the years. However, the focus of previous studies has been to investigate the link between road infrastructure, which is an aggregated measure, and economic growth

The World Development Report noticed that as the economy develops, an increasing proportion of the country would need to open up by the construction of roads (World Bank, 1994). Work by Fernald (1999) provides evidence that increasing the road stock induces faster productivity growth in those industries that use more intensively, implying that the causation is more likely to be from infrastructure investment to output growth, rather than the other way around.

Previous studies based on Cobb-Douglas production function could not confirm the direction of causation between the development of the road network and economic growth. Sanchez-Robles (1998) also find a positive impact of road length and electricity generating capacity in explaining subsequent economic growth. The results obtained by Montolio and Solé-Ollé (2009) support the idea that productive public investment in road infrastructure has positively affected relative provincial productivity performance in Spain. Fan et al. (2002), Fan and Chan-Kang (2005), Canning and Bennathan (2000), Canning and Pedroni (2004) used the standard Cobb-Douglas type production function to analyze the impact of road network expansion on the overall GDP growth (economic growth).

The study also looks at the impact of road network on sectoral GDP. For instance, Dorosh et al. (2009) analyzed the importance of road connectivity to agricultural productivity in Africa. The findings indicate that lower return from having high density is exhibited to be low for West Africa. Whereas, longer travel time decreases total crop production, and reducing travel time

significantly increases adoption of high-input/high yield technology in East Africa. The findings showed the importance of increased road connectivity in East Africa.

Dercon et al. (2008) also used an analogous type of specification to see the impact of road and agricultural extension on growth and poverty reduction in a panel data set of selected fifteen Ethiopian villages. Fan and Chan-Kang (2005) indicated that there is strong link between road development, economic growth, and poverty reduction. Worku (2011) attempts the econometric analysis is based on time series data extending from 1971-2009. The Augmented Cobb-Douglas production function model is estimated using a two-step efficient generalized method of model (GMM) estimator. The findings reveal that the total road network has significant growth spurring impact. When the road network is disaggregated, asphalt road also has a positive sectorial impact, but gravel roads fail to significantly affect both overall and sectorial GDP growth, including agricultural GDP.

In conclusion, this study utilizes similar specifications to see the impact of roads on the overall economic growth. The general specification of the model is an augmented Solow Growth model. Such a model is basically a log transformation of the Cobb-Douglas production function. The logarithmic form of this production function of Solow growth model allows including any relevant variable which affects the growth of GDP. In addition, Fan and Chan-Kang (2005) indicated that different types of roads can create different economic return. Therefore, it is important for us to see the implication of road quality on the productivity.

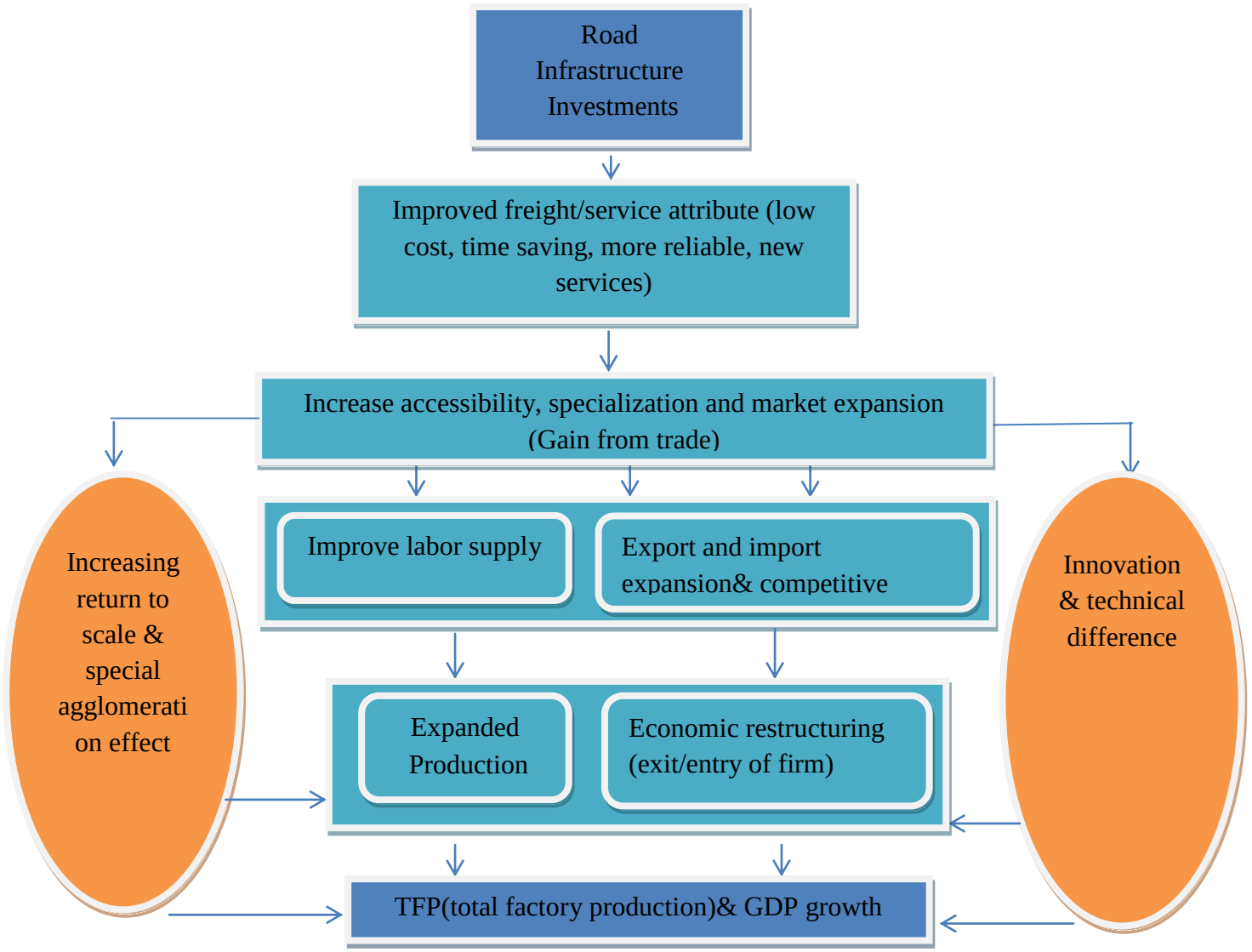
23. Conceptual Framework

This study is conducted impact of road infrastructure development for the economic growth in Ethiopia. The literature review shown that in Ethiopia and as in most of developing countries, decisions concerning road infrastructure investments are usually made to meet the utilitarian need to move people to urban areas, where the jobs and schools are often located, without any other formal plan to connect or measure the economic development benefits of those investments. (EDRI, 2011)

Akshmanan (2011) offered a different conceptual framework, shown in Figure 1, arguing that any road network investment lowers costs and increases accessibility due to the fact that transport improvements modify the marginal costs of transport producers, the households' mobility, exporting goods and demand for goods and services. Such changes ripple through the market mechanisms endogenizing employment, output and income in the short run.

According to Oberhelman (2015) transportation infrastructure investing is the backbone of a modern, competitive and productive economy. Specifically, interrelated and mutually reinforcing transportation infrastructure systems facilitate the efficient movement of goods and services, promote trade and commerce, connect supply chains, and reduce operating costs across a diverse set of industries.

Figure 2.1: Transport infrastructure and economy-wide benefits



Source: Lakshmanan, 2011

This conceptual framework is complex and addresses the multidimensional aspect of the relationship between transport, market expansion, development, and other factors that play key roles in understanding the economic growth that may be fueled by transportation investments.

CHAPTER THREE

ROAD SECTOR DEVELOMENT PROGRAM AND ECONOMIC GROWTH IN ETHIOPIA

3.1 Road Sector Development Program in Ethiopia

The starting point is the federal government's vision, which is to transform Ethiopia from a least developed country into a middle-income country by 2028, by sustaining the two digits economic growth registered in the recent years (2003–2010/11). Achieving this Government vision requires sustainable growth of the Ethiopian economy, which in turn depends on the development of infrastructure in general and expansion and improvement of the road network of the country in particular. (MOFED, 2011)

Since its commencement the Ethiopian Roads Authority (ERA) has administered the road sector. ERA was established in 1967 by proclamation No 256/67 to provide for the control and regulation of travel and transport on the road. The ERA is responsible for the use of all roads within Ethiopia, vehicles using these roads, and to all matters relating to road transport activities of the country. After the downfall of the military government, ERA restructured its obligations with a vision to ensure the provision of a modern, integrated, and safe road transport service to meet the needs of all the communities of a strong and unitary economic and political system in Ethiopia. (ERA, 2011)

When we look at the road network of the country over the past five decades, compared to the year 1951 the total road network has increased with factor seven to reach the level in 2009. In 1951 the total stock of road network was only 6400 km; in 2009 that is 46812 km (ERA 2009). The rise in the length of road is due to the emphasis given to the sector. In particular, the current government, the Federal Democratic Republic of Ethiopia, has placed increased emphasis on improving the quality and size of the road infrastructure. To address the constraints in the road

sector related to restricted road network coverage and low standards, the Government originally formulated a 10-year Road Sector Development Program in 1997. (RSDP, 1997-2017)

The first phase of the RSDP (1997-2002) focused on the restoration of the road network to an acceptable condition. Specifically, the program focused on (1) rehabilitation of main roads; (2) upgrading of main roads; (3) construction of new roads; and (4) regular maintenance on the network. Side by side, the program also considered major policy and institutional reforms.

The program was launched with a very significant donor support to create adequate capacity in the road sector and to facilitate the economic recovery process through the restoration of essential road network. The first five year of the program (RSDP I), 2005- 2010, was officially launched in September 2005, and has been completed in June 2010. Accomplishment under RSDP II is rather encouraging. The total disbursement rate of investment on federal and regional roads for the 5 years of RSDP II is about 125% and 73%, respectively, whilst the corresponding physical accomplishment is 134% and 145% of the planned. Within the ten years period of the program, the total disbursement of projects planned for the execution amount 25.4 billion Birr (US$ 2.9 billion). This would enhance the integration of domestic markets and the potential growth of exports in terms of volume and international competitiveness (ERA, 2014). Having looked at policies road sector policies, hereafter achievements and constraints of the sector are described.

3.1.1 Road network

The government of Ethiopia has been engaged in investment of infrastructure development to sustain economic growth, improving product competitiveness and encourage private investors. In particular, the government noted that, the development of road transport creates a network over a wide array of infrastructural facilities so as to improve the accessibility and mobility of agricultural and industrial products. As a result, the road transport in Ethiopia has been the dominant mode of economy.

One possible cause for the negative growth in gravel roads would be the fact that community roads, which could be considered as part of gravel road, are being constructed with Productive Safety Net Projects (PSNP). This type of road is not counted or included as gravel road for the very reason that it fails to meet the standard set by the Ethiopian Roads Authority (ERA). In addition, either the federal or regional road authorities do not administer this type of road. Another cause may be the fall in expenditure for maintenance and reconstruction, mainly over the period 2003 and 2005.

In 1951 the total stock of road network was only 6400 km of which 3400 km was asphalt and the remaining 3000 km was gravel road. This entire network was found only in urban areas. When the Imperial regime lost power, the network has reached to 9160 km in 1973. On average, the network has been growing at a rate of 2.05 percent per annum over the period 1951-1973. During the Derg regime, 1974-1991, the stock road increased to 19017 km with a growth rate of 6.2 percent per annum. With the current EPRDF regime, the road network has reached 110,595 km in 2017 with an average annual growth rate of 1.79 percent. Over the period 2008 to 2017, 63783 km of new road network was constructed. (RSDP, 1997-2017)

During the fiscal year 2012/13, the total stock of road network reached 85,966km of which 25,756 km Federal1, 32,582km rural road and 27,628 are woreda road. The Federal road includes11, 301 km (43.9 percent) asphalt and 14,455 km (56.1 percent) gravel road, showed annual expansion of 14.4percent and reduction of 1.5 percent, respectively. The asphalt road network in 2012/13 constituted about 13.1 percent of the total stock of road network in the country.

As shows in table 3.1 shows the road network length in Ethiopia by type. Though there was an increase in the length of roads between 1974 and 1989, it was somewhat constant in the years 1989 to 1991. After, the takeover of EPDRF the government has invested much in construction of asphalt roads. Especially after 2001 there is a significant growth in asphalt road length. However, there is a negative growth in gravel road length. This happened in the recent years like 2003, 2005 and the last two years

Table 3.1: Classification of road network (length in km)

	Year	Asphalt	Growth Asphalt	Gravel	Gravel Growth	Rural	Urban	Total	Growth
1	1974/75	3280		6080			9360	9360	1.08
2	1975/76	3200	-2.5	6200	1.97	120	9400	9520	1.709
3	1976/77	3126	-2.36	6290	1.45	652	9416	10068	5.756
4	1977/78	3051	-2.45	6801	8.12	790	9852	10642	5.701
5	1978/79	3115	2.1	7328	7.75	1091	10443	11534	8.382
6	1979/80	3285	5.46	7328	0	1595	10613	12208	5.844
7	1980/81	3515	7	7430	1.39	1830	10945	12775	4.644
8	1981/82	3769	7.23	8532	14.83	2630	12301	14931	16.877
9	1982/83	3916	3.9	8532	0	3053	12448	15501	3.818
10	1983/84	4000	2.15	8738	2.41	3420	12738	16158	4.238
11	1984/85	4042	1.05	8788	0.57	3808	12830	16638	2.971
12	1985/86	4050	0.2	8989	2.29	4198	13039	17237	3.6
13	1986/87	4062	0.3	8994	0.06	5158	13056	18214	5.668
14	1987/88	4109	1.16	9270	3.07	5232	13379	18611	2.18
15	1988/89	4109	0	9270	0	5232	13379	18611	0
16	1989/90	4109	0	9287	0.18	5550	13396	18946	1.8
17	1990/91	4109	0	9298	0.12	5610	13407	19017	0.375
18	1991/92	3542	-13.8	8966	-3.57	5573	12508	18081	-4.922
19	1992/93	3555	0.37	9011	0.5	5800	12566	18366	1.576
20	1993/94	3622	1.88	10100	12.09	7812	13722	21534	17.249
21	1994/95	3630	0.22	12000	18.81	8043	15630	23673	9.933
22	1995/96	3656	0.72	12133	1.11	9100	15789	24889	5.137
23	1996/97	3708	1.42	12162	0.24	10680	15870	26550	6.674
24	1997/98	3760	1.4	12240	0.64	11737	16000	27737	4.471
25	1998/99	3812	1.38	12250	0.08	12600	16062	28662	3.335
26	1999/00	3824	0.31	12250	0	15480	16074	31554	10.09

	Year	Asphalt	Growth Asphalt	Gravel	Gravel Growth	Rural	Urban	Total	Growth
27	2000/01	3924	2.62	12467	1.77	16480	16391	32871	4.174
28	2001/02	4053	3.29	12564	0.78	16680	16617	33297	1.296
29	2002/03	4362	7.62	12340	-1.78	17154	16702	33856	1.679
30	2003/04	4635	6.26	13905	12.68	17956	18540	36496	7.798
31	2004/05	4972	7.27	13640	-1.91	18406	18612	37018	1.43
32	2005/06	5002	0.6	14311	4.92	20164	19313	39477	6.643
33	2006/07	5452	9	14628	2.22	22349	20080	42429	7.478
34	2007/08	6066	11.26	14363	-1.81	23930	20429	44359	4.549
35	2008/09	6938	14.38	14234	-0.9	25640	21172	46812	5.53
36	2009/10	7476	7.19	14373	0.97	26944	21849	48793	4.06
37	2010/11	8295	9.87	14136	-1.67	31566	22431	53997	9.67
38	2011/12	9875	16	14675	3.67	38533	24550	63083	14.40
39	2012/13	11301	12.61	14455	-1.52	60210	25756	85966	26.62
40	2013/14	12,640	10.59	14,217	-1.67	72,665	26,857	99,522	13.62
41	2014/15	13,551	6.72	14,055	-1.15	77,451	27,606	105,057	5.26
42	1915/16	14,462	6.29	14,217	1.14	81,913	28,679	110,592	5.00
43	1916/17	15,373	5.92	14,379	1.13	86,375	29,752	116,127	4.77

Source: Note Based on ERA, NBE and World Bank development indicators database, 2017.

According to the government recognition of the importance of the road sector for national economic growth and for profiting to a maximum from the country's assets, the RSDP was launched in 1997 and during its first five years, the intention is to maintain, rehabilitate and upgrade the main trunk roads, link roads and regional roads. It is estimated that more than half of Ethiopia's produce is transported by pack animals, reflecting the inadequacy of the country's road network. In 1951 the total stock of road network was only 6400 km of which 3400 km was asphalt and the remaining 3000 km was gravel road. (ERA, 2014)

Consequently, in 2016/17, total stock of road network reached 116,127Km, showing a 4.7 percent annual expansion. Of the total roads, 28,032 Km (24.8 %) was Federal1, 31,620 Km (28 %) rural, 5,357 Km (4.7 %) urban and 48,057 Km (42.5 %) is Woreda’s road. The Federal

road included 14,632 Km (52.2 %) asphalt and 13,400 Km (47.8 %) gravel road which depicted 8 percent annual expansion and 4.7 percent reduction, respectively. (NBE, 2017)

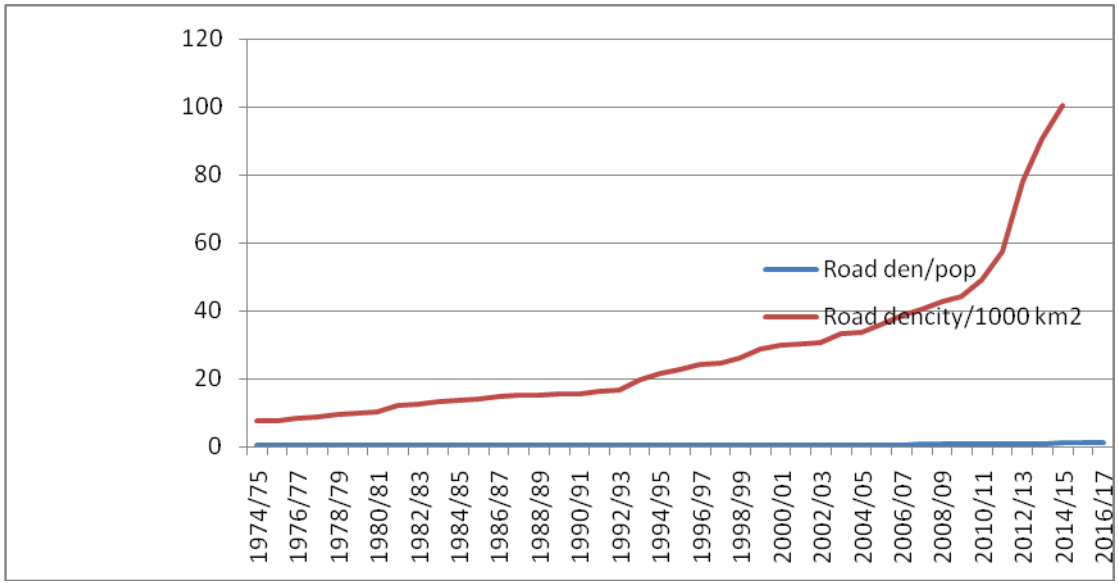
3.1.2 Road Density

The proper level of road network is assessed by road density, which is measured by road length per 1000 persons or by road length per 1000 km2. In the three RSDP periods, there was a plan to increase the road density form 0.46 to 24.1 km per 1000 persons and from 1.25 to 120.2 km per 1000 persons starting 1997 through 2017. At the end of the first phase the road density has increased achieving the target of the government. In 2002 the road density was exactly at the aimed level, which is 0.49 km road density per 1000 persons whereas the road length per 1000 km2 is more than the target level by 30.3 km per 1000 km2. (EDRI, 2011)

When the second phase of RSDP continued, the government has also targeted for higher levels, i.e. targeted road density of 0.5 km per 1000 persons and 30 km per 1000 square km. At the end of RSDP II, road density has reached 0.55 km per 1000 persons and 38.6 km per 1000 km2 in the year 2007. (RSDP, 2007)

In the five year GTP period, the plan is to increase the road density from 44.5 Km to 123.7 km per 1,000 persons and from 0.64 Km to 1.54 km per 1000 km2. At the end of 2012/13, the road density per 1,000 square Km showed improvement to 78.2 km from 57.3 km a year ago; though GTP target is 89.3 for the year 2012/13. The road density per 1,000 populations in 2016/17 was 1 km and up by 120.2 percent from 1.25 Km in the preceding fiscal year (Figures: 3.1).

Figures: 3.1 Road densities per 1000 persons and per 1000 km2



Source: Ethiopian Road Authority

However, the targeted figures 3.2 were a bit high for the third phase, which could not be attained at the end of the period. This phase is the shortest period, which lasted only for two years. Road density of Ethiopia has reached 0.57 km per 1000 persons and 42.6 km per 1000 km2, where 1.5 km per population and 116 km per 1000 km2 were the targeted ones. Although road density has increased, it has not improved that much as planned. At the year 2017, the road density is still much below the average road density of Africa, that is, 120.2 km per 1000 km2. (EDRI, 2017)

3.1.3. Road Accessibility

Access refers to the opportunity to use or the right to or the ability to reach some destiny. Accessibility is measured as the percentage of population having access to all weather roads. The benefits of having access to a road network is measured in terms of reductions in monetary costs or time needed by beneficiaries to access output markets or key public social services like health and education. (EDRI, 2017)

The accepted theory, according to ERA"s (2008b) study, is that accessibility has three elements: 1) the location of the individual; 2) the location of the supply, service, or facility to which the individual needs access; 3) the link to bring the two together. The study used three approaches, namely, the random model approach, the graph theory approach, and the squire grid approach to cover the country's network demand. This demand was estimated as such that all rural population could have access to all weather roads within a 5 km distance. (EDRI, 2008)

According to the ERA study the country is required to construct 200,000 km of optimum national road network, which is considered as a target road network on the assumption that it will give reasonably good accessibility. Whereas, for the country to be competitive enough and enter into middle income category, the targeted road density which secures the rural population to have access to all weather road is estimated to be 0.3 km/km2, the average road density of the lower middle countries. In this case the road transport network has to reach 330,000 km.

The same study defined the concept measured in terms of average distance from the road network and proportion of area farther than 5 km from all-weather roads as lack of access, which deprives people from the opportunities to improve their lives. Access is composed of two elements: mobility, reflecting the ease or difficulty in traveling to a service or facility; and proximity of those services and facilities. The study considered access to be one key element in providing the opportunity for both social and economic development, and a key determinant of both poverty itself and opportunities to escape from the poverty trap.

All-weather road grew by 3.3 percent per annum constituting 38 percent or 32,582 km of the total road network in 2012/13. Besides, the annual average distance from all-weather roads declined by 31 percent from 8.7 kilometers to 6 kilometers. Similarly, the proportion of area more than 5 km from all-weather roads went down to 46 percent in 2012/13 from 56.4 percent in 2011/12, though the growth and transformation plan for 2012/13 was 40.9 percent. About 70 percent of the total road network in the country is found in good condition. This indicates 6 percentage points improvement over the preceding year 2011/12. Unlike the other road types, the highest proportion of asphalt road which constitutes 74 percent was in a good condition.

Moreover, there has been slight improvement in gravel road from 57 to 58 percent. While rural roads status declined from 57 to 54 percent (Table 3.2).

When we look at the recent trend regarding society's access to the all-weather road network, we find a slight improvement over the past seven years. However, in 2016 only about 35.8 % of the rural population has access to an all-weather road within a distance of 5 km. Given the fact that around 80 million people are living in rural area, such a low rate exacerbates the problem of poverty. Improving the current access rate should be a major concern of the country's road sector expansion program.

Similarly, African Development Indicators (ADI) (2008/09) data indicates that the country has made an effort to provide access to all weather roads, though it is not satisfactory. The graph below depicts that the problem of accessibility is resolved only very sluggishly. Within a period of seven years (2002 to 2016), an additional seven percent of the rural population is provided with access to all weather roads (from 26% to 35.8% of the rural population).

The expansion of rural road infrastructure helps the physically isolated people to have an access to service centers and minimize long distance traveling to reach the main roads to get transportation services. Road condition indicators prove the overall road improvement in the country. In 2015/16, average distance from all-weather roads declined from 5 km to 4.9 kilometers and the proportion of area more than 5km from all-weather roads went down to 35.8 percent from 36.6 percent a year ago.

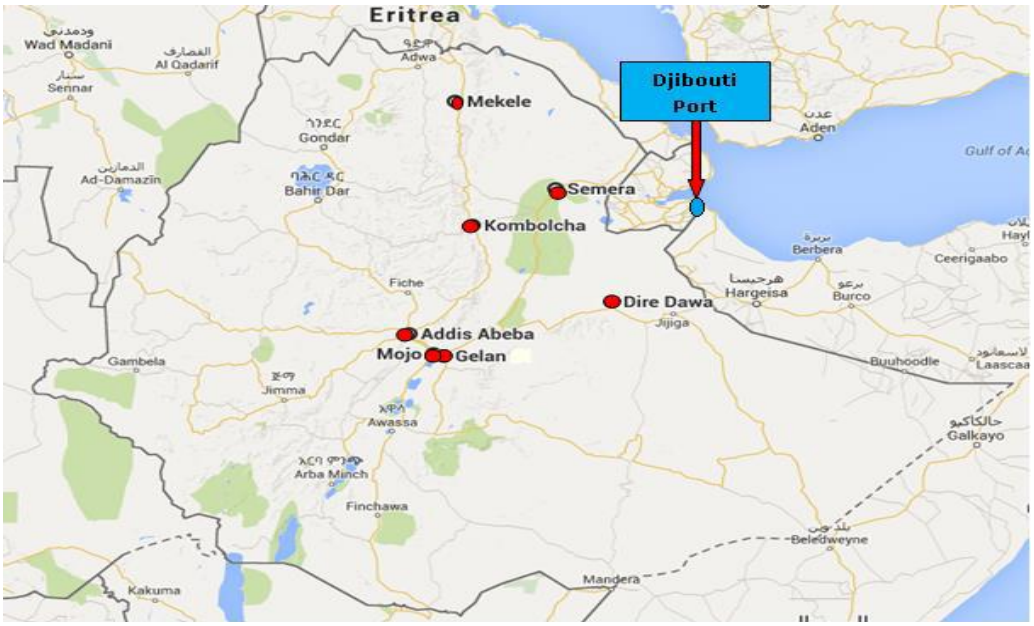
Table 3.2 Road Accessibility

Indicator	2014/15	2015/16	Percentage change
Proportion of area more than 5Km from all-weather road	36.6%	35.8%	-2.2%
Average distance from all-weather roads	5 km	4.9 km	-2.0%

Source: Ethiopian Roads Authority

The Ethiopian Dry Port Service Enterprise is established in 1999 E.C as a public enterprise supervised by Ministry of Transport. It is established for the purpose of operating dry ports and to provide services like: loading and unloading and storage of imported and exported goods, storing and unpacking or containerized exports and imported goods, and to provide container depot services. Currently there are 7 dry ports in the country handling imported cargoes (see Figure 2). (Minister of transportation, 2015)

Figure 3.2: Location of the Dry ports in Ethiopia



Road network plays a significant role in the transit transport. For which, Ethiopia has concluded Road Transport Agreements with Djibouti and Sudan. The transit transport system between Ethiopia and its transit countries, in particular Djibouti, is unit-modal transport. This transport system makes Ethiopian importers to receive their imported goods at the port of Djibouti through their agents and Ethiopian Exporters to send their cargoes to the port of Djibouti for being stuffed in containers at Djibouti Port. Thus, the port of Djibouti is not only used as a getaway to Ethiopian transit cargoes, but also as a point of destination. Currently containerization of the world trade is in the order of the day; just in time delivery of goods is

the basis to satisfy customers; and hence the arrangement of multimodal transport is a recommended option. (Anbalagan et al, 2014)

3.1.4 Region road network

According to the ERA (20016) study, community roads are being developed in different woreda. The roads are being constructed as part of the Productive Safety Net Project (PSNP). Table 3.3 Depicts that 28,032 km of regions roads network were constructed Paved Unpaved and in the period under the "food for work" scheme. Within this food for work, substantial amounts of community roads are being maintained and constructed in all the regions.

Table 3.3 Existing stock of Regions roads network (2016)

It. No	Region	Road Count	Surface Type		Total length
			Paved	Unpaved	
1	Afar	35	1,538	364	1,902
2	Amhara	132	3,314	3,039	6,353
3	Benishangul	12	243	464	707
4	Diredawa	4	27	18	45
5	Gambela	9	170	351	521
6	Oromia	166	4,334	4,697	9,031
7	Somali	25	798	1,754	2,552
8	South	88	2,074	2,254	4,328
9	Tigray	38	2,098	449	2,547
10	Harar	4	37	10	47
Total		513	14,632	13,400	28,032

Source; Ethiopian Roads Authority, 2016

As per the same study, it shows that regions roads network are not well accounted and managed by either the federal or regional road administration. In this regard the study clearly cites the

problem as follows: However, it's worth noting that, for these community roads their design standard, location, condition, ownership and for that matter their existence is not known in1qwthe form of a national database. Further, the issue of how sustainable (in terms of both financially and administratively) these community roads are with respect to development and maintenance is unclear – as there is no institution that finances the maintenance costs of these rural/community roads and nobody is accountable to them institutionally both at the federal and regional levels. The mileage of community roads will continue to grow rapidly and the needed maintenance costs for rural/community roads alone would become substantial. (EDRI, 2016)

Community road development and its sustained maintenance is a key point in ensuring the accessibility/mobility of the rural poor and to connect them to the improved federal and regional road network. Hence, an in-depth assessment of the status of the community road development program and the future development and maintenance strategy is recognized as an urgent task.

The Ethiopian Dry Port Service Enterprise is established in 1999 E.C as a public enterprise supervised by Ministry of Transport. It is established for the purpose of operating dry ports and to provide services like: loading and unloading and storage of imported and exported goods, storing and unpacking or containerized exports and imported goods, and to provide container depot services. Currently there are 7 dry ports in the country handling imported cargoes (see Figure 3.2). (Minister of transportation, 2015)

3.1.5. Road Sector Financing

Construction and maintenance of roads remained among the key investment for the government in the past years. Hence, large sum of finance has been mobilized for road construction and maintenance from extern alones and grants as well as domestic sources.

The cumulative investment capital in the road construction and expansion sector had rose by 17.6 to 33.7 billion from Br 28.6billion a year earlier. Investment in the Federal road construction and expansion also reached Br 22.7 billion usually making up the lion's share (67.2 percent) of the total road investment capital.

The higher percentage change of investment registered 50.4 and 44.8 for regional road and community road respectively; federal road also rose by 7.6 percent vis-à-vis2011/12 fiscal year, while investment in urban road declined by 12.1 percent (Table1.9).Figure 1.5 depicts that investment capital in the road construction and expansion has showed an increasing trend over the past eight years and reached Birr 33.7 billion in 2012/13.

Table 3.4: Investments in the Road Sector (In million Birr)

Road type	2011/12		2012/13		Percentage Change
	A	Share (in %)	B	Share (in %)	
Federal roads	21,023.7	73.5	22,615.5	67.2	7.6
Regional road	1,506.9	5.3	2,266.9	6.7	50.4
Woreda road	6,027.2	21.1	8,725.1	25.9	44.8
Urban road*	58.5	0.2	51.4	0.2	-12.1
Total	28,616.3	100.0	33,658.9	100.0	17.6

Source: Ethiopian Road Authority

* All municipalities' maintenance

3.2 THE OVERALL ECONOMIC PERFORMANCE IN ETHIOPIA

3.2.1 Economic Growth in Ethiopia

The Ethiopian economy continued to grow and the overall economic performance reflected the rapid expansion of the country. Real GDP continued to grow on average by 10.9 percent in the past decade (2003/04-2012/13). During the 2012/13, the real GDP revealed a remarkable growth of 9.7 percent compared to the5.6 percent forecast for sub-Saharan Africa countries for 2013. The growth was mainly contributed by the service sector (46.1 percent), agricultural sector (31.2 percent) and industrial sector (23.8 percent). Nominal GDP per capita went up to USD 550 from

USD 510 in the preceding year, registering a 7.8 percent increase. Real per capita GDP increased by 1.6percent to USD 359 against the preceding year. The Ethiopian economy projected to grow by 11.2 percent in 2013/14 (MoFED, 2005) compared with the 6.1 percent forecast for sub-Saharan Africa countries and its robust growth will continued as it was observed in the past ten years. The inflation level is also expected to be contained in a single digit level. (Annual Report, 2012/13)

Ethiopian economy which had exhibited9.8 percent average annual growth during 2010/11-2015/16, registered 8 percent growth in 2015/16 despite challenging macroeconomic and weather conditions. The 8 percent real GDP growth was 3.2 percentage point lower than base case scenario GTPII target set for the fiscal year. (NBE, 2016) Although it was significantly higher than 1.6 percent average growth estimated for Sub - Saharan Africa. (MoFED, 2016)The growth in real GDP was mainly attributed to 8.7 percent growth in services, 2.3 percent in agriculture and 20.6 percent in industrial sectors. (Table 3.5)

Table 3.5: Sectorial Contributions to GDP and GDP Growth (In Billions of Birr)

Item		2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Sector	Agriculture	144.8	158.5	170.3	181.2	195	2.12.5	222.9	238.8	251.8	267.8	274.0
	Industry	29.3	32.1	35.4	38.8	43.0	49.8	59.6	73.9	86.5	103.7	125.0
	Services	106.9	123.3	143.1	163.1	163.2	216.6	237.4	258.8	292.5	325.0	353.0
Total		278.5	311.3	346.7	381.7	421.8	478.9	519.5	571.7	630.3	696.5	752.0
Growth in RGDP		277.0	309.7	344.3	378.9	418.9	11.4	8.7	9.9	10.3	10.4	8.0

Source: Ministry of Finance and Economic Development (MoFED)

3.2.2 GDP by Sector in Ethiopia

The share of agriculture to Ethiopian economy during the 2012/13 was 42.7 percent. The sector contributed 31.2 percent to GDP growth rate and grew by 7.1 percent in comparison with the 4.9 percent growth recorded in the preceding year. This was due to a high increase in crop production which improved from 5 percent to 8.2 percent as compared to previous year

performance and contributing about 26percent to GDP growth and 80 percent to agriculture growth.

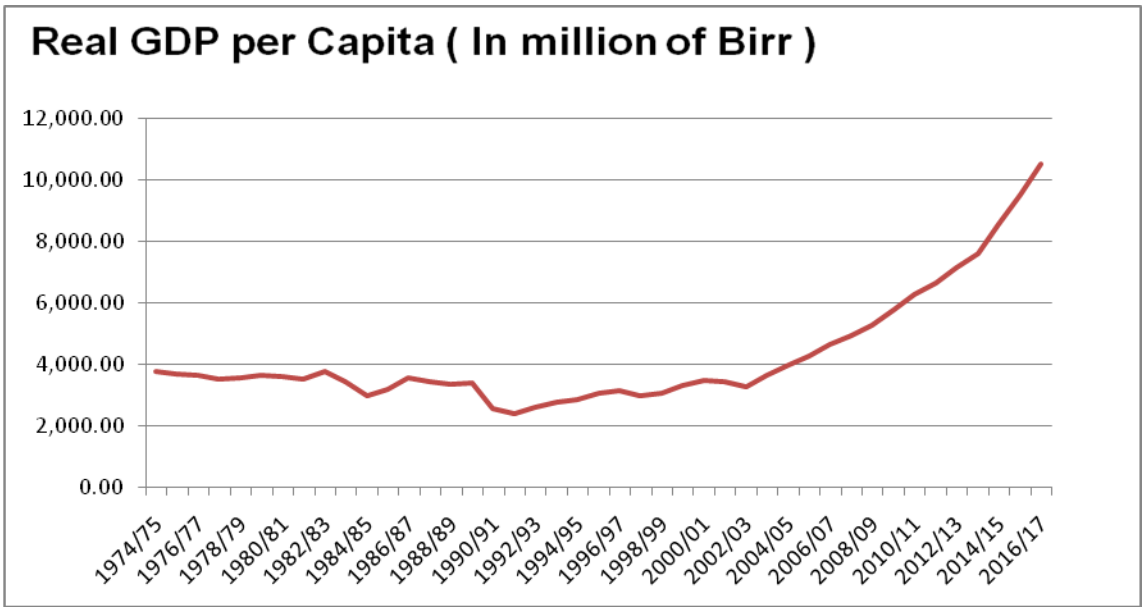
The growth in agricultural output was mainly attributed to productivity improvements supported by favorable conditions and conductively agricultural development policies. In 2012/13, the total cultivated land area was expanded by 1.6 percent to 12.3 million hectares. As a result, the total agricultural crop production was enhanced by 5.8 percent and reached 231.3 million quintals. Productivity was improved slightly to 18.8 quintal per hectare compared to 18.1 quintal per hectare in the preceding year. Cereal production accounted for 85 percent of the total crop production during the period. Pulse production was increased by18.8 percent as cultivated land area increased by 15.3 while oil seeds reflected a moderate decline of the total crop production by 0.6 percent, as cultivated land area declined by 0.7 percent for the year 20112/13.

Similarly, the industrial sector had achieved 18.5 percent growth show again improvement of 1.5 percentage points against the preceding year. The sector had contributed 23.6 percent to the overall economic growth. Manufacturing contributed about 21percent to industrial output growth and4.6 percent to real GDP growth during the period.

The construction sector of the industry contributed 15 percent to GDP growth and 68 percent to industrial sector growth; implying that currently it is sector is currently the leading subcomponents in the industry due to expansion in the construction of roads, dams and housing infrastructures. Manufacturing output grew by 10.8 percent in 2012/13.

On the other hand, the service sector was relatively the dominant economy in Ethiopia. The share of service sector was about 45 percent of the overall economy representing a principal contribution of about 46.1 percent to the GDP growth in 2012/13 with 9.9 percent of its sectoral growth. The widespread service work during the period was whole sale and retail trade; constituting 15.7 percent of the whole economy followed by ‘real estates, and business activities ‘comprising 8.5 percent. (Annual Report, 2013)

Figure 3.3: Trend of Real GDP



Source: Own computation from National Bank of Ethiopia (NBE) data

CHAPTER FOUR

METHODOLOGY

4.1 Data Source

The period chosen for economic analysis for this study is 1975/76 -2016/17 using annual data. This is consideration of data availability over time and the major variables road infrastructure the development is asphalt, gravel, total road, road den/1000 per, road density /1000 km2 to indicate for the development of road density in Km^2, goods value of exports and imports per total road in national currency and real GDP. The data used is from secondary sources, specifically: central statistics agency, World Bank, IMF, MoFED, World Bank, ERA and African Development Bank (ADB).

4.2. Econometric Model Specification

With the purpose of analyzing impact of road infrastructure development on the economic growth and growth process of a country studies is implemented ‘’augmented Solow growth model‟. However, the focus of previous studies has been to investigate the link between infrastructure, which is an aggregated measure, and economic growth. Previous studies, for instance, Fan et al. (2002), Fan and Chan-Kang (2005), Canning and Bennathan (2000), Canning and Pedroni (2004) used the standard Cobb-Douglas type production function to analyze the impact of road infrastructure development on the overall GDP growth, which per is assumed to be a measure of overall economic growth.

In specifying the production function, it has different specifications for the capital accumulation which are classification of road network length in asphalt/gravel, recent total road length in Ethiopia, road length per person, road density per 1000 km^2, goods values export, and import per total road length overall GDP growth. For the reason cited above, augmented Solow model production function is used to see impact of road infrastructure investment and GDP growth.

The possible existence of reverse causality, i.e. the fact that road network accumulation could be driven by productivity growth, need to be accounted in analyzing the relationship between road network variables and economic growth. In this regard, Canning (1999), Canning and Bennthan (2000), Canning and Pedroni (2004) and Calderon (2009) explicitly stated the need to account for the possible existence of reverse causality in estimating the growth function which is augmented with infrastructure variables.

According to the above mentioned studies, this study utilizes similar specifications to see the impact of road infrastructure development for the overall economic growth. The general specification of the model is an augmented Solow Growth model. Such a model is basically a VAR. The logarithmic form of this production function of Solow growth model allows including any relevant variable which impact for growth of GDP.

4.3 Variable Determination

The road network variable the study use asphalt road, gravel road, total road, road den/1000 person, road density in Km^2, value of exports and imports goods in national currency per total road length on economic growth. (Fan et al., 2004)

Economic growth, which is defined as an increase in Gross National Product (GNP) or increase in Gross Domestic Product (GDP), has been the main purpose of most economic studies and models from Adam Smith (the father of Classical Economics) until the present time. (Chogugudza et al., 2012)

As already explained above, since most economists argue that economic growth can be measured as growth in real GDP, it includes in the model as main dependent variable in order to measure economic growth. Real GDP is the dependent variable in this study which is the market value of the goods and services produced by an economy over time. It is conventionally measured as the percent rate of increase in real Gross Domestic Product. Since most economists argue that economic growth can be measured as growth in real GDP, it includes in the model as main dependent variable in order to measure economic growth. It is incorporated in the model in its growth rate.

Road transport is the dominant mode of transport in Ethiopia, having a wider network and accessibility thereby contributing to mobility of goods and services as well as sustained economic growth and investment. Improved road access offers for the rural poor the ability to reach, visit or use services effectively and also contributes to the country's economy and development. Improving rural road access can provide an effective poverty alleviation catalyst by reducing constraints and providing access to new opportunities and to stimulate growth for poverty reduction. Road infrastructure is one of the independent variable for running of the study road length or density per $km^2$of the sector infrastructure. The proper level of road network is assessed by road density, which is measured by road length per 1000 km^2.

Finally, for human capital, labor force is used as a variable. Theoretically, road density per person (labor force) is a major element for sustainable rate of economic expansion. It could be the engine of growth for labor intensive economies like Ethiopia. But if it couldn't be used efficiently and if it is less productive, it may be a burden for the economy because of high rate of unemployment. It is incorporated in the model in its growth rate.

4.3.1 Analytical Framework of the model

Having the theoretical inter-linkage on impact of road infrastructure development to economic growth from the above discussion, the following section provides the conceptual framework used in modeling road infrastructure. To do so, the starting point is the simplest production function that has the following specification.

$$GDP = f(L, K) \ldots \ldots \ldots \ldots \ldots \ldots (1)$$

Where, *GDP* is the gross domestic product of the country, *L* is labor and *K* denotes capital. The above general Cobb-Douglas type functional specification will be augmented with road infrastructure so as to identify its relationship and economic growth. Accordingly, the above functional specification will be reformulated as follows;

$$GDP = f(L, K, R) \ldots \ldots \ldots \ldots \ldots \ldots (1.1)$$

Where, *R* is Road infrastructure and the others are as stated above.

Here again, in this study the road infrastructure variables will be classified into road network including asphalt and gravel road length, in order to see their relationship between economic growth separately. The function, which takes care of the difference on road network type, will be specified as;

$$GDP = f(L, K, R) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1.2)$$

$$GDP = f(L, K, R_a, R_g) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.3)$$

Where; Ra, and Rg, is class of road network in asphalt and gravel to the road infrastructures respectively.

4.3.2 Specification of the Model

In order to estimate the impact of road infrastructure for economic growth the study follows the approach described by Canning (1999) using the Cobb-Douglass production function:

$$Y = A_t K_t^{\alpha} L_t^{\beta} ------------------------------(2)$$

The theoretical inter-linkage on the relevance of road infrastructure to economic growth from the above discussion, the following section provides the conceptual framework used in modeling road infrastructure using the equation (2) on the above general Cobb-Douglas type functional specification will be augmented with road infrastructure so as to identify its impact on economic growth.

$$Y = A_t K_t^{\alpha} L_t^{\beta} \left(R_{at}.R_{gt}.\right)^{\rho} ------------------------(2.1)$$

Where: Y is the GDP produced in the country in year t; A_t is the aggregate factor of productivity at time t; K_t is physical capital at time t; L_t is the labor force at time t; $R_{at,}$ R_{gt} is asphalt and gravel class of road network development. Moreover α, and ρ are parameters of interest.

The model is then transformed to the logarithmic form whereby the resulting equation is set as follows.

$$lny = aA_t + \alpha lnK\alpha_1 + \beta lnL_t \ + \rho_1 lnR_{at} + \rho_2 lnR_{gt} + \epsilon_t - - - - - - - - - - (2.3)$$

Our dependent variable is the economic growth of the country, has been measured by GDP. And the independent variable is the road infrastructures development. Finally, the estimable functional form specification is reached in the estimation procedure GDP is further be disaggregated to identify the impact of road infrastructure development on economic growth.

4.4 Data Analysis

4.4.1 Unit Roots Tests

The data set deployed for this study is a time series data. When dealing with time series data it is important to test the stationary or non-stationary nature of the data set for the reason that non-stationary variables might lead to spurious regression (Harris, 1995).

i. Augmented Dickey-Fuller (ADF test

To test the stationary nature of the variables, the Augmented Dickey-Fuller (ADF), the modified version of the Dickey-Fuller, test is used. According to the ADF test, null hypothesis is that the variable is assumed to have contained a unit root. The time series nature of the data is be tested against the alternative, where a stationary process generates the variable. Other common unit-root tests that could alternatively be used to test stationarity include Rothenberg, and Stock (1996) and the Phillips-Perron (1988) test.

The most common test for testing I (0) versus I (1) is the Dickey Fuller test. The Dickey Fuller test involves fitting the regression model. In this case existence of serial correlation will cause problem. Thus to avoid this problem ADF test regression includes lags of the first difference of the variables.

In the ADF test, the lags of the first difference are included in the regression equation in order to make the error term ε_t white noise and, therefore, the regression equation is presented in the following form:

$$\Delta Y_t = \delta Y_{t-1} + \mu_i \sum_{i=1}^{K} \theta_i \Delta Y_{t-i} + \varepsilon_t \quad \text{----------} \quad (3)$$

To be more specific, the intercept may be included, as well as a time trend t, after which the model becomes;

$$\Delta Y_t = \mu_1 + \omega_{2t} + \delta Y_{t-1} + \sum_{i=1}^{K} \theta_i \Delta Y_{t-i} + \varepsilon_t \quad \text{----------} \quad (3.1)$$

Where; μ is a constant, ω is the coefficient on a time trend series, δ is the coefficient of y_{t-1}, ρ is the lag order of the autoregressive process $yt = y_t - y_t - 1$ are first differences of $\boldsymbol{y_t}, \boldsymbol{y_{t-1}}$ are lagged values of order one of $y_t, \Delta y_{t-1}$ is changes in lagged values, and $\boldsymbol{\epsilon_{it}}$ it is the white noise.

The ADF test can be tested on at least three possible models:

1. A pure random walk without a drift. This is defined by using the constraint μ = 0, ω =0 and δ= 0 in equation 3.1,This leads to the equation,

$$\Delta y_t = \Delta y_{t-1} 1 + \varepsilon_t \quad \text{----------} \quad 3.2$$

Equation 3 is a non-stationary series because its variance grows with time (Pfaff, 2006).

2. A random walk with a drift. This is obtained by imposing the constraint ω =0 and δ= 0 in equation 3.1, which yields to the equation

$$\Delta y_t = \mu + \Delta y_{t-1} + \varepsilon_t \quad \text{----------} \quad 3.3$$

3. A deterministic trend with a drift. For $\boldsymbol{\mu \neq 0}$, equation 3.1 becomes the following deterministic trend with a drift model,

$$\Delta y_t = \mu + \omega_t + \Delta y_{t-1} 1 + \varepsilon_t ----------3.4$$

The sign of the drift parameter (μ) causes the series to wander upward if positive and downward if negative, whereas the size of the absolute value affects the steepness of the series (Pfaff, 2006).

The parameter of interest in the ADF model is δ. For δ= 0, the y_t sequence contains the unit root and hence is integrated of order d = 1.

Where, Δ is first difference operation; t is the time trend; k is the lag order of autoregressive process; U is the error term; α is constant β is coefficient of a time trend and; δ is the coefficient of $Yt - 1$.

The test is; H_o = the variable contains a unit root,

H_A; is that the variable is generated by a stationary process

When the P-value is less than 5%, we reject the null. If we reject the null we conclude that Y_t does not contain a unit root.

4.4.2 Optimal Lag Length Selection

When specifying a VAR, one first has to decide which variables to include into the model. Since one cannot include all variables of potential interest, one has to refer to economic theory or any a priori ideas when choosing variables. This involves some process of marginalization; in that the joint probability density of the VAR model must be interpreted as having been marginalized with respect to some variables that are potentially relevant (see e.g. Clements and Mizon 1991, or the discussion in Canova, 1995a, b).

Having specified the model, the appropriate lag length of the VAR model has to be decided. In deciding the number of lags, it has been common to use a statistical method. Alternatively, one can choose a rather large lag length a priori, and thereafter check that the results are independent of this assumption. (Blanchard et al, 1989)

However, a large lag length relatively to the number of observations, will typically lead to poor and inefficient estimates of the parameters. On the other hand, a too short lag length will induce spurious significance of the parameters, as unexplained information is left in the disturbance term.

To determine the optimal lag length different information criteria can be used .The most popular information criteria Akaike information criteria (1973, AIC), Schwarez's Bayesian information criterion (SBIC,1978) and Hannan-Quinn information criterion (HQIC, 1990).The lag length which is selected by most of these criteria will be included in the VAR system.

$$AIC(p,s) = \sum_{i=n-s+1}^{T} \ln\left(1-\lambda_i^2(p)\right) + \frac{2}{T} xN \quad ----------(4.1)$$

$$HQ(p,s) = \sum_{i=n-s+1}^{T} \ln\left(1-\lambda_i^2(p)\right) + \frac{2\ln(lnT)}{T} xN \quad ----------(4.2)$$

$$SBIC(p,s) = \sum_{i=n-s+1}^{T} \ln\left(1-\lambda_i^2(p)\right) + \frac{lnT}{T} xN \quad ----------(4.3)$$

The study carried out by Liew (2004) in which he compared five lag length selection criteria AIC, SIC, FPE, HQC and BIC with true lag length fixed at 4. According to his results for small sample size (60 or less) AIC and FPE has highest probability of correct estimation and for large sample (greater than 60) HQ has the best performance. Thus in this study AIC and FPE are used on the ground.

4.4.3 Co-Integration Test

Having tested time-series for stationary, the next step of time-series analysis is testing for co-integration, which amounts to checking whether the linear combination of the variables is also stationary or not. Co-integration analysis has done to find out the number of co-integrated vectors necessary to run VAR model. Co-integration tells us if there exists a long run relation

among the Variables in the model. To run the co-integration analysis we assume that all the variables are non-stationary and integrated of the same order. It requires that the variables of interest have the same order of integration.

It is only when the variables are integrated of the same order that a linear relationship among them can be expected. Variables are said to be co-integrated if a long run equilibrium relationship exists among them.

The Johansen Test for Co-integration

The Johansen test makes it possible to estimate all co-integrating vectors when there are more than two variables. Generally, if there are n variables there are n-1 co-integration vectors, it provides estimate of all co-integrating vectors.

Johansen's method takes as a starting point the vector auto regression (VAR) of order p given by;

$$Y_t = \pi_1 x_{t-1} + \pi_2 x_{t-1} + \cdots \ldots\ldots\ldots\ldots\ldots\ldots + x_{t-p} + u_t ---------(5)$$

Where; Y_t is an n x 1 vector of variables that are integrated of order one, that is, I(1), u_t is and n x 1 vector of innovations while $\boldsymbol{\pi_1}$ through $\boldsymbol{\pi_p}$ are m x m coefficient matrices. Re-parameter zing the equation 5, that is, subtracting Y_{t-1} on both sides, leads to

$$\Delta Y_t = \tau_1 \Delta Y_{t-1} + \tau_2 \Delta Y_{t-1} + \cdots \ldots\ldots\ldots + \tau_{p-1} \Delta Y_{t-p+1} - \pi Y_{t-p} + u_t ----(5.1)$$

Where; $\tau_1 = \pi_1 - I\ , \tau_2 = \pi_2 - \tau_1, \tau_3 = \pi_3 - \tau_2 and \pi = I - \pi_1 - \pi_2 --- \pi_p$

The matrix $\boldsymbol{\pi}$ determines the extent to which the system is cointegrated and is called the impact matrix.

The Johansen proposes two different likelihood ratio tests, which are the maximum Eigen value test and the trace test. For both test statistics, the null hypothesis is no co-integration while the alternative is co-integration (Gerald, 2014).The test statistic is given by;

Trace test; $\tau_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) - - - - - - - - - - - - - - - - - (5.2)$

Maximum Eigenvalue test; $\tau_{trace} = -T(1 - \hat{\lambda}_{r+1}) - - - - - - - - - - - - - (5.3)$

4.4.4 Short Run Co-integration -VECM

The study also interested in the short-run dynamics; the way that the dependent and independent variables actuate around this long-run relationship. This is done by estimating an error correction model, which contains first differences of co-integrated I(1) variables, their lags, and an error correction term. VECM is constructed from first differences of co-integrated I (1) variables, their lags, and some error correction terms. In vector-matrix notation, a VECM is

$$Dyt = \mu + \Pi yt - 1 + \sum_{i=1}^{p} \gamma i * Dyt - 1 + et - - - - - - - - - - - - - - - (6)$$

Where: y_t is an m×1 vector of variables like in a VAR; Dyt is an m×1 vector if the first differences of the variables in yt; μ is an m×1 vector of intercept coefficients; Π and the γ^*_i is are m×m coefficient matrices; e_t is an m×1 error vector with contemporaneous correlation but no autocorrelation, like the error vector in a VAR.

4.4.5 Causality Analysis – Granger causality

In multivariate time series analysis, causality test is done to check which variable causes (precedes) another variable. Given in this study road infrastructure development and economic growth, road infrastructure development is said to Granger cause on economic growth ,if lagged values of road infrastructure development variables is predicts economic growth well. If lagged values of road infrastructure development variables predict economic growth and at the different time lagged values of economic growth predict road infrastructure development variables, then there is a bi-directional and unit-directional causality between them.

According to Granger (1988), the existence of co-integration between X and Y must be checked before running causality test. Granger (1985) suggests that if there is a co-integration

relation between two variables, then Granger causality will exist in at least one direction. However, although a co-integration test can determine the existence of Granger causality between variables it cannot determine the direction of this relation. Engle and Granger (1987) indicate that if two variables are co-integrated then a relationship will exist that can be measured by Granger causality test.

4.4. Post Estimation Diagnostic Tests

Model miss-specification in regression analysis gives wrong implication for estimator forecasts and inferences drawn from the model. Thus to examine the quality of the model it is necessary to undertake diagnostic tests.

These tests include serial correlation, heteroskedesticity and normality tests. If a time series is serially uncorrelated no linear function of the lagged variables can account for the behavior of the current variable. For a serially independent time series there is no relation between the current and the past variables. Thus diagnostic test can be applied to evaluate model residuals which also serve as tests of model adequacy.

One of the key assumptions in a regression model is that the errors have the same variance throughout the sample but if the error variance is not constant, the data is said to be heteroskedesticity.

Normality is tested by comparing how far the asymmetry and kurtosis measures diverge from the values of the normal distribution using the third and fourth moment of the variables. Jarque-Bera is a test statistic for testing whether the series or normally distributed.

CHAPTER FIVE

Empirical Analysis and Findings

This chapter presents and discusses the results of empirical analysis based on the econometric framework given in chapter two. The econometrical methods of data analysis are to analyze the macroeconomic impact of Ethiopia during the study period; the study used tables and figure. On the other hand standard econometrical technique would apply to analyze impact of road infrastructure development for economic growth under the study period. Lastly, Eview 8.0 versions have been used as statistical software package for the entire analyze running this study.

5.1. The Unit Root Test Analysis

The data set deployed for this study is a time series data. When dealing with time series data it is important to test the stationary or non-stationary nature of the data set for the reason that non-stationary variables might lead to spurious regression. In this regard Harris (1995) stated that models containing non-stationary variables will often lead to a problem of spurious regression, where by the results obtained suggest that there is statistically significant relationship between the variables in the regression model when in fact all that obtained is evidence of contemporaneous correlation rather than meaningful causal relation.

Thus, the first step is to test the stationary nature of individual variables that is being included in the regression. To test the stationary nature of the variables, the Augmented Dickey-Fuller (ADF), the modified version of the Dickey-Fuller, test is used. According to the ADF test, null hypothesis is that the variable is assumed to have/contain a unit root. The time series nature of the data is being tested against the alternative, where a stationary process generates the variable.

Before any meaningful regression is performed with the time series variables, it is essential to test the existence of unit roots in the variables and hence to establish their order of integration.

The variables used in the analysis need to be stationary and/or should be co-integrated in order to infer a meaningful relationship from the regression. The test for unit root is a pre requisite condition when working with a time series data. The presence of a unit root implies that the time series data is non-stationary, while the absence of a unit root shows that it is stationary. The test is necessary because results obtained using non-stationary time series can be spurious and thus not consistent and reliable. (Harris, 1995)

The test has done using the Augmented Dickey Fuller (ADF) test. When the test statistics is larger than the critical value in absolute terms, the null hypothesis of unit root is rejected, and if the test statistics is less than the critical value in absolute terms, we fail to reject the null hypothesis in both tests. Table 4.1and 4.2 shows the results of ADF for unit root respectively.

Table 5.1: Augmented Dickey Fuller unit root test results (Appendix B)

Variable	Augmented Dickey Fuller Test Statistic	Critical Values at 1% level of Significance	Critical Values at 5% level of Significance	Critical Values at 10% level of Significance	Order of Integration	Result
Unit Root tests at levels						
ΔGDP	6.710595	-3.596616	-2.933158	-2.604867	I(1)	Stationary
LOG-RA	1.081758	-3.600987	-2.935001	-2.605836	I(0)	Has unit root
LOG-RG	-1.361866	-3.596616	-2.933158	-2.604867	I(0)	Has unit root
LO-GRT	2.171440	-3.605593	-2.936942	-2.606857	I(0)	Has unit root
LOG-RDL	2.112532	-3.600987	-2.935001	-2.605836	I(0)	Has unit root
LOG-RDP	3.048586	-3.596616	-2.933158	-2.604867	I(0)	Has unit root
LOG-EX	0.186098	-3.600987	-2.935001	-2.605836	I(0)	Has unit root
LOG-IM	0.735702	3.639407	2.951125	-2.614300	I(0)	Has unit root

Notes: a, 1%, Critical Values at levels -3.596616 has unit root b, 1%, 5%, and 10% Critical Values at levels with trend are -3.639407, 2.951125 and -2.614300 and c, 1%, 5%, and 10% Critical Values at difference are -3.63940, 2.951125 and -2.614300

Source: own computation from EViews version 8 using the data from NBE, ER and World Bank development indicators database respectively.

The Augmented dickey fuller unit root tests are carried out on five series to investigate stationarity properties of the underlying data and to determine integrating order of the variables. Following convention log of the independent variables are used so that spurious regressions are less likely to appear and the problem of heteroskedesticity in the series could be minimized. The variables are differenced once or twice such that the rejection of null hypothesis of unit roots represents stationarity of the variables at one integrating orders.

The stationarity of data $\Delta\dddot{GDP}$ is important. Because, it affects the long run relationship of the LOG-RA, LOG-RG, LO-GRT, LOG-RDL, LOG-RDP, LOG-EX, and LOG-IM; VAR model in general. Shows that in the table 5.1 the none stationarity of the variables causes previous values of the error terms to have none declining effect on the current value, as time progresses which in turn leads to spurious regression.

Table.5.1 shows that LOG-RA, LOG-RG, LO-GRT, LOG-RDL, LOG-RDP, LOG-EX, and LOG-IM have unit root on their level in ADF tests. Then they became stationary at their first differences. Once the stationarity status of the variables has been determined, and then move on to the next step, which is the test of co-integration between variables.

The determination of the co-integrating relationship is determined using the Johansen approach. However, before conducting this test determination of the lag length is important. This is because the Johansen test is very sensitive to the number of lags included in the model.

5.2 Optimum Lag Length

Johansen's co-integration tests' first procedure involves choosing the optimum lag length VAR models. Therefore, the optimum lag length is selected using lag length selection criteria. The identification of lags was provided by the Sequential modified AIC (Akaike information criterion), SIC (Schwarz information criterion), FPE (Final prediction error) and HQC (Hannan-Quinn information criterion) each test at 5% level of significance. In contrast, AIC and FPE should be a better choice for smaller sample. (Liew, 2004)

Table.5.2: VAR Lag Order selection Criteria (Appendix D)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2241.046	NA	9.50e+38	112.4523	112.7901	112.5744
1	-1810.871	666.7718	1.13e+31	94.14354	97.18352	95.24270
2	-1671.624	160.1334	3.91e+29	90.38122	96.12341	92.45741
3	-1538.656	99.72622*	4.43e+28*	86.93280*	95.37720*	89.98603*

Source: EViews version 8 using the data from NBE, ER and World Bank development indicator database

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

It is possible that the optimal lag selected to have insignificant contribution in the model. Thus in order to make sure information about the model are not excluded in the estimation of VAR we use Wald exclusion test. As the test shows the first two lags of all the variables are jointly significant. Hence this study employs tree lag lengths for estimation techniques.

Table.5.3: VAR Lag Exclusion Wald Tests (Appendix D)

	Chi-squared test statistics for lag exclusion								
	ΔGDP	LOG_RA	LOG_RG	LOG_R	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM	Joint
Lag 1	32.99940	59.80164	28.04560	LOG_RT	18.62454	32.57802	96.50492	204.4423	1110.383
	[6.16e-05]	[5.10e-10]	[0.000466]	[0.000166]	[0.017002]	[7.34e-05]	[0.000000]	[0.000000]	[0.000000]
Lag 2	3.101127	9.696921	18.48539	80.35607	71.55064	61.03801	41.18296	45.28752	529.7289
	[0.927852]	[0.286946]	[0.017868]	[4.14e-14]	[2.41e-12]	[2.92e-10]	[1.93e-06]	[3.25e-07]	[0.000000]
Df	8	8	8	8	8	8	8	8	64
Numbers in [ ] are p-values									

Source: own computation from E-Views version 8

5.3 Johansen Co-Integration Test Result

Lacks of co-integration between variables suggest there is no long run relationship between them. Thus to determine whether there exists co-integration or in other words long run relationship between the variables the Johansen co-integration method is applied.

Table.5.4: Unrestricted Co-integration Rank Test (Trace) (Appendix F)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.940076	370.6907	159.5297	0.0000
At most 1 *	0.865835	258.1039	125.6154	0.0000
At most 2 *	0.767681	177.7564	95.75366	0.0000
At most 3 *	0.736335	119.3706	69.81889	0.0000
At most 4 *	0.631777	66.04748	47.85613	0.0004
At most 5	0.351080	26.08476	29.79707	0.1262
At most 6	0.193577	8.786959	15.49471	0.3855
At most 7	0.004517	0.181089	3.841466	0.6704

Source: own computation from E-Views version 8 using the data from NBE, ER and World Bank development indicators database

Table.5.5: Unrestricted Cointegration Rank Test (Maximum Eigenvalue) (Appendix F)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value	Prob.**
None *	0.940076	112.5868	52.36261	0.0000
At most 1 *	0.865835	80.34748	46.23142	0.0000
At most 2 *	0.767681	58.38583	40.07757	0.0002
At most 3 *	0.736335	53.32311	33.87687	0.0001
At most 4 *	0.631777	39.96271	27.58434	0.0008

At most 5	0.351080	17.29780	21.13162	0.1584
At most 6	0.193577	8.605870	14.26460	0.3204
At most 7	0.004517	0.181089	3.841466	0.6704

Source: own computation from E-Views version 8 using the data from NBE, ER and World Bank development indicators database.

The result of testing the number of co-integrating vectors is shown in table 5.4 and 5.5 the unrestricted co-integration rank test (Trace and Maximum Eigen Value) respectively shows only one co-integrating vectors at the 5% critical value. Thus the Johansen co integration analysis test indicates that there is significant long run relationship among the variables that ΔGDP, LOG_RA, LOG_RG, LOG_RDL, LOG_RDP, LOG_EX, and LOG_IM. From the results of Johansen, we reject the null hypothesis that there is no co integration and all variables are co integrated i.e. they have long run association and thus we can run a vector error correction model (VECM).

5.4 Vector Auto Regressive Model (VAR)

After identifying the existence of long run relationship among the variables in the model, the VAR is estimated. The VAR have the long run co-integration coefficient and short run coefficients as following model.

5.4.1 Long Run Model

The result of the co-integrated VAR with two lag selected by the optimum lag length selection criteria gives us the long run model.

Table 5.6: Normalized co-integrating coefficients (standard error in parentheses) (Appendix F)

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
1.000000	1.134701	0.421206	-0.605583	516.2404	-3589.796	0.480788	-0.156535
	(0.12487)	(0.03584)	(0.10080)	(96.4549)	(1227.14)	(0.03135)	(0.00880)

Notice; standard error in parentheses

The long run relationship is derived by normalizing growth in real GDP from Table 5.6 the long run relationship is identified as in the below equation;

$$\Delta GDP = 1.134701\mathbf{RA} + 0.421206\mathbf{LOGRG} - 0.605583\mathbf{LOGRT} + 516.2404\mathbf{LOGRDL} - 3589.796\mathbf{LOGRDP} + 0.480788\mathbf{LOGEX} - 0.156535\mathrm{IM} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5.1)$$

The Appendix: C Vector Autoregression Estimates results of the equation used in the study, from the results the R-squared of 0.99 indicates that 99 percent variation in the dependent variable is accounted for by the estimated equation. This implies that 99 percent variation in the Gross Domestic Product in Ethiopia is caused by the independent variables.

The Adjusted R-squared of 99 percent suggests that the model in used is fit in explanation the variation in GDP put in consideration the losses of degree of freedom cause by the number of independent variables that is the independent variables are statistically significant in determining the total variation in Gross Domestic Product in Ethiopia. The F-statistic suggest that the model is statistically significant given the value as 151.311, meaning at 5 percent level of significant, the equation in use is statistically significant that means, useful in explaining a unit change in Gross Domestic Product in Ethiopia. Those variable is asphalt road, gravel road, and road density per 1000 km^2 given its coefficient (1.134701), (0.421206), (516.2404), and (0.480788) of the equation. This From the equation (5.1) on the above shows that the result impacts of road infrastructure development for gravel road length, asphalt road length, road density per 1000 km^2, and the values of export goods in national currency per total road length contribution to Gross Domestic Product has a positive impact on economic growth in Ethiopia. Implies a road network contribution is because 0.01134701, 0.00421206, 5.162404 and 0.00480788 percent change in Gross Domestic Product in Ethiopia. But, those variable is total road, road density per 1000 person (labour force), and the values import goods in national currency per total road length given its coefficient (-0.605583), (-3589.796), and (-0.15653) of the equation have a negative impact on Gross Domestic Product in Ethiopia. This implies that in determining the impact of road infrastructure development on the road density per 1000 person 3.58 percent decreases one economic growth. Labour force is statistically insignificant in determining the changes in economic growth, but it has a negative effect on Gross Domestic Product in Ethiopia.

The results show that the values export of goods in national currency in national per total road length is found to be positively related to Gross Domestic Product in Ethiopia, and given the coefficient of 0.480788. This implies that the values export of goods in national currency per total road length to increase in economic growth in Ethiopia. But, in the same ways the values import goods in national currency per total road length to decreases 0.156535 in Gross Domestic Product (economic growth) in Ethiopia.

5.4.2 Vector Error Correction Model (VECM)

Identifying the long run relationship among the variables, the vector error correction model is estimated. VECM makes short and long runs distinctions on the parameters, where the coefficients for $e_{t-1}$is the long run adjustment parameter.

Table 5.7 shows the result of D (ΔGDP) equation in the error correction model, from which the short run impact of asphalt road length, gravel road length, total road length, road density per 1000 km^2, road density per person and the values export or import goods in national currency per total road length on economic growth. The coefficients of the error correction term are speed of adjustment to long run equilibrium.

Table 5.7: Error Correction Model (Appendix H)

Variable	Coefficient	Std. Error	t-Statistic
CointEq1	-0.181404	0.20179	-0.8989
D(_GDP(-1))	0.208845	0.22955	0.90981
D(_GDP(-2))	-0.442840	0.24778	-1.78723
D(LOG_RA(-1))	0.541600	0.38673	1.40046
D(LOG_RA(-2))	0.132146	0.50895	0.25964
D(LOG_RG(-1))	0.140432	0.10201	1.37662
D(LOG_RG(-2))	0.076881	0.12865	0.59760
D(LOG_RT(-1))	0.033633	0.15491	0.21711
D(LOG_RT(-2))	-0.084284	0.20011	-0.42119
D(LOG_RDL(-1))	-23.11594	201.452	-0.11475
D(LOG_RDL(-2))	105.7727	8316.55	0.01272
D(LOG_RDP(-1))	-1851.268	6194.55	-0.29885
D(LOG_RDP(-2))	105.7727	8316.55	0.01272
D(LOG_EX(-1))	0.084564	0.07379	1.14608
D(LOG_EX(-2))	0.047846	0.09481	0.50466

Variable	Coefficient	Std. Error	t-Statistic
D(LOG_IM(-1))	-0.023609	0.02884	-0.81849
D(LOG_IM(-2))	-0.009691	0.02927	-0.33110

Source: own computation from EViews version 8

The coefficients of the error terms indicate speed of adjustment of disequilibrium. The equilibrium error correction coefficient, estimated -0.181404 is significant, has the correct sign, and imply a speed of adjustment to equilibrium after a shock. Approximately 18.14 percent of the disequilibrium from the previous year's shock converges back to the long-run equilibrium in the current year.

In the short run road density per 1000 km^2 has a negative and positive relationship in both lag one and two but it is highly significant in the second lag which is the fact the outcomes of growth in the economy implies such as an increase in infrastructure development takes time to make an impression, but it negative impact in the first lag is -0.23. And the result explained on average that a 1 percent increase in road density per 1000 km^2 make 1.05 million birr and 0.23 million birr decrease growth on GDP.

The result on table 5.7 identifies that term of the values export goods in national currency per total length have a positive relationship the first lag and the second lag, Which indicate that a one percent growth in term of values export goods increase the growth of GDP by 0.00084564 and 0.00047846 million birr on the short run.

Table.5.8: Summary Pairwise Granger Causality Tests (Appendix G)

Null Hypothesis:	Obs	F-Statistic	Prob.
LOG_RA does not Granger Cause _GDP	41	3.26326	0.0498*
_GDP does not Granger Cause LOG_RA		5.48665	0.0083*
LOG_RG does not Granger Cause _GDP	41	2.62905	0.0860*
_GDP does not Granger Cause LOG_RG		1.51273	0.2340
LOG_RT does not Granger Cause _GDP	41	4.66328	0.0158*
_GDP does not Granger Cause LOG_RT		1.67505	0.2016

Null Hypothesis:	Obs	F-Statistic	Prob.
LOG_RDL does not Granger Cause _GDP	41	4.76338	0.0146*
_GDP does not Granger Cause LOG_RDL		2.10024	0.1372
LOG_RDP does not Granger Cause _GDP	41	3.10854	0.0568*
_GDP does not Granger Cause LOG_RDP		2.77703	0.0756
LOG_EX does not Granger Cause _GDP	41	1.76460	0.1857
_GDP does not Granger Cause LOG_EX		3.76478	0.0328*
LOG_IM does not Granger Cause _GDP	41	3.43493	0.0431*
_GDP does not Granger Cause LOG_IM		2.09628	0.1377
LOG_RT does not Granger Cause LOG_RA	41	0.08011	0.9232
LOG_RA does not Granger Cause LOG_RT		9.99317	0.0004*
LOG_RDL does not Granger Cause LOG_RA	41	0.10122	0.9040
LOG_RA does not Granger Cause LOG_RDL		11.5557	0.0001*
LOG_EX does not Granger Cause LOG_RA	41	11.4455	0.0001*
LOG_RA does not Granger Cause LOG_EX		4.87409	0.0134*
LOG_RDP does not Granger Cause LOG_RT	41	5.06119	0.0116*
LOG_RT does not Granger Cause LOG_RDP		3.42284	0.0436*
LOG_IM does not Granger Cause LOG_RT	41	2.54026	0.0929
LOG_RT does not Granger Cause LOG_IM		10.9273	0.0002*
LOG_RDP does not Granger Cause LOG_RDL	41	1.48695	0.2396
LOG_RDL does not Granger Cause LOG_RDP		2.37842	0.1071
LOG_EX does not Granger Cause LOG_RDL	41	24.8193	2.E-07
LOG_RDL does not Granger Cause LOG_EX		2.36402	0.1085
LOG_IM does not Granger Cause LOG_RDL	41	4.97639	0.0124*
LOG_RDL does not Granger Cause LOG_IM		4.28377	0.0214*
LOG_IM does not Granger Cause LOG_RDP	41	6.08211	0.0053*
LOG_RDP does not Granger Cause LOG_IM		3.43617	0.0431*
LOG_IM does not Granger Cause LOG_EX	41	6.89449	0.0029*
LOG_EX does not Granger Cause LOG_IM		27.9190	5.E-08

Source: own computation from EViews version 8

The above result implies the F statistics of the first equation proved the causality between road asphalt length, road total length, and the values of import goods in national currency per total road length, does Granger Cause for economic growth is bi-directional causality. In same way the causality between the values of import goods in national currency per total road length, the values of export goods in national currency per total road length does Granger Cause for asphalt road and the values of import goods in national currency per total road length does Granger Cause for road density per 1000 km^2 is bi-directional causality with estimated F-Statistic is significant at the 5 %. These results suggest that the bi-direction of causality is road infrastructure to real GDP growth.

Additionally, Granger Causality tests revealed that there is one-way causality effect between road infrastructure investments and economic growth. Show that table 4.8 road gravel length, total road length, road density per 1000 km, road density per 1000 person, and the values import goods in national currency per total road length does Granger Cause economic growth. GDP does Granger Cause LOG_EX, LOG_IM does Granger Cause _GDP, LOG_RA does Granger Cause LOG_RT, LOG_RA does ranger Cause LOG_RDL, LOG_RT does Granger Cause LOG_IM and LOG_IM does Granger Cause LOG_EX. Those variables is inverse resulted that means there is not granger cause and during the study period with estimated F is significant at the 5 %.These results suggest that the one-direction of causality is from road infrastructure to real GDP growth.

5.3 Diagnostic Tests

Diagnostic test is usually conducted to detect model misspecification. The heteroskedesticity test is conducted to determine whether the variances in the model are constant or not. The results of Breusch-Pagan-Godfrey test show that the test fails to reject the null hypothesis of homoscedasticity in the significant level due to its p-value associated with the test statistics are greater than the standard significance. Therefore, the residuals in the model are found to be homoscedasticity.

The test for normality is conducted using the Jarque-Bera test. The Jarque-Bera test also failed to reject the null hypothesis of normal distribution of the residuals as a result, that the p-value associated with the Jarque-Berra normality test is larger than the standard significance level.

The study used LM test to identify the existence of serial correlation. LM test revealed that the null hypothesis of the residuals are not serially correlated is accepted. Thus, the residuals in the model do not show any evidence of autocorrelation problem. See the results on the appendixes.

Finally, the coefficient diagnostic test of Wald test is done for the both equations which the result shows that all the variables are jointly significant. And also the coefficient of determination R^2 indicates 99 % variation in the growth in real GDP is explained by the independent variable included in the regression. Though, it's greater than the conventional 60% it can be taken as granted. All the diagnostic test output gets below on the Appendixes C.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The objective of this study is to investigate impact of road infrastructure development for Economic growth in Ethiopia during 1975/76 -2016/17 study period. To determine the long run and short run relationship among the variables, VAR model was applied. Before applying the VAR model, asphalt road, gravel road, total road, road density per 1000 person, road density per 1000 Km^2, value of exports and imports goods in national currency per total road length are tested for their time series properties (stationarity properties) using the ADF.

From the result road infrastructure development for road infrastructure development for asphalt road growth, gravel road growth, road density per 1000 km^2 and the values export of goods per total road length have a positive impact with economic growth in the long run. But, total road length, road density per 1000 person and values import of goods in national currency per total road growth has a negative impact in the long run. In estimating the error correction model the study adopts difference lag for all the variables. The equilibrium error correction coefficient, estimated -0.181404 is significant, has the correct sign, and which implies that speed of adjustment to equilibrium after a shock. Approximately 18.14 percent of the disequilibrium from the previous year's shock converges back to the long-run equilibrium in the current year. And also the result total road length, and road growth per 1000 person (labour force) shows a negative relationship in long run it is difficult to justify the exact reason behind such unexpected result using this research study. Hence, further detailed research should be done to identify the reason behind such result.

6.2 Recommendation

The expansion of road infrastructure development is expected to contribute to economic growth. Increasing accesses of road network is improvements in transport facilities raise living standards and exchange goods. The improved performance of the road sector development on the Ethiopia economy, which in turn depends on the development of infrastructure in the stock total road increased to 116127 km with goods, value Exchange in national currency per total road decreasing to 142332.3 percent per annum.

Currently, Ethiopia has reached at the road density of 90.5 km per thousand square km which falls far behind the average road density of lower middle income countries which is about 260 km/1000 sq.km. Therefore, it needs further attention by the government and international donors to enhance the road infrastructure in the country. In this case the government should maintain various initiatives to investing road density.

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Appendix A: Descriptive Statistics of Major Variables

Year	Real GDP per Capita In millions of Birr	Road Asphalt (RA)	Road Gravel (RG)	Total road (TR)	Road den/1000 person (RDL)	Road density/1000 km2 (RDP)	Goods, Value of Exports, National Currency(EX)/RT	Goods, Value of Imports, National Currency (IM)/RT
1974/75	3,778.55	3280	6080	9360	0.28	7.7	497.82	648
1975/76	3,694.34	3200	6200	9520	0.28	7.8	580.56	729.5
1976/77	3,637.05	3126	6290	10068	0.29	8.3	688.98	728
1977/78	3,521.70	3051	6801	10642	0.3	8.7	632.64	942.7
1978/79	3,587.78	3115	7328	11534	0.31	9.5	864.33	1,174.60
1979/80	3,663.10	3285	7328	12208	0.32	10	878.74	1,483.10
1980/81	3,611.58	3515	7430	12775	0.33	10.5	787.35	1,528.80
1981/82	3,512.18	3769	8532	14931	0.37	12.2	825.38	1,627.70
1982/83	3,762.13	3916	8532	15501	0.38	12.7	833.68	1,810.30
1983/84	3,429.24	4000	8738	16158	0.38	13.2	862.73	1,949.20
1984/85	3,010.50	4042	8788	16638	0.38	13.6	689.46	2,056.50
1985/86	3,215.78	4050	8989	17237	0.39	14.1	941.64	2,280.40
1986/87	3,564.07	4062	8994	18214	0.4	14.9	767.2	2,279.50
1987/88	3,461.11	4109	9270	18611	0.39	15.3	888.6	2,336.20
1988/89	3,373.78	4109	9270	18611	0.38	15.3	935	1,951.30
1989/90	3,410.41	4109	9287	18946	0.37	15.5	613.8	2,238.50
1990/91	2,575.23	4109	9298	19017	0.36	15.6	390.48	976.7
1991/92	2,408.65	3542	8966	18081	0.34	16.4	448.39	2,479.90
1992/93	2,617.69	3555	9011	18366	0.34	16.7	994.16	3,936.67
1993/94	2,772.69	3622	10100	21534	0.39	19.6	2,062.38	5,658.01
1994/95	2,859.10	3630	12000	23673	0.42	21.5	2,602.91	7,041.70
1995/96	3,066.05	3656	12133	24889	0.43	22.6	2,650.55	7,108.58
1996/97	3,144.58	3708	12162	26550	0.46	24.1	3,701.53	7,490.60
1997/98	2,977.55	3760	12240	27737	0.46	24.8	3,966.00	10,387.00
1998/99	3,064.44	3812	12250	28662	0.47	26.1	3,552.90	10,514.74
1999/00	3,313.79	3824	12250	31554	0.5	28.7	3,959.00	10,369.70
2000/01	3,495.66	3924	12467	32871	0.5	29.9	3,866.60	12,319.90
2001/02	3,458.77	4053	12564	33297	0.49	30.3	3,864.30	14,485.30
2002/03	3,300.47	4362	12340	33856	0.49	30.8	4,142.40	15,929.70
2003/04	3,652.59	4635	13905	36496	0.51	33.2	5,176.60	22,298.00

2004/05	3,976.65	4972	13640	37018	0.51	33.7	7,949.47	35,770.22
2005/06	4,300.47	5002	14311	39477	0.53	35.9	8,683.50	39,869.70
2006/07	4,634.24	5452	14628	42429	0.55	38.6	10,422.30	45,081.10
2007/08	4,962.84	6066	14363	44359	0.56	40.3	13,549.70	62,959.60
2008/09	5,266.11	6938	14234	46812	0.58	42.6	15,088.90	80,515.00
2009/10	5,776.60	7476	14373	48793	0.59	44.4	26,115.30	108,956.00
2010/11	6,265.75	8295	14136	53997	0.65	49.1	44,297.10	133,025.00
2011/12	6,647.70	9875	14675	63083	0.75	57.3	54,772.30	190,845.00
2012/13	7,154.88	11301	14455	85966	1.04	78.2	56,691.10	208,521.90
2013/14	7,625.19	12,640	14,217	99,522	1.1	90.5	62,947.90	261,559.50
2014/15	8,571.18	13,551	14,055	105,057	1.15	100.4	60,671.00	330,745.20
2015/16	9,517.17	14462	14217	110592	1.2	110.3	62947.9	138371.4
2016/17	10517.17	15373	14379	116127	1.25	120.2	65224.8	207557.1

Sources: Note Based on ERA, NBE and World Bank development indicators database

Appendix B: Unit Root Test

Null Hypothesis: GDP has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		6.710595	1.0000
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: GDP has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

t-Statistic Prob.*

Augmented Dickey-Fuller test statistic		6.710595	1.0000
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RA has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.081758	0.9967
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RG has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.361866	0.5917
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RT has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*

Augmented Dickey-Fuller test statistic		2.171440	0.9999
Test critical values:	1% level	-3.605593	
	5% level	-2.936942	
	10% level	-2.606857	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RDL has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.112532	0.9999
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RDP has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		3.048586	1.0000
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: EX has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Augmented Dickey-Fuller test statistic		0.186098
Test critical values:	1% level	-3.600987
	5% level	-2.935001
	10% level	-2.605836

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: IM has a unit root

Exogenous: Constant

Lag Length: 8 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.735702	0.8241
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

Appendix C: Vector Autoregression Estimates

Vector Autoregression Estimates
Date: 09/02/20 Time: 10:55
Sample (adjusted): 3 43
Included observations: 41 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
_GDP(-1)	0.920309	0.379852	-0.147324	1.104750	8.30E-05	9.98E-06	-0.932658	2.908439
	(0.22205)	(0.13664)	(0.37004)	(0.89598)	(0.00074)	(1.3E-05)	(1.73613)	(7.75260)
	[4.14463]	[2.77996]	[-0.39812]	[1.23301]	[0.11152]	[0.75500]	[-0.53721]	[0.37516]
_GDP(-2)	-0.111812	-0.132919	-0.457982	-1.216828	-0.000999	-2.14E-05	1.260183	-0.554753
	(0.28146)	(0.17320)	(0.46905)	(1.13569)	(0.00094)	(1.7E-05)	(2.20062)	(9.82676)
	[-0.39726]	[-0.76745]	[-0.97641]	[-1.07145]	[-1.05956]	[-1.27950]	[0.57265]	[-0.05645]
LOG_RA(-1)	0.328187	1.238603	0.670936	1.718688	0.001458	5.40E-05	2.135347	32.97266
	(0.39407)	(0.24249)	(0.65672)	(1.59009)	(0.00132)	(2.3E-05)	(3.08112)	(13.7586)
	[0.83281]	[5.10775]	[1.02164]	[1.08087]	[1.10408]	[2.30147]	[0.69304]	[2.39651]
LOG_RA(-2)	-0.403862	-0.462915	-0.404090	1.319813	0.000637	-1.54E-05	-0.662218	-21.06648
	(0.53222)	(0.32750)	(0.88694)	(2.14752)	(0.00178)	(3.2E-05)	(4.16123)	(18.5818)
	[-0.75883]	[-1.41346]	[-0.45560]	[0.61458]	[0.35707]	[-0.48641]	[-0.15914]	[-1.13372]
LOG_RG(-1)	0.069900	0.028775	0.508780	0.156393	0.000264	8.33E-06	0.081293	-6.109048
	(0.10873)	(0.06691)	(0.18120)	(0.43874)	(0.00036)	(6.5E-06)	(0.85014)	(3.79625)
	[0.64287]	[0.43006]	[2.80782]	[0.35646]	[0.72500]	[1.28650]	[0.09562]	[-1.60923]
LOG_RG(-2)	-0.072395	0.017545	0.025465	0.312637	-5.14E-05	-5.58E-07	1.390879	7.897764
	(0.10641)	(0.06548)	(0.17733)	(0.42935)	(0.00036)	(6.3E-06)	(0.83195)	(3.71504)
	[-0.68037]	[0.26795]	[0.14361]	[0.72816]	[-0.14429]	[-0.08806]	[1.67183]	[2.12589]
LOG_RT(-1)	-0.000619	-0.113072	-0.000347	-0.030342	-0.000416	-1.91E-05	-0.097466	19.81423
	(0.16518)	(0.10164)	(0.27527)	(0.66650)	(0.00055)	(9.8E-06)	(1.29148)	(5.76703)
	[-0.00375]	[-1.11243]	[-0.00126]	[-0.04552]	[-0.75082]	[-1.94717]	[-0.07547]	[3.43578]
LOG_RT(-2)	-0.013051	0.211106	-0.183287	-0.410572	-0.000445	-1.37E-05	-0.983266	-23.57493

	(0.20493)	(0.12610)	(0.34151)	(0.82689)	(0.00069)	(1.2E-05)	(1.60226)	(7.15480)
	[-0.06368]	[1.67408]	[-0.53669]	[-0.49653]	[-0.64835]	[-1.12243]	[-0.61368]	[-3.29498]
LOG_RDL(-1)	58.73222	191.2181	-220.0831	-4.542977	0.447419	0.008993	728.1237	2922.005
	(263.707)	(162.274)	(439.469)	(1064.07)	(0.88352)	(0.01570)	(2061.84)	(9207.06)
	[0.22272]	[1.17836]	[-0.50079]	[-0.00427]	[0.50640]	[0.57276]	[0.35314]	[0.31737]
LOG_RDL(-2)	-29.60171	-285.4387	576.0806	1538.517	1.517600	0.022950	29.27719	1930.507
	(246.574)	(151.731)	(410.916)	(994.935)	(0.82612)	(0.01468)	(1927.88)	(8608.87)
	[-0.12005]	[-1.88121]	[1.40194]	[1.54635]	[1.83703]	[1.56328]	[0.01519]	[0.22425]
LOG_RDP(-1)	-3197.223	-2013.477	19222.78	36620.49	20.23190	0.853940	-11336.24	-1231233.
	(6498.89)	(3999.14)	(10830.4)	(26223.3)	(21.7738)	(0.38693)	(50812.7)	(226902.)
	[-0.49196]	[-0.50348]	[1.77489]	[1.39649]	[0.92919]	[2.20696]	[-0.22310]	[-5.42628]
LOG_RDP(-2)	2076.423	548.8321	-22374.84	-65435.00	-44.28043	-0.140259	-6331.154	999201.0
	(7196.54)	(4428.45)	(11993.1)	(29038.3)	(24.1112)	(0.42847)	(56267.4)	(251260.)
	[0.28853]	[0.12393]	[-1.86565]	[-2.25340]	[-1.83651]	[-0.32735]	[-0.11252]	[3.97676]
LOG_EX(-1)	0.006865	0.049732	0.043396	0.164664	0.000111	2.77E-06	1.136810	4.195175
	(0.02395)	(0.01474)	(0.03992)	(0.09666)	(8.0E-05)	(1.4E-06)	(0.18729)	(0.83634)
	[0.28657]	[3.37384]	[1.08706]	[1.70359]	[1.38796]	[1.93957]	[6.06972]	[5.01608]
LOG_EX(-2)	-0.044922	-0.036900	-0.075798	1.061233	0.000942	1.26E-05	-1.412279	-5.114464
	(0.04502)	(0.02771)	(0.07503)	(0.18168)	(0.00015)	(2.7E-06)	(0.35203)	(1.57198)
	[-0.99772]	[-1.33185]	[-1.01019]	[5.84137]	[6.24782]	[4.70360]	[-4.01180]	[-3.25351]
LOG_IM(-1)	0.004264	-0.001558	0.003607	-0.048674	-3.85E-05	-2.96E-07	0.114361	0.031254
	(0.00453)	(0.00279)	(0.00754)	(0.01826)	(1.5E-05)	(2.7E-07)	(0.03539)	(0.15802)
	[0.94208]	[-0.55925]	[0.47817]	[-2.66518]	[-2.54125]	[-1.10027]	[3.23168]	[0.19778]
LOG_IM(-2)	0.010436	-0.000587	-0.021256	-0.230156	-0.000150	-2.66E-06	0.230469	0.309651
	(0.01906)	(0.01173)	(0.03177)	(0.07692)	(6.4E-05)	(1.1E-06)	(0.14905)	(0.66556)
	[0.54745]	[-0.05005]	[-0.66908]	[-2.99218]	[-2.34501]	[-2.34012]	[1.54629]	[0.46525]
C	1092.238	-189.9747	4701.189	-1415.337	3.499389	0.032771	-5506.767	6191.149
	(1566.40)	(963.899)	(2610.42)	(6320.51)	(5.24806)	(0.09326)	(12247.2)	(54689.4)

	[0.69729]	[-0.19709]	[1.80093]	[-0.22393]	[0.66680]	[0.35139]	[-0.44963]	[0.11321]
R-squared	0.990184	0.998748	0.985957	0.999265	0.999486	0.998000	0.995102	0.993331
Adj. R-squared	0.983640	0.997914	0.976595	0.998775	0.999143	0.996666	0.991837	0.988885
Sum sq. resids	1472080.	557425.2	4088315.	23967753	16.52423	0.005218	89990765	1.79E+09
S.E. equation	247.6624	152.4010	412.7305	999.3280	0.829765	0.014745	1936.392	8646.876
F-statistic	151.3110	1197.049	105.3128	2040.040	2917.264	748.4296	304.7514	223.4167
Log likelihood	-273.1931	-253.2855	-294.1329	-330.3888	-39.54723	125.6917	-357.5102	-418.8614
Akaike AIC	14.15576	13.18466	15.17722	16.94579	2.758401	-5.302032	18.26879	21.26153
Schwarz SC	14.86627	13.89516	15.88772	17.65630	3.468907	-4.591526	18.97930	21.97204
Mean dependent	4309.357	5557.390	11291.37	36143.63	33.06341	0.527073	13218.27	48760.00
S.D. dependent	1936.277	3336.918	2697.790	28557.29	28.35205	0.255384	21431.99	82016.29

Determinant reside covariance (dof adj.)	1.87E+28
Determinant reside covariance	2.58E+26
Log likelihood	-1712.112
Akaike information criterion	90.15181
Schwarz criterion	95.83585

Appendix D: VAR Lag Exclusion Wald Tests

VAR Lag Exclusion Wald Tests
Date: 09/02/20 Time: 10:58
Sample: 1 43
Included observations: 41

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM	Joint
Lag 1	32.99940 [6.16e-05]	59.80164 [5.10e-10]	28.04560 [0.000466]	30.58774 [0.000166]	18.62454 [0.017002]	32.57802 [7.34e-05]	96.50492 [0.000000]	204.4423 [0.000000]	1110.383 [0.000000]

Lag 2	3.101127 [0.927852]	9.696921 [0.286946]	18.48539 [0.017868]	80.35607 [4.14e-14]	71.55064 [2.41e-12]	61.03801 [2.92e-10]	41.18296 [1.93e-06]	45.28752 [3.25e-07]	529.7289 [0.000000]
Df	8	8	8	8	8	8	8	8	64

Appendix E: VAR Residual Normality Test

VAR Residual Normality Tests

Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 09/02/20 Time: 10:59
Sample: 1 43
Included observations: 41

Component	Skewness	Chi-sq	Df	Prob.
1	-1.249326	10.66557	1	0.0011
2	-0.631401	2.724226	1	0.0988
3	0.654306	2.925459	1	0.0872
4	0.586861	2.353442	1	0.1250
5	0.507852	1.762411	1	0.1843
6	0.256442	0.449376	1	0.5026
7	-0.211291	0.305066	1	0.5807
8	0.213653	0.311925	1	0.5765
Joint		21.49747	8	0.0059

Component	Kurtosis	Chi-sq	Df	Prob.
1	7.118366	28.97494	1	0.0000
2	4.376659	3.237615	1	0.0720
3	3.468922	0.375641	1	0.5399
4	4.872871	5.992228	1	0.0144
5	2.957177	0.003133	1	0.9554

6	2.318296	0.793897	1	0.3729
7	3.224191	0.085863	1	0.7695
8	2.471426	0.477291	1	0.4897
Joint		39.94061	8	0.0000

Component	Jarque-Bera	Df	Prob.
1	39.64050	2	0.0000
2	5.961842	2	0.0507
3	3.301101	2	0.1919
4	8.345670	2	0.0154
5	1.765544	2	0.4136
6	1.243273	2	0.5371
7	0.390929	2	0.8225
8	0.789216	2	0.6739
Joint	61.43808	16	0.0000

Appendix F: Unrestricted Cointegration Rank Test

Date: 09/02/20 Time: 11:03
Sample (adjusted): 3 43
Included observations: 41 after adjustments
Trend assumption: Linear deterministic trend
Series: _GDP LOG_RA LOG_RG LOG_RT LOG_RDL LOG_RDP LOG_EX LOG_IM
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.948336	314.5607	159.5297	0.0000
At most 1 *	0.774735	193.0780	125.6154	0.0000
At most 2 *	0.751005	131.9684	95.75366	0.0000
At most 3 *	0.508219	74.96523	69.81889	0.0183
At most 4	0.480242	45.86665	47.85613	0.0760
At most 5	0.230980	19.03658	29.79707	0.4903
At most 6	0.157317	8.268384	15.49471	0.4372
At most 7	0.030043	1.250652	3.841466	0.2634

Trace test indicates 4 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.948336	121.4827	52.36261	0.0000
At most 1 *	0.774735	61.10956	46.23142	0.0007
At most 2 *	0.751005	57.00317	40.07757	0.0003
At most 3	0.508219	29.09858	33.87687	0.1673
At most 4	0.480242	26.83007	27.58434	0.0622
At most 5	0.230980	10.76819	21.13162	0.6704
At most 6	0.157317	7.017732	14.26460	0.4871
At most 7	0.030043	1.250652	3.841466	0.2634

Max-eigenvalue test indicates 3 cointegratingeqn (s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

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

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
-0.000688	-0.001505	-0.000284	0.000682	-0.669754	9.268085	-0.000673	0.000204
0.002237	-0.000157	0.000184	0.001565	-1.427267	-9.623717	0.000156	-0.000121
0.000982	0.001476	0.000299	-0.002338	2.112468	13.45833	-0.000486	-4.24E-05
-0.001611	0.002387	-6.66E-05	0.000266	0.170230	-54.99618	8.01E-05	-1.30E-05
-0.000827	0.000976	-0.001889	0.000868	-0.170872	-0.693169	0.000218	-0.000241
9.67E-05	-0.004316	-0.000822	0.004038	-3.427132	-55.81946	0.000189	4.25E-05
0.001128	-0.001454	0.000235	-0.001415	1.501991	1.877216	1.14E-05	1.13E-05
-0.004032	-0.006424	0.000951	0.004148	-4.483210	-13.35982	-0.000259	0.000382

Unrestricted Adjustment Coefficients (alpha):

D(_GDP)	46.97060	-11.75888	6.229808	46.63521	19.18988	-19.10688	47.68407	24.78506
D(LOG_RA)	-14.92197	51.57980	12.50306	-17.25143	-28.37476	37.28101	34.94609	-3.648646
D(LOG_RG)	68.71719	-207.5012	35.36679	78.75279	196.0965	39.68562	52.95622	-24.02739
D(LOG_RT)	-1598.447	-304.4319	-396.1586	333.7818	-63.05545	-105.2890	179.1402	-37.53434
D(LOG_RDL)	-1.283035	-0.479353	-0.529044	0.257513	-0.023912	-0.072517	0.106093	-0.018587
D(LOG_RDP)	-0.022867	-0.010582	-0.003760	0.003407	-0.001814	-0.000925	0.002782	-0.000274
D(LOG_EX)	1469.233	641.1264	506.2368	907.2690	-787.8624	-297.8703	11.60117	-57.93642
D(LOG_IM)	-1868.472	1901.019	5836.254	3791.422	173.5491	1028.312	-124.6088	651.0918

1 Cointegrating Equation(s): Log likelihood -1808.651

Normalized Cointegrating coefficients (standard error in parentheses)

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
1.000000	2.185598	0.412250	-0.991073	972.8403	-13462.20	0.977610	-0.296666
	(0.45747)	(0.14107)	(0.34649)	(324.212)	(4759.19)	(0.05536)	(0.02368)

Adjustment coefficients (standard error in parentheses)

D(_GDP)	-0.032337
	(0.02530)
D(LOG_RA)	0.010273

	(0.01755)
D(LOG_RG)	-0.047309
	(0.05441)
D(LOG_RT)	1.100455
	(0.12329)
D(LOG_RDL)	0.000883
	(0.00012)
D(LOG_RDP)	1.57E-05
	(2.1E-06)
D(LOG_EX)	-1.011497
	(0.25932)
D(LOG_IM)	1.286354
	(1.21997)

2 Cointegrating Equation(s): Log likelihood -1778.096

Normalized Cointegrating coefficients (standard error in parentheses)

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
1.000000	0.000000	0.092599	0.646908	-587.9618	-4586.294	0.097868	-0.061498
		(0.09559)	(0.16505)	(138.454)	(3232.27)	(0.03800)	(0.01242)
0.000000	1.000000	0.146253	-0.749443	714.1303	-4061.088	0.402518	-0.107599
		(0.07540)	(0.13020)	(109.217)	(2549.71)	(0.02998)	(0.00980)

Adjustment coefficients (standard error in parentheses)

D(_GDP)	-0.058643	-0.068833
	(0.08589)	(0.05551)
D(LOG_RA)	0.125664	0.014369
	(0.05558)	(0.03592)
D(LOG_RG)	-0.511517	-0.070878
	(0.16313)	(0.10544)
D(LOG_RT)	0.419399	2.452862
	(0.39915)	(0.25798)
D(LOG_RDL)	-0.000189	0.002006
	(0.00037)	(0.00024)
D(LOG_RDP)	-7.93E-06	3.61E-05
	(5.4E-06)	(3.5E-06)
D(LOG_EX)	0.422789	-2.311202
	(0.83945)	(0.54255)

D(LOG_IM)	5.539191	2.513530
	(4.07006)	(2.63055)

3 Cointegrating Equation(s): Log likelihood -1749.595

Normalized Cointegrating coefficients (standard error in parentheses)

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
1.000000	0.000000	0.000000	-20.69976	18109.93	269191.8	-13.34830	1.958653
			(4.35542)	(4009.90)	(94461.3)	(1.09538)	(0.24237)
0.000000	1.000000	0.000000	-34.46480	30245.96	428349.7	-20.83463	3.083068
			(6.87928)	(6333.54)	(149199.)	(1.73012)	(0.38282)
0.000000	0.000000	1.000000	230.5275	-201922.7	-2956592.	145.2082	-21.81606
			(47.2132)	(43467.7)	(1023969)	(11.8740)	(2.62732)

Adjustment coefficients (standard error in parentheses)

D(_GDP)	-0.052524	-0.059639	-0.013637
	(0.09310)	(0.07751)	(0.01655)
D(LOG_RA)	0.137945	0.032821	0.017472
	(0.06001)	(0.04996)	(0.01067)
D(LOG_RG)	-0.476780	-0.018686	-0.047169
	(0.17618)	(0.14668)	(0.03132)
D(LOG_RT)	0.030294	1.868238	0.279251
	(0.39339)	(0.32753)	(0.06995)
D(LOG_RDL)	-0.000709	0.001225	0.000118
	(0.00032)	(0.00026)	(5.7E-05)
D(LOG_RDP)	-1.16E-05	3.05E-05	3.42E-06
	(5.6E-06)	(4.7E-06)	(1.0E-06)
D(LOG_EX)	0.920014	-1.564132	-0.147669
	(0.88062)	(0.73318)	(0.15658)
D(LOG_IM)	11.27154	11.12628	2.623700
	(3.52170)	(2.93205)	(0.62617)

4 Cointegrating Equation(s): Log likelihood -1735.045

Normalized Cointegrating coefficients (standard error in parentheses)

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
1.000000	0.000000	0.000000	0.000000	52.75490	-451.2507	-1.167287	0.140155

				(67.7927)	(7949.84)	(0.10493)	(0.02481)
0.000000	1.000000	0.000000	0.000000	181.0222	-20602.23	-0.553421	0.055295
				(56.8985)	(6672.32)	(0.08807)	(0.02082)
0.000000	0.000000	1.000000	0.000000	-825.0004	46348.49	9.551636	-1.563958
				(516.813)	(60605.1)	(0.79996)	(0.18915)
0.000000	0.000000	0.000000	1.000000	-872.3375	-13026.39	0.588461	-0.087851
				(28.1774)	(3304.27)	(0.04361)	(0.01031)

Adjustment coefficients (standard error in parentheses)

D(_GDP)	-0.127656	0.051676	-0.016741	0.011473
	(0.10735)	(0.11384)	(0.01629)	(0.10381)
D(LOG_RA)	0.165737	-0.008358	0.018621	0.036702
	(0.07046)	(0.07471)	(0.01069)	(0.06813)
D(LOG_RG)	-0.603654	0.169292	-0.052412	-0.339563
	(0.20428)	(0.21662)	(0.03100)	(0.19755)
D(LOG_RT)	-0.507445	2.664958	0.257031	-0.551878
	(0.42966)	(0.45562)	(0.06520)	(0.41550)
D(LOG_RDL)	-0.001124	0.001840	0.000101	-0.000320
	(0.00035)	(0.00037)	(5.3E-05)	(0.00034)
D(LOG_RDP)	-1.71E-05	3.86E-05	3.19E-06	-2.25E-05
	(6.4E-06)	(6.8E-06)	(9.7E-07)	(6.2E-06)
D(LOG_EX)	-0.541640	0.601473	-0.208066	1.062880
	(0.92079)	(0.97642)	(0.13973)	(0.89044)
D(LOG_IM)	5.163381	20.17621	2.371304	-10.94079
	(3.63410)	(3.85363)	(0.55146)	(3.51429)

5 Cointegrating Equation(s):	Log likelihood	-1721.630

Normalized Cointegrating coefficients (standard error in parentheses)

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
1.000000	0.000000	0.000000	0.000000	0.000000	5178.952	-0.340061	-0.005830
					(1375.05)	(0.04196)	(0.01022)
0.000000	1.000000	0.000000	0.000000	0.000000	-1282.854	2.285106	-0.445637
					(5160.31)	(0.15746)	(0.03835)
0.000000	0.000000	1.000000	0.000000	0.000000	-41698.68	-3.384818	0.719017
					(10444.4)	(0.31870)	(0.07763)
0.000000	0.000000	0.000000	1.000000	0.000000	-106125.6	-13.09026	2.326117
					(36457.6)	(1.11247)	(0.27097)
0.000000	0.000000	0.000000	0.000000	1.000000	-106.7238	-0.015681	0.002767

					(42.7037)	(0.00130)	(0.00032)

Adjustment coefficients (standard error in parentheses)

D(_GDP)	-0.143519	0.070411	-0.052981	0.028135	3.144268
	(0.11082)	(0.11850)	(0.06905)	(0.10784)	(94.0747)
D(LOG_RA)	0.189194	-0.036060	0.072207	0.012066	-35.30001
	(0.07132)	(0.07627)	(0.04444)	(0.06941)	(60.5470)
D(LOG_RG)	-0.765758	0.360738	-0.422741	-0.169302	304.7458
	(0.18118)	(0.19374)	(0.11289)	(0.17631)	(153.808)
D(LOG_RT)	-0.455320	2.603398	0.376111	-0.606626	735.7940
	(0.44421)	(0.47500)	(0.27678)	(0.43227)	(377.092)
D(LOG_RDL)	-0.001104	0.001816	0.000146	-0.000341	0.473817
	(0.00036)	(0.00039)	(0.00023)	(0.00035)	(0.30806)
D(LOG_RDP)	-1.56E-05	3.69E-05	6.62E-06	-2.40E-05	0.023365
	(6.5E-06)	(7.0E-06)	(4.1E-06)	(6.4E-06)	(0.00554)
D(LOG_EX)	0.109650	-0.167704	1.279815	0.378816	-540.6060
	(0.84693)	(0.90565)	(0.52771)	(0.82416)	(718.967)
D(LOG_IM)	5.019916	20.34564	2.043556	-10.79010	11482.81
	(3.76772)	(4.02893)	(2.34763)	(3.66643)	(3198.46)

6 Cointegrating Equation(s):	Log likelihood	-1716.246

Normalized Cointegrating coefficients (standard error in parentheses)

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.657752	-0.192048
						(0.06289)	(0.01479)
0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	2.037942	-0.399509
						(0.13908)	(0.03270)
0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	-11.41878	2.218366
						(0.91291)	(0.21467)
0.000000	0.000000	0.000000	1.000000	0.000000	0.000000	-33.53716	6.142049
						(2.62735)	(0.61783)
0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	-0.036243	0.006605
						(0.00281)	(0.00066)

0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	-0.000193	3.60E-05
						(1.5E-05)	(3.6E-06)

Adjustment coefficients (standard error in parentheses)

D(_GDP)	-0.145367	0.152870	-0.037282	-0.049020	68.62609	-879.1900	
	(0.11035)	(0.19292)	(0.07462)	(0.17868)	(153.183)	(2852.11)	
D(LOG_RA)	0.192798	-0.196951	0.041575	0.162608	-163.0670	-1578.992	
	(0.06823)	(0.11928)	(0.04614)	(0.11048)	(94.7137)	(1763.47)	
D(LOG_RG)	-0.761921	0.189470	-0.455348	-0.009050	168.7379	-3572.474	
	(0.17990)	(0.31450)	(0.12165)	(0.29128)	(249.724)	(4649.60)	
D(LOG_RT)	-0.465501	3.057787	0.462621	-1.031787	1096.633	-29652.25	
	(0.44049)	(0.77006)	(0.29786)	(0.71321)	(611.449)	(11384.5)	
D(LOG_RDL)	-0.001111	0.002129	0.000205	-0.000633	0.722341	-24.49601	
	(0.00036)	(0.00063)	(0.00024)	(0.00058)	(0.50081)	(9.32447)	
D(LOG_RDP)	-1.57E-05	4.09E-05	7.38E-06	-2.78E-05	0.026535	-0.295201	
	(6.5E-06)	(1.1E-05)	(4.4E-06)	(1.1E-05)	(0.00904)	(0.16831)	
D(LOG_EX)	0.080847	1.117795	1.524557	-0.823997	480.2349	-18463.19	
	(0.83074)	(1.45229)	(0.56174)	(1.34508)	(1153.16)	(21470.6)	
D(LOG_IM)	5.119350	15.90782	1.198657	-6.637735	7958.654	-223099.6	
	(3.72524)	(6.51246)	(2.51898)	(6.03166)	(5171.07)	(96279.8)	

7 Cointegrating Equation(s): Log likelihood -1712.737

Normalized Cointegrating coefficients (standard error in parentheses)

_GDP	LOG_RA	LOG_RG	LOG_RT	LOG_RDL	LOG_RDP	LOG_EX	LOG_IM
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.075563
							(0.00809)
0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.038598
							(0.00974)
0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.196149
							(0.06234)
0.000000	0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	0.202758
							(0.16816)
0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000	0.000186
							(0.00017)
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	1.84E-06
							(1.3E-06)
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	-0.177096

							(0.01281)

Adjustment coefficients (standard error in parentheses)

D(_GDP)	-0.091574	0.083551	-0.026072	-0.116479	140.2471	-789.6767	-0.031632
	(0.11386)	(0.19372)	(0.07285)	(0.18003)	(157.313)	(2768.01)	(0.03077)
D(LOG_RA)	0.232222	-0.247752	0.049791	0.113169	-110.5783	-1513.390	0.011886
	(0.06950)	(0.11826)	(0.04447)	(0.10990)	(96.0331)	(1689.76)	(0.01878)
D(LOG_RG)	-0.702180	0.112487	-0.442898	-0.083968	248.2777	-3473.063	-0.038632
	(0.18868)	(0.32103)	(0.12073)	(0.29835)	(260.700)	(4587.17)	(0.05099)
D(LOG_RT)	-0.263410	2.797371	0.504735	-1.285220	1365.700	-29315.97	1.216167
	(0.45608)	(0.77598)	(0.29182)	(0.72117)	(630.161)	(11088.0)	(0.12326)
D(LOG_RDL)	-0.000991	0.001975	0.000230	-0.000784	0.881691	-24.29685	0.001049
	(0.00038)	(0.00064)	(0.00024)	(0.00060)	(0.52283)	(9.19953)	(0.00010)
D(LOG_RDP)	-1.26E-05	3.68E-05	8.03E-06	-3.17E-05	0.030714	-0.289977	1.53E-05
	(6.7E-06)	(1.1E-05)	(4.3E-06)	(1.1E-05)	(0.00929)	(0.16346)	(1.8E-06)
D(LOG_EX)	0.093935	1.100931	1.527284	-0.840410	497.6597	-18441.41	-1.290489
	(0.88336)	(1.50296)	(0.56520)	(1.39680)	(1220.52)	(21475.8)	(0.23874)
D(LOG_IM)	4.978777	16.08897	1.169362	-6.461449	7771.493	-223333.5	-0.750492
	(3.96065)	(6.73867)	(2.53413)	(6.26269)	(5472.34)	(96289.0)	(1.07040)

Appendix G: Pairwise Granger Causality Tests

Pairwise Granger Causality Tests
Date: 09/02/20 Time: 11:04
Sample: 1 43
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LOG_RA does not Granger Cause _GDP	41	3.26326	0.0498
_GDP does not Granger Cause LOG_RA		5.48665	0.0083
LOG_RG does not Granger Cause _GDP	41	2.62905	0.0860
_GDP does not Granger Cause LOG_RG		1.51273	0.2340
LOG_RT does not Granger Cause _GDP	41	4.66328	0.0158
_GDP does not Granger Cause LOG_RT		1.67505	0.2016

LOG_RDL does not Granger Cause _GDP	41	4.76338	0.0146
_GDP does not Granger Cause LOG_RDL		2.10024	0.1372
LOG_RDP does not Granger Cause _GDP	41	3.10854	0.0568
_GDP does not Granger Cause LOG_RDP		2.77703	0.0756
LOG_EX does not Granger Cause _GDP	41	1.76460	0.1857
_GDP does not Granger Cause LOG_EX		3.76478	0.0328
LOG_IM does not Granger Cause _GDP	41	3.43493	0.0431
_GDP does not Granger Cause LOG_IM		2.09628	0.1377
LOG_RG does not Granger Cause LOG_RA	41	1.29949	0.2852
LOG_RA does not Granger Cause LOG_RG		0.15328	0.8584
LOG_RT does not Granger Cause LOG_RA	41	0.08011	0.9232
LOG_RA does not Granger Cause LOG_RT		9.99317	0.0004
LOG_RDL does not Granger Cause LOG_RA	41	0.10122	0.9040
LOG_RA does not Granger Cause LOG_RDL		11.5557	0.0001
LOG_RDP does not Granger Cause LOG_RA	41	0.50590	0.6072
LOG_RA does not Granger Cause LOG_RDP		13.4313	4.E-05
LOG_EX does not Granger Cause LOG_RA	41	11.4455	0.0001
LOG_RA does not Granger Cause LOG_EX		4.87409	0.0134
LOG_IM does not Granger Cause LOG_RA	41	0.42398	0.6577
LOG_RA does not Granger Cause LOG_IM		16.2123	1.E-05
LOG_RT does not Granger Cause LOG_RG	41	0.19439	0.8242
LOG_RG does not Granger Cause LOG_RT		0.61389	0.5468
LOG_RDL does not Granger Cause LOG_RG	41	0.21556	0.8071
LOG_RG does not Granger Cause LOG_RDL		0.08788	0.9161
LOG_RDP does not Granger Cause LOG_RG	41	0.09801	0.9069
LOG_RG does not Granger Cause LOG_RDP		0.47281	0.6271
LOG_EX does not Granger Cause LOG_RG	41	0.19523	0.8235
LOG_RG does not Granger Cause LOG_EX		1.66511	0.2034

LOG_IM does not Granger Cause LOG_RG	41	0.14557	0.8650
LOG_RG does not Granger Cause LOG_IM		1.88585	0.1664
LOG_RDL does not Granger Cause LOG_RT	41	0.33408	0.7182
LOG_RT does not Granger Cause LOG_RDL		0.63198	0.5373
LOG_RDP does not Granger Cause LOG_RT	41	5.06119	0.0116
LOG_RT does not Granger Cause LOG_RDP		3.42284	0.0436
LOG_EX does not Granger Cause LOG_RT	41	16.0474	1.E-05
LOG_RT does not Granger Cause LOG_EX		1.94568	0.1576
LOG_IM does not Granger Cause LOG_RT	41	2.54026	0.0929
LOG_RT does not Granger Cause LOG_IM		10.9273	0.0002
LOG_RDP does not Granger Cause LOG_RDL	41	1.48695	0.2396
LOG_RDL does not Granger Cause LOG_RDP		2.37842	0.1071
LOG_EX does not Granger Cause LOG_RDL	41	24.8193	2.E-07
LOG_RDL does not Granger Cause LOG_EX		2.36402	0.1085
LOG_IM does not Granger Cause LOG_RDL	41	4.97639	0.0124
LOG_RDL does not Granger Cause LOG_IM		4.28377	0.0214
LOG_EX does not Granger Cause LOG_RDP	41	23.4060	3.E-07
LOG_RDP does not Granger Cause LOG_EX		1.64213	0.2077
LOG_IM does not Granger Cause LOG_RDP	41	6.08211	0.0053
LOG_RDP does not Granger Cause LOG_IM		3.43617	0.0431
LOG_IM does not Granger Cause LOG_EX	41	6.89449	0.0029
LOG_EX does not Granger Cause LOG_IM		27.9190	5.E-08

Appendix H: Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 09/12/20 Time: 03:44
Sample (adjusted): 4 43
Included observations: 40 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
_GDP(-1)	1.000000
LOG_RA(-1)	1.134701
	(0.12487)
	[9.08717]
LOG_RG(-1)	0.421206
	(0.03584)
	[11.7533]
LOG_RT(-1)	-0.605583
	(0.10080)
	[-6.00752]
LOG_RDL(-1)	516.2404
	(96.4549)
	[5.35215]
LOG_RDP(-1)	-3589.796
	(1227.14)
	[-2.92533]
LOG_EX(-1)	0.480788
	(0.03135)
	[15.3354]
LOG_IM(-1)	-0.156535

	(0.00880)							
	[-17.7893]							
C	-7063.855							
Error Correction:	D(_GDP)	D(LOG_RA)	D(LOG_RG)	D(LOG_RT)	D(LOG_RDL)	D(LOG_RDP)	D(LOG_EX)	D(LOG_IM)
CointEq1	-0.181404	-0.035264	-1.071093	1.831436	0.000841	1.51E-05	1.522180	6.572119
	(0.20179)	(0.13788)	(0.36723)	(0.96195)	(0.00091)	(1.6E-05)	(1.20212)	(8.08838)
	[-0.89898]	[-0.25576]	[-2.91666]	[1.90388]	[0.92432]	[0.96628]	[1.26624]	[0.81254]
D(_GDP(-1))	0.208845	0.426942	0.434727	-0.572188	-0.001057	-9.99E-06	-0.387183	-1.210130
	(0.22955)	(0.15685)	(0.41775)	(1.09428)	(0.00104)	(1.8E-05)	(1.36749)	(9.20105)
	[0.90981]	[2.72206]	[1.04064]	[-0.52289]	[-1.02078]	[-0.56230]	[-0.28313]	[-0.13152]
D(_GDP(-2))	-0.442840	-0.050298	0.261199	-0.564884	-0.000362	-1.49E-05	-0.979358	-19.53609
	(0.24778)	(0.16930)	(0.45093)	(1.18120)	(0.00112)	(1.9E-05)	(1.47612)	(9.93190)
	[-1.78723]	[-0.29709]	[0.57924]	[-0.47823]	[-0.32385]	[-0.77714]	[-0.66347]	[-1.96700]
D(LOG_RA(-1))	0.541600	0.444781	0.875383	0.474785	0.000968	3.48E-05	4.439417	22.69315
	(0.38673)	(0.26424)	(0.70380)	(1.84359)	(0.00174)	(3.0E-05)	(2.30388)	(15.5014)
	[1.40046]	[1.68322]	[1.24379]	[0.25753]	[0.55530]	[1.16295]	[1.92693]	[1.46394]
D(LOG_RA(-2))	0.132146	0.038954	0.467454	0.356081	0.000985	-3.16E-07	-3.096409	-11.67375
	(0.50895)	(0.34776)	(0.92624)	(2.42625)	(0.00229)	(3.9E-05)	(3.03202)	(20.4007)
	[0.25964]	[0.11202]	[0.50468]	[0.14676]	[0.42933]	[-0.00803]	[-1.02124]	[-0.57222]
D(LOG_RG(-1))	0.140432	-0.026387	-0.242754	-0.158960	-4.72E-05	3.91E-06	0.669564	-4.641733
	(0.10201)	(0.06970)	(0.18565)	(0.48631)	(0.00046)	(7.9E-06)	(0.60772)	(4.08901)
	[1.37662]	[-0.37856]	[-1.30758]	[-0.32687]	[-0.10268]	[0.49505]	[1.10176]	[-1.13517]
D(LOG_RG(-2))	0.076881	-0.028340	0.132869	-0.414867	-0.000333	-4.62E-06	-0.242857	-0.011705
	(0.12865)	(0.08790)	(0.23413)	(0.61329)	(0.00058)	(1.0E-05)	(0.76641)	(5.15674)

	[0.59760]	[-0.32240]	[0.56750]	[-0.67646]	[-0.57355]	[-0.46457]	[-0.31688]	[-0.00227]
D(LOG_RT(-1))	0.033633	0.006686	-0.078946	-0.953985	-0.000966	-2.47E-05	-0.711601	22.11305
	(0.15491)	(0.10585)	(0.28192)	(0.73849)	(0.00070)	(1.2E-05)	(0.92286)	(6.20941)
	[0.21711]	[0.06317]	[-0.28003]	[-1.29181]	[-1.38328]	[-2.06507]	[-0.77108]	[3.56121]
D(LOG_RT(-2))	-0.084284	0.064696	-0.513453	-1.800977	-0.001759	-3.44E-05	-1.399278	-2.724590
	(0.20011)	(0.13673)	(0.36418)	(0.95396)	(0.00090)	(1.5E-05)	(1.19213)	(8.02115)
	[-0.42119]	[0.47316]	[-1.40989]	[-1.88790]	[-1.94946]	[-2.21971]	[-1.17376]	[-0.33968]
D(LOG_RDL(-1))	-23.11594	71.39935	-142.0254	945.6580	0.976246	0.018243	1512.644	-8202.322
	(201.452)	(137.648)	(366.621)	(960.350)	(0.90835)	(0.01559)	(1200.12)	(8074.91)
	[-0.11475]	[0.51871]	[-0.38739]	[0.98470]	[1.07475]	[1.17052]	[1.26041]	[-1.01578]
D(LOG_RDL(-2))	74.37305	-115.9024	224.0833	2391.687	2.421115	0.036928	-1394.815	-6808.201
	(192.826)	(131.754)	(350.922)	(919.226)	(0.86945)	(0.01492)	(1148.73)	(7729.13)
	[0.38570]	[-0.87969]	[0.63856]	[2.60185]	[2.78464]	[2.47542]	[-1.21422]	[-0.88085]
D(LOG_RDP(-1))	-1851.268	-3562.834	19411.56	22331.68	13.62685	0.456450	-66821.76	-813874.0
	(6194.55)	(4232.62)	(11273.4)	(29530.3)	(27.9313)	(0.47924)	(36903.1)	(248299.)
	[-0.29885]	[-0.84176]	[1.72189]	[0.75623]	[0.48787]	[0.95245]	[-1.81073]	[-3.27779]
D(LOG_RDP(-2))	105.7727	8.414585	14942.30	-8698.480	-6.027985	0.393079	124436.3	474699.5
	(8316.55)	(5682.54)	(15135.2)	(39646.1)	(37.4994)	(0.64340)	(49544.6)	(333356.)
	[0.01272]	[0.00148]	[0.98725]	[-0.21940]	[-0.16075]	[0.61094]	[2.51160]	[1.42400]
D(LOG_EX(-1))	0.084564	0.051125	0.404305	-0.636231	-0.000285	-4.36E-06	0.062795	1.929655
	(0.07379)	(0.05042)	(0.13428)	(0.35174)	(0.00033)	(5.7E-06)	(0.43957)	(2.95757)
	[1.14608]	[1.01406]	[3.01088]	[-1.80879]	[-0.85700]	[-0.76398]	[0.14286]	[0.65245]

D(LOG_EX(-2))	0.047846	0.028151	0.398655	0.238092	0.000550	6.63E-06	-2.073728	-4.912026
	(0.09481)	(0.06478)	(0.17254)	(0.45196)	(0.00043)	(7.3E-06)	(0.56481)	(3.80025)
	[0.50466]	[0.43456]	[2.31050]	[0.52679]	[1.28728]	[0.90326]	[-3.67157]	[-1.29255]
D(LOG_IM(-1))	-0.023609	-0.006212	-0.143136	0.261541	0.000118	2.38E-06	0.369121	0.240762
	(0.02884)	(0.01971)	(0.05249)	(0.13751)	(0.00013)	(2.2E-06)	(0.17184)	(1.15621)
	[-0.81849]	[-0.31520]	[-2.72667]	[1.90201]	[0.90903]	[1.06617]	[2.14806]	[0.20823]
D(LOG_IM(-2))	-0.009691	-0.003941	-0.123143	0.059647	-1.99E-05	-4.69E-07	0.665284	0.638334
	(0.02927)	(0.02000)	(0.05327)	(0.13953)	(0.00013)	(2.3E-06)	(0.17437)	(1.17323)
	[-0.33110]	[-0.19704]	[-2.31177]	[0.42748]	[-0.15095]	[-0.20690]	[3.81536]	[0.54408]
C	-34.02857	53.32549	543.0275	362.3524	0.273992	0.003550	840.2654	-653.1403
	(83.9816)	(57.3830)	(152.838)	(400.352)	(0.37867)	(0.00650)	(500.308)	(3366.28)
	[-0.40519]	[0.92929]	[3.55297]	[0.90508]	[0.72356]	[0.54637]	[1.67950]	[-0.19402]
R-squared	0.712677	0.919006	0.478718	0.954167	0.959891	0.911478	0.907269	0.957912
Adj. R-squared	0.490654	0.856419	0.075909	0.918751	0.928899	0.843074	0.835614	0.925390
Sum sq. resids	1422221.	663996.2	4710407.	32320784	28.91542	0.008512	50474673	2.29E+09
S.E. equation	254.2565	173.7287	462.7196	1212.075	1.146445	0.019670	1514.696	10191.49
F-statistic	3.209927	14.68378	1.188450	26.94142	30.97129	13.32502	12.66153	29.45395
Log likelihood	-266.3346	-251.1006	-290.2856	-328.8044	-50.26745	112.3449	-337.7196	-413.9731
Akaike AIC	14.21673	13.45503	15.41428	17.34022	3.413373	-4.717247	17.78598	21.59866
Schwarz SC	14.97672	14.21503	16.17428	18.10021	4.173368	-3.957251	18.54598	22.35865
Mean dependent	172.0030	306.1750	202.2250	2651.475	2.797500	0.024000	1613.396	5170.728
S.D. dependent	356.2588	458.4832	481.3496	4252.260	4.299463	0.049655	3735.877	37311.16
Determinant reside covariance (dof adj.)		2.70E+28						
Determinant reside covariance		2.26E+26						

Log likelihood	-1667.708
Akaike information criterion	90.98540
Schwarz criterion	97.40314

Appendix I: VAR Residual Serial Correlation LM Tests

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 09/12/20 Time: 08:34
Sample: 1 43
Included observations: 41

Lags	LM-Stat	Prob
1	101.0526	0.0022
2	76.80484	0.1309
3	77.97458	0.1125
4	88.78961	0.0219
5	104.1794	0.0011
6	66.75811	0.3824
7	105.9737	0.0008
8	63.62165	0.4898
9	77.31883	0.1226
10	89.36199	0.0199
11	98.51841	0.0036
12	100.0949	0.0026

Probs from chi-square with 64 df.

Appendix J: VAR Residual Normality Tests

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 09/12/20 Time: 09:41

Sample: 1 43

Included observations: 41

Component	Skewness	Chi-sq	Df	Prob.
1	-1.249326	10.66557	1	0.0011
2	-0.631401	2.724226	1	0.0988
3	0.654306	2.925459	1	0.0872
4	0.586861	2.353442	1	0.1250
5	0.507852	1.762411	1	0.1843
6	0.256442	0.449376	1	0.5026
7	-0.211291	0.305066	1	0.5807
8	0.213653	0.311925	1	0.5765
Joint		21.49747	8	0.0059

Component	Kurtosis	Chi-sq	Df	Prob.
1	7.118366	28.97494	1	0.0000
2	4.376659	3.237615	1	0.0720
3	3.468922	0.375641	1	0.5399
4	4.872871	5.992228	1	0.0144
5	2.957177	0.003133	1	0.9554
6	2.318296	0.793897	1	0.3729
7	3.224191	0.085863	1	0.7695
8	2.471426	0.477291	1	0.4897
Joint		39.94061	8	0.0000

Component	Jarque-Bera	Df	Prob.
1	39.64050	2	0.0000
2	5.961842	2	0.0507
3	3.301101	2	0.1919
4	8.345670	2	0.0154
5	1.765544	2	0.4136
6	1.243273	2	0.5371

7	0.390929	2	0.8225
8	0.789216	2	0.6739
Joint	61.43808	16	0.0000

