

**ADDIS ABABA UNIVERSITY**  
**COLLEGE OF BUSINESS AND ECONOMICS**  
**DEPARTMENT OF MANAGEMENT**



**Nexus between Innovation and Economic Growth in  
Ethiopia**

**By**

**Omer Mohammed**

**ADDIS ABABA**  
**JUNE, 2018**

*Addis Ababa  
University*

*(Since 1950)*



**Nexus between Innovation and Economic Growth in Ethiopia**

**By:**

**Omer Mohammed**

**Advisor:**

**Yohannes Workaferaw (PhD)**

**A Thesis submitted to College of Business and Economics of Addis Ababa University in partial fulfillment of the requirement for award of the degree of Master Science in Management Program**

**Addis Ababa University  
College of Business and Economics  
Department of Management**

**Addis Ababa**

**June, 2018**

### ***Declaration***

I, Omer Mohammed Ahmed, hereby declare that this thesis entitled “***Nexus between Innovation and Economic Growth in Ethiopia***” submitted by me for the award of the Degree of Master Science in Management specializing on Innovation and Entrepreneur Management, Addis Ababa University at Addis Ababa, Ethiopia, is ***my original work and it has never been presented in any university. All sources and materials used for this thesis have been duly acknowledged.***

Name: **Omer Mohammed Ahmed**

Signature\_\_\_\_\_

Place: Addis Ababa

Date of Submission: June 2018

This master thesis, has been submitted for examination with my approval as thesis

Advisor Name: **Yohannes Workaferaw(PhD)**

Signature\_\_\_\_\_ Date\_\_\_\_\_



**Addis Ababa University**  
**College of Business and Economics**



## **Addis Ababa University**

### **School of Graduate Studies**

This is to certify that the thesis entitled, “*Nexus between Innovation and Economic Growth in Ethiopia*” was carried out by **Omer Mohammed Ahmed** under the supervision of **Yohannes Workaferaw(PhD)**, submitted in partial fulfillment of the requirements for the degree of Master of Science in Management specializing on innovation and enterprenal management complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

#### **Approved by:**

Internal examiner: Lakew Alemu(PhD) Signature \_\_\_\_\_ Date \_\_\_\_\_

External examiner: Abdulrezak Mohammed(PhD) Signature \_\_\_\_\_ Date \_\_\_\_\_

Advisor: Yohannes Workaferaw (PhD) Signature \_\_\_\_\_ Date \_\_\_\_\_

## Acknowledgment

*First and for most, I acknowledge almighty Allah for showering me with grace and mercies in every step of my life. I attribute all my successes to His unwavering presence.*

*I am grateful to all my lecturers and management of Addis Ababa University, College of Business and Economics for the knowledge and wisdom they have impacted in me since joining the postgraduate program. I am in particular grateful to my advisor, Yohannes Workaferaw(PhD) for his honest prompt and admirable guidance creative comments and invaluable suggestions which always inspired me to learn more and to strive for high quality work throughout the project. Also I would like to extend my deepest gratitude for Abebaw Kassie (PhD) of Addis Ababa University for spending his valuable time during the model specification stage of the project as well as his assistance during the late stage of the project.*

*I am grateful to the staff of The National Planning Commission particularly Mr Abel Mesfin for his support in directing me in the right direction during the data gathering process and Mr Deresse Kebede of Debremarkos University and YOM institute of Economic development for his unprecedented support during the data gathering as well as his technical support during the analysis. I also would like to acknowledge my fellow classmates who were my second family; I am especially indebted to Faiza Yimer, Henok Tefera, Mattios Kinf, I have benefited exuberantly from our discussions during the project.*

*Special Thanks are due to the late Kr. Abdulmuheymin Abdulnasir, may he rest in peace for his insight and invaluable support throughout my study and throughout my hardship.*

*I also wish to thank my friend and family Adenew Teshome and Worku Gezahegn for their support during my study helping me to better myself on each step of the way.*

*Finally, I would like to thank my mother, and the rest of my family for their understanding and unconditional emotional support they provided to see me this far and being my sanctuary.*

## Table of Contents

<i>Declaration</i> .....	i
Acknowledgment .....	iii
<i>List of Tables</i> .....	vii
<i>List of Figures</i> .....	viii
List of abbreviation\acronyms .....	ix
<i>Abstract</i> .....	x
CHAPTER ONE .....	1
INTRODUCTION.....	1
1.1    Background of the Study.....	1
1.2    Statement of the Problem.....	3
1.3    Objectives of the Research.....	5
1.3.1    General objective .....	5
1.3.2    Specific objectives .....	5
1.4    Research question .....	5
1.5    Research Hypotheses .....	5
1.6    Significance of the study.....	6
1.7    Scope and limitations of the study .....	6
1.7.1.    Scope of the Study .....	6
1.7.2.    Limitation of the study.....	7
1.8    Structure of the study .....	7
CHAPTER TWO .....	8
LITERATURE REVIEW .....	8
2.1.    Theoretical review of Innovation.....	8
2.1.1.    Innovation in Economic theory.....	8
2.1.2.    Innovation Verses invention .....	10
2.1.3.    System of innovation .....	12
2.1.4.    Stages of Innovation.....	14
2.1.5.    Innovation and long waves in economic thought.....	15
2.2.    Economic growth and Innovation .....	19

2.2.1.	Equilibrium versus Disequilibrium.....	20
2.2.2.	Innovation as an exogenous or endogenous factor .....	21
2.3.	Empirical Review.....	24
2.4.	Measures of innovation.....	27
2.4.1.	<i>Patent</i> .....	27
2.4.2.	<i>Research and Development</i> .....	28
2.4.3.	<i>Imported capital goods</i> .....	28
2.5.	Conceptual Framework of the model.....	29
Chapter three.....		30
Research Methodology .....		30
3.1	Research Approach .....	30
3.2	Research Design .....	30
3.3	Model Specification .....	31
3.4	Operationalization of Variables .....	31
3.5.	Data collection Method and sources .....	32
3.6.	Estimation method .....	32
3.6.1.	Autoregressive Distributed Lag (ARDL) Model .....	32
3.6.2.	Granger causality tests .....	33
3.7.	Unit Root Test.....	34
3.8.	Cointegration Test.....	34
3.9.	Optimal lag selection .....	35
3.10.	Diagnostic Test .....	35
3.10.1.	Model Stability.....	36
3.10.2.	Test for residual autocorrelation .....	36
3.10.3.	Test for residual heteroscedasticity .....	37
3.10.4.	Test for Normality.....	37
3.11.	Conclusion .....	38
CHAPTER FOUR.....		39
DATA ANALYSIS AND INTERPRETATION .....		39
4.1.	Unit root test .....	39
4.2.	Optimal lag selection .....	40
4.3.	Cointegration Test.....	41

4.4.	Diagnostic tests .....	42
4.4.1.	Model Stability.....	42
4.4.2.	Test for residual autocorrelation .....	43
4.4.3.	Test for residual heteroscedasticity .....	44
4.4.4.	Test for Normality.....	45
4.5.	Discussion of result.....	47
4.5.1.	The Association of Patent on Economic Growth.....	48
4.5.2.	The Association of R&D on Economic Growth .....	49
4.5.3.	The Association of Imported capital good on Economic Growth.....	51
4.5.4.	Result of Error correction term .....	52
CHAPTER FIVE .....		53
CONCLUSTION AND RECOMMENDATION .....		53
5.1.	Conclusion .....	53
5.2.	Recommendation .....	54
5.3.	Future Research Direction .....	55
References.....		56
<i>Appendices</i> .....		63
Appendix I Major innovations during 19th and 20th centuries .....		i
Appendix II. ARDL(2, 2, 0, 1).....		ii
Appendix III ARDL Bounds Test.....		iii
Appendix III Breusch-Godfrey Serial Correlation LM Test.....		iv
Appendix III Heteroskedasticity Test: ARCH .....		v

### *List of Tables*

Table 1 Trend and analysis of Kondratiev cycles .....	18
Table 2 operationalization and justification of variables .....	31
Table 3 Variables and source of data .....	32
Table 4: Unit Root result of the variables .....	39
Table 5 Breusch-Godfrey serial correlation LM test result .....	44
Table 6 Result of Heteroskedasticity ARCH Test .....	44
Table 7 Co-integrating and Long Run Result of ARDL model (2, 2, 0, 1) .....	47
Table 8 Pairwise Granger Causality Tests between Patent and GDP .....	49
Table 9 Pairwise Granger Causality Tests between R &D and GDP .....	50
Table 10 Pairwise Granger Causality Tests between imported capital goods and GDP .....	52

## *List of Figures*

Figure 1 Five cases of innovation on a given economic entity .....	9
<i>Figure 2 The stages of the innovation process .....</i>	<i>14</i>
Figure 3 Schumpeter's Four-Phase Cycle .....	17
Figure 4 Inventions in each cycle of the wave.....	17
<i>Figure 5 Conceptual Framework of the model.....</i>	<i>29</i>
Figure 6 Akaike Information Criteria .....	40
<i>Figure 7 Result of ARDL Bounds Test.....</i>	<i>41</i>
Figure 8 Cumulative sum of recursive residuals test (CUSUM test).....	42
Figure 9 Cumulative sum of squares of recursive residuals test (CUSUMQ test) .....	43
<i>Figure 10 Result of Normality Test: Bera-Jarque test.....</i>	<i>45</i>

## **List of abbreviation\acronyms**

ARDL	Autoregressive Distributed Lag
EIPO	Ethiopian Intellectual Property Office
GDP	Gross domestic Product
ImpCapG	Imported capital good
IPR	Intellectual Property Rights
NBE	National Bank of Ethiopia
NPC	National Planning Commission
Pat	Patent
R&D	Research and development

## ***Abstract***

*The relationship between innovation and economic growth has been one of the contended subjects by scholars in the field. Conventional economic growth theory among many of it is draw backs assumes innovation as exogenous. Hence, following the emergence of new growth theory in the 80<sup>th</sup> and the era of information technology has put the validity of conventional model into question. The increased globalization has forced developing countries to make an emphasis to alleviate part of the ill of the economy to innovation. The Ethiopian economy has registered an impressive economic growth in the last few years. The Growth and Transformation plan progress report indicate the GDP rate is rapid, in broad-based and well above the average growth rate of other Sub-Saharan African countries. Thus, the study puts innovation into the perspective aims to empirically examine the relationship to economic growth using Patent, R&D and imported capital goods during the period of 1996 to 2017. The study employed ARDL multiple regression model and pairwise Granger causality test technique for estimation. The estimated result show patent has a negative significant impact on both short and long term indicating rampant imitation in the economy. Furthermore, the unidirectional causality that goes form growth to patent confirms the level of economic development is essential for strong IPR regime. R&D on the other hand has a positive significant impact on economic growth both in short and long term the unidirectional causality that goes form growth to R&D indicate economic growth is causing the R&D investment. Lastly, imported capital goods have positive insignificant association on economic growth and the pairwise causality unlike the previous variables has a unidirectional relationship that emerges from imported capital goods to growth. The study implies a major policy implication arising from the results is that innovation has a significant impact on the economic growth of the country during the study period and fundamental to the realization of sustained economic growth in Ethiopia.*

***Key Words: - Innovation, Economic growth, Patent, Intellectual Property Rights, Research and Development, Gross Domestic Product, Autoregressive Distributed Lag***

# CHAPTER ONE

## INTRODUCTION

This chapter deals with the introductory part of the study. It includes: background information, problem statement, basic research questions, objectives, significance, scope, limitation and organization of the study.

### 1.1 Background of the Study

Increasing material output, consumption and human welfare levels are the ultimate objectives' of modern society. It is unthinkable to achieve enhanced quality level of life without increasing the level of production, increasing consumption, and innovation. Narkus, (2012) Essential part is played by most innovations as most is meant to add value to the society it considerably influences human welfare.

The importance of innovation has been outlined by pioneer of economics Smith ( 1776) as great increase in three conditions through first increased skill of every particular worker, secondly, through saving time that could have been lost by using conventional method and lastly through the use of limited labor it enables workers to do many tasks Yet, when the classical economists model total factor of production they use capital, labor and land. Unlike the classical economists neoclassical economic growth model represented by Solow (1956) recognize technological progress as an exogenous variable which admits the effect of innovation on the economic growth of the economy.

The inclusion of innovation as a main source of economy was first contended by Schumpeter who developed a development theory with innovation as the major driver, endogenous to the economy and disturbing the equilibrium. He was little concerned with the effect of the exogenous shocks to the economy, and he focused on the endogenous effect of innovation on the development process. (Hanusch & Pyka, 2007)

In the late 80<sup>th</sup> “New Growth Theory” represented by Romer (1986) consider technology as an endogenous and most significant motive to enhance the economic growth and social development.

Thus, generally innovations are considered beneficial due to their ability to stimulate output for increasing number of population. Narkus (2012) argue innovation has a direct impact on relationships between nations as different economic structures' are spread within these countries. Furthermore, technological innovations and high accessibility to scientific levels are also reflected on the economic structure of the country. Nations that incorporate and apply technological advancements are able to produce higher level of output even though capital and labor level remains constant. Hence, countries cannot change their economic structures instantaneously and become global leader through the use of less innovative technologies as it takes time and resource to create, apply and benefit from the creation of innovation.

The long held conventional wisdom that innovation was the strength of the West and that what gets developed in the West was modified and transferred to 'the Rest' is no longer the privilege of high-income countries alone Petrick & Juntiwassarakij (2011). Developing countries are increasingly focusing on innovation activities to sustain economic growth of their respective country (Zeng & Williamson, 2007) .

In this first chapter statement of the problem, general and specific objectives of the study, significance of the study and scope and limitations of the study are discussed in detail. This study aims to fill the existing empirical research gap by analyzing the relationship between innovation and economic growth. Proxies such as Patent, R&D innovation and imported capital goods are used in this research. This study will help policy makers, stakeholders, academicians, and other who further want to conduct study in this field.

## 1.2. Statement of the Problem

Innovation have long been recognized as a stimulus for raising total factor productivity and living standards through the production and provision of better quality goods and services in various economies.(Sattar & Mahmood, 2011).

It is recognized as key to economic transformation, growth and poverty reduction. A country's ability to tap the creativity of its population and foster new, commercially relevant, ideas and products is becoming critical in reducing poverty. The national innovation system essentially consists of three sectors: industry, universities, and the government, interacting with each other, while at the same time playing its own role (Goto, 2000) . They contribute to the economic grow and innovation through involving in expenditure on R&D, protection of intellectual Property Rights and investment in imported capital goods.

Innovation activities in developing countries has been proven to have been difficult to undertake domestically due to a high resource constraint, poor intellectual property right regime to reap the benefit of invention as the scope for imitation is high as most industries rely on pirated and imitated technologies (Falvey *et al.*, 2006). Studies measuring patent as an output of innovation include Thompson & Rushing (1996) state a positive but statistically insignificant relationship between patent and economic growth. Furthermore Thompson & Rushing (1999) claim patent protection has a positive and significant impact on total factor productivity in more advance countries. On contrary, Janjua & Samad (2007) found a negative association between patent and growth. They assert the presence of strong IPR regiem create confidence to investors, and productivity while the absence of it obviously affects the economy in a loss of significant output.

Expenditure on R&D which has been considered an inputs of innovation and countries behind the frontier increases their productivity growth by doing R&D (Griffith, et al. 2004). Investment in R&D and economic growth usually have an interactive relationship and sustainable economic growth requires increase in the expenditure of R&D (Yanyun & Mingqian, 2004).Furthermore, Falk (2007), Peng (2010) and Kim (2011), conform the significant contribution of R&D on economic growth. Hence, Ethiopia's R&D expenditure is only accounts about 0.61% form the GDP of which 79% is contributed by the government and is ranked (133<sup>rd</sup> out of 142) and unlikely to achive1% in terms GDP that is set by Executive Council of the African Union on

Science and Technology in 2006 countries STIC (2014), and the growing skilled man power is faced with unemployment and encourage a brain drain.

Zerayehu (2013) argue that developing countries that uses innovation in production activity is proxied by importing capital goods. Similarly, Iyoboyi & Na-Allah (2014) , Veeramani , (2008) and Cavallo & Landry (2009), conform innovation through use of imported capital goods on economic growth has an increasing source of economic growth and leads to an even faster growth rate of income per capita in the subsequent years. Furthermore, Arawomo (2014) state capital goods import has both short-run and long-run impact although the long run has a significant impact on economic growth.

This study seeks to put to light how innovation has an effect on economic growth in country level using Patent, R&D and imported capital goods as these variables exclusively represent innovation in the economic system. Previous literature that has addressed innovation exemplified by Janjua & Samad( 2007), Sattar & Mahmood, (2011) and Arawomo, (2014) provide important policy implications especially for African countries which are under researched. Notably, Ethiopia has not featured in the stated cross country studies using similar variable in African countries. Derese (2016), examining the economic growth of Sub-Saharan African countries featuring Ethiopia has used only capital imported goods as a proxy to innovation have conform a positive significant effect on economic growth.

In terms of Single country studies none have been carried out in the scope of this particular study on Ethiopia prior studies conducted by Zerayehu (2013) only shows the induced industrial total factor of productivity is better in fostering structural change of the economy and does not include patent and R&D as a variable.

Hence, previous researches featuring Ethiopia have viewed innovation using an element that does not well represent the innovation activity of the country due to the unavailability of data and also the studies emphasis on liner relationship between economic growth and innovation mostly. The current study conversely shall use variables which haven't been put to use to represent innovation that accounts for longer period of time assessing the relationship between innovation and economic growth to show policy implication of innovation in the country.

### **1.3 Objectives of the Research**

The research has the following general and specific objective.

#### **1.3.1 General objective**

The general objective of this study is aimed to examine the relationship between innovation and economic growth in Ethiopia. In this regard, this study intends to particularly investigate the following significant objectives.

#### **1.3.2 Specific objectives**

In view of the general objective this paper attempts to achieve the following specific objectives:

The specific objectives of the study are as follows:

1. To examine the relationship of Patent with economic growth in Ethiopia
2. To examine the relationship of R&D with economic growth in Ethiopia
3. To examine the relationship of imported capital goods with economic growth in Ethiopia

### **1.4 Research question**

The central research question of the study is - Does innovation has a relationship with economic growth in Ethiopia?

Specific questions include;

Is there a relationship between patent and economic growth?

Is there a relationship between R&D expenditure and economic growth?

Is there a relationship between imported capital good and economic growth?

In light of these research questions, the following hypotheses are developed:

### **1.5. Research Hypotheses**

As mentioned above, the main objective of this study is to examine the relationship between innovation and economic growth in general particularly emphasizing on element of innovation and economic growth that shall be discussed briefly in chapter two section 2.2 of empirical review of the study.

Subsequent to the preceding research question of the study, the following hypotheses will be tested in this study.

- ⇒ **H1:** *There is positive and significant relationship between patent and economic growth*
- ⇒ **H2:** *There is positive and significant relationship between R&D expenditure and economic growth*
- ⇒ **H3:** *There is positive and significant relationship between imported capital good and economic growth*

## **1.6. Significance of the study**

Innovation has been one of the main forces for the growth of emerging countries and yet it hasn't received much focus on country level as well as in sub-Saharan African countries. Since 1992 EPRDF officially denounced the socialist system and supported market-oriented economic system has been a green light for entrepreneurs' both domestic and foreigners who were willing to invest prior 1992 started operating in the economy. Since then the Ethiopian economy has an impressive performance over the last decade with an average GDP growth of 11% which is twice the average growth of the Sub Saharan African countries and triple the world average growth over this period and has led to Ethiopia being rated as one of the fastest growing economies in the world (UNDP, 2014). Hence, the findings of this study are believed to provide a useful contribution to the empirical basis needed for proper understanding of the contribution of innovation on the economic growth of the country. The study also adds value to the stock of knowledge by using acceptable approach to measure the impact of exogenous and endogenous innovation factors on the progress in the Ethiopian economy.

## **1.7. Scope and limitations of the study**

The study has its own scope and limitations as it is presented below.

### **1.7.1. Scope of the Study**

The scope of this study was limited in terms of coverage and method. With regard to coverage, it was limited to the effect of innovation on the economic growth of the country. This is due the absence of studies that featured in the current research scope in neither cross-sectional nor case wise, according to the researcher's knowledge within the current studies objective in the past. In terms of time, it covers the time period 1996-2017 G.C. this period is selected due to the data availability of major variables used in this study. The data's cannot stretch for more than 22 years as some of the major variables have not been functional in the country.

### **1.7.2. Limitation of the study**

Every study conducted may have certain shortcomings. When conducting Preliminary search for data there occur some constraints that potentially affected the research work. The major constraint of the problem is data about an important policy variable namely human capital in aggregate level has not been availed in time series data to assess the impact of input to innovation on growth in the country. The use of this particular variable would have been one of the important policy tool in terms of using Human resource training and development, hence the existing proxies used in developing countries by other scholars were adopted to assess the impact of innovation on growth in Ethiopia. It is hoped that this did not bias the results since the inexistence of the variable can be captured indirectly through the reasonable representation of the variables incorporated in the study.

### **1.8. Structure of the study**

This study is organized in five chapters. The first chapter deals with background of the study, research questions, objectives of the research, significance of the study, scope and limitation of the study, and finally the Structure of the study. The second chapter discusses concepts and theories related to the area of study. The review of the literature includes the theoretical review in its first section which is followed by the review of the previous studies related to the area and conclusion and knowledge gap finally. Third chapter presents the research design and methodology as well as the model specification. The fourth chapter discusses the presentation, analysis and interpretation of the data collected and the last chapter makes summary of main findings, conclusion and recommendations.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

The first chapter introduced the problem to be investigated in this study along with purpose and research question. In order to put the study within the context of the existing literature, the subsequent section of this chapter present the review of both theoretical and empirical studies related to innovation, and growth.

This literature review has two sections; the first section contains the theoretical underpinning that comprises issues such as innovation concept, system and stage of innovation as well as Innovation in economic thoughts. These theoretical models are the basis for the hypothesis of this research study.

The second section review empirical research results incorporating the hypothesis of the study and analysis that focus on the link between innovation and economic growth. Similarly, studies that examine the factors that have impact on economic growth in direct collusion with agents of innovation are reviewed thoroughly.

#### **2.1. Theoretical review of Innovation**

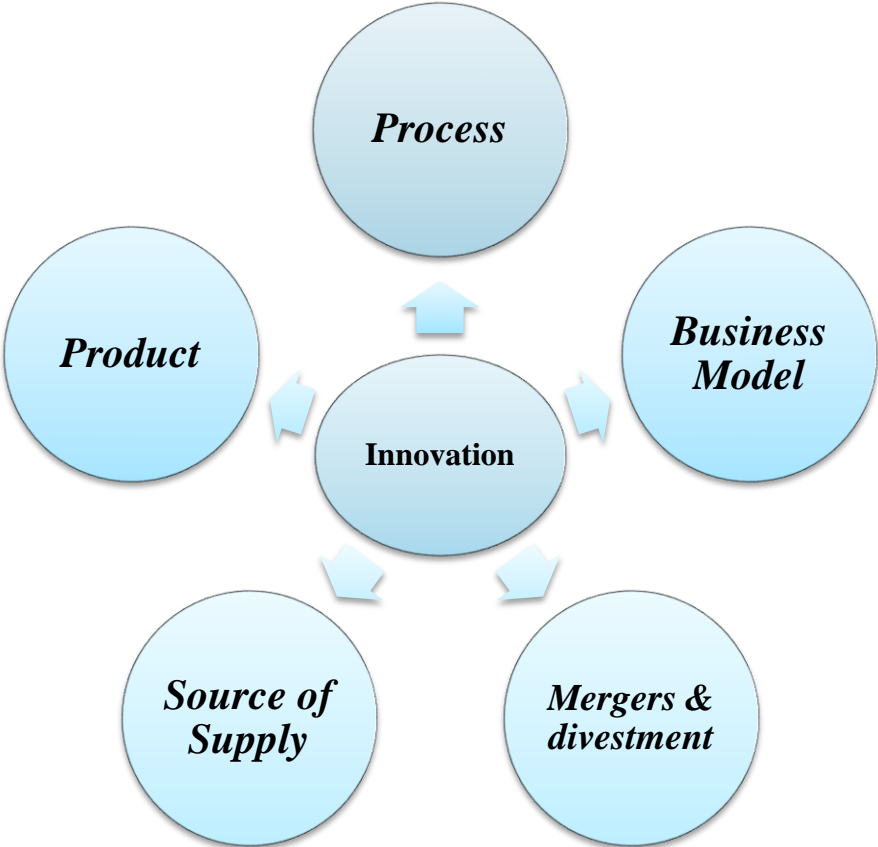
Theoretical framework guides research, determining what variables to measure, and what statistical relationships to look for in the context of the problems under study. Thus, the theoretical literature helps the researcher to identify clearly the variables of the study; provides a general framework for data analysis; and helps in the selection of applicable research design. Hence, this section discusses the theoretical association between innovation and economic growth briefly.

##### **2.1.1. Innovation in Economic theory**

There were numerous literatures' that seek to define innovation and yet there haven't been an agreement on one specific definition so far due to the multifaceted phenomenon that cannot be easily squeezed into a particular branch of the social sciences for the purpose of this study innovation definition and types of innovation use Joseph Schumpeter's version due to most of innovation definitions with other prominent scholars to have an inclusive understanding of the concept in terms of economic growth.

Innovation is a process of transforming the new ideas, new knowledge into new products and services. Schumpeter (1934) defines innovation as an activity which leads to new producing function, new product. He states five activities that cover a wider perspective of that covers the five cases it could be a new or improved product, Process, Business model, Source of supply and Merger and Divestment as portrayed on Figure 1 Below.

**Figure 1** Five cases of innovation on a given economic entity



Source: Authors construct

In line with the Schumpeterian concept, innovation are related to radical or incremental changes that have a significant impact on the structural changes in individual industries and market segments. (Smith K. , 2005) , states innovation is about novelty, something may be old, but it can be new to the firm, or it can be a radically novel idea or it can be only an incremental change. The new production methods are not necessarily based on new scientific discoveries. It may be the use of technologies that have already been used in other industries can also be attributed to new methods. Because innovation is associated with the processes of manufacturing of the

product and its use, the contents of this concept in international development is based on different principles and each cluster of definitions has its specific characteristics (Linton , 2002)

*Incremental innovations* are those that improve price/performance advance at a rate consistent with the existing technical trajectory (Gatignon *et al*, 2002). These are progressive modification of existing product and processes. They are learning by doing and using are small scale but do accumulate leading to significant change over time whereas *Radical innovations* advance the price/performance frontier by much more than the existing rate of progress (Gatignon *et al*, 2002). They are discontinues events that drastic changes existing product or processes. While they are radical they are not sufficient to have wide spread impact on economic system as a whole. Although a cluster of this innovations could have a systemic impact. Peter Dickens classification of innovation has two more types of innovation beside the already stated incremental and radical innovation the Third type of innovation as he noted is a *change in technology system* which involves the combination of both incremental and radical innovation and impact several parts of the economy that may create new sectors. The Fourth type is *change in techno economic paradigm* which are truly large scale revolutionary changes involving new technology systems.

The term “*technological change*” is often used in literature when referring to innovation that confuse many to think innovation is technological progress .Accordingly Mansfield (1969) define technological change as the advancement of technology, such advance often taking the form of new methods of producing existing products, new designs which enable the production of products with important new characteristics, and new techniques of organization, marketing, and management. Bloch (2007), argue due to innovation being the more inclusive concept. Technological change is often perceived to be restricted to manufacturing and not applicable to services.

### **2.1.2. Innovation Verses invention**

The terms innovation and invention are closely related, but although sometimes confused as synonyms, are two very different concepts. Audretsch (2004) argue that invention and innovation are related, but not identical the difference is innovation is a process that begins with an invention, proceeds with the development of the invention, and results in the introduction of a new product, process or service to the marketplace. The definition implies that an invention is a

prerequisite for innovation to take place. Yet, this is not necessarily the case. (Schumpeter, 1961) notes innovations need not necessarily be any inventions at all. They often only are improvements or modifications of products, process or system that has been used for a long period. This implies that no new invention preceded the innovation. It is equally true that all inventions do not necessarily become innovations either. Likewise Herrick & Kindleberger (1983) noted that some inventions cannot be developed into profitable innovations due to cost constraints; therefore inventions do not necessarily become commercially effective.

Herrick & Kindleberger (1983) viewed the distinction as two type; inventions as a deliberate effort by teams or individuals purely for making discoveries while innovations are concerned with making profit. They further describe, the prior as an autonomous technological change, which is undertaken for “idle curiosity”. The later as induced technological change where there is a strong need to convert the products, through systematic development, into something that consumers might prefer. Similarly, Schumpeter (1961) affirms the importance of inventions to be carried into practice in order to become economically relevant. Freeman *et al*, (1982) similarly defined invention as, “The first idea, sketch or contrivance of a new product, process or system, which may or may not be patented” and innovation as “The first introduction of a new product, process or system into the ordinary commercial or social activity of a country”. Freeman (1982) giving a credit for Schumpeter to put innovation on economic development theory he summarized Schumpeter’s distinction of the two concepts as “invention being an idea, a sketch or model for a new or improved device, product, process or system. Such inventions may often (not always) be *patented* but they do not necessarily lead to technical innovations. In fact, the majority do not. An innovation in the economic sense is accomplished only with the first *commercial transaction* involving the new product, process, system or device, although the word is used also to describe the whole process”.

The distinction between the two could also be attributed to institutions that carry them out invention most usually attributed to nonprofit making organization such as research institutes, universities and so on. On contrary, innovation is undertaken in firms. Schumpeter (1961), state invention and innovation are entirely different tasks that require different aptitudes. It is only a coincidence the person who carries out the function of innovation and invention are the same person.

Herrick & Kindleberger, (1983) use the similar concept where they categorize pure science performed by scientists' results in research and produce invention; managers and entrepreneurs' carryout innovation. The former is seen as performing pure science, and the latter is seen as applying the science. Likewise Rogers (1995) distinguish technology and innovation using the same analogy technology is seen as the product of basic research but to design an innovation, the scientific knowledge need to be put into practice to solve a perceived need or problem. However, there is not a clear cut between where basic research ends and applied research begins. Invention and innovation cannot be classified under either pure or applied science. Inventions can be the product of pure science or can be an application of already-existing science. An invention is not yet a commercial application, but can be a science application, where innovation exists when the product or process is commercialized.(Eggink, 2011)

The occurrence of time lags or length between invention and innovation is also one of the elements to distinguish between them Fagerberg, *et al* ( 2005) and Van Duijn (1983) list dates of 160 inventions presented in table 11 in appendix section of this paper show and the corresponding dates of innovation accordingly it shows the different time lags between an invention and the innovation. The time lags ranges, for instance, from one year between the invention of Freon refrigerants and their related innovation to a fifty-six years difference between the invention of the remote control and its related innovation. Mansfield (1969) states the possible reason for the lag may be caused for instance by the entrepreneurs' uncertainty regarding public acceptance of the innovation, by doubts concerning the profitability of the innovation or even just maintenance problems.

In summery innovation and invention as stated earlier are though strongly linked they are two different concepts. They can be distinguished using commercial application, the person or institution who engage on them and range of time lags they take between them.

### **2.1.3. System of innovation**

According to Eggink (2011) innovation system consists of the participants or actors and their activities and interactions, as well as the socio-economic environment within which these actors or participants function that together determine the innovative performance of the system. Greenhalgh & Rogers (2010) define national innovation system as a complex, interrelated system that is behind innovation. According to Goto (2000) national innovation system

essentially consists of three sectors: industry, universities, and the government, with each sector interacting with the others, while at the same time playing its own role. Clearly, innovation by private business does not take place independently of other important actors and institutions. The three main groups of players and their principal roles stated by Greenhalgh & Rogers (2010), is presented as follows.

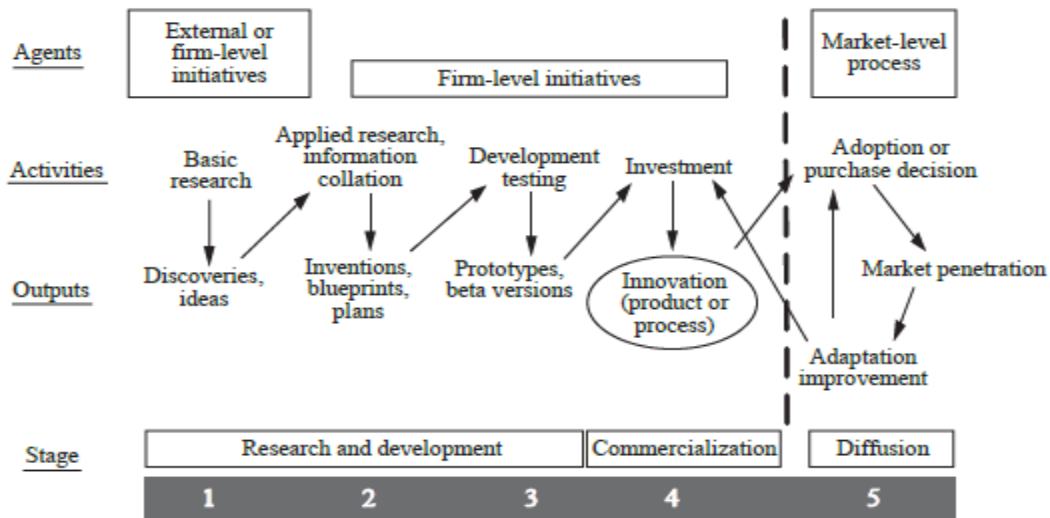
1. **Universities.** These institutions undertake basic science and technology research to discover new knowledge and expand the knowledge base. In turn this generates new possibilities that can be exploited by business. Universities educate the scientists and technicians needed by business and government, as well as the next generation of university scientists. In many countries, scientific research and training is also done by public research laboratories.
2. **Government.** The government designs innovation policy and sets the parameters of the IPR system. Government departments may commission research related to public goods, such as defense and health. They also use tax revenues to finance universities and public research institutions and they may also offer subsidies to business R&D.
3. **Business.** Firms conduct R&D to develop new commercial products using the science knowledge base, acting within the constraints and opportunities of the IPR system and the R&D policy framework. When successful, they launch product and process innovations in response to the perceived needs of their customers and markets. Entrepreneurs start up new firms in response to market opportunities and, if successful, these provide the basis for the large firms of the future.

There are overlaps of objectives and activity of these actors universities sometimes produce commercially viable products while the private sector conducting elements of basic research and are not just focused on the near-market applications of university science. The government has a strong interest in the commercial viability of domestic industries, which depends in part on their innovation record, as viable industries create jobs, earn profits, and also contribute tax revenues. Government also has an interest in supporting the quality of domestic universities, thus acting as the custodian of the part of tax revenues used to fund public science, and guaranteeing the quality of manpower for the science base and industrial R&D of the future. (Greenhalgh & Rogers, 2010)

### 2.1.4. Stages of Innovation

The innovation process has a number of stages that can be distinguished, as shown in figure 1 at each stage of the process there are activities requiring inputs of knowledge, embodied in skilled personnel and specialized equipment, and investment of time in using these resources. Additionally, each stage, if successful, produces an output, initially intangible in the form of new knowledge but later tangible if applied to goods for sale although sometimes remaining intangible if applied to some kinds of service activities.

*Figure 2 The stages of the innovation process*



Source: (Greenhalgh & Rogers, 2010)

The first stages (1–3) of the innovation process produce basic scientific knowledge, plans for new processes or blueprints, and initial prototypes of new products or processes. This is when we may talk of “inventions being made” and the hard work, or genius, of inventors. All of this activity is frequently lumped together as research and development (R&D), but it represents premarket activity by a variety of agents, including public scientific institutions, universities, lone inventors, and firms. It is only when stage 4 is reached, at the point where there is a marketable product or new process, that innovation is achieved. This phase of commercialization triggers the start of another chain of events, broadly characterized as diffusion (stage 5), which covers the widespread adoption of the new product or process by the market. It is also vital to understand that there is feedback between the various stages: innovation is rarely a linear progression through the stages shown. There is also feedback between the diffusion and

innovation stages. As consumers, or other firms, start using the innovations, they often adapt or improve them, or relay information on how to do so back to the innovating firms. (Von Hippel, 2005) This type of refinement, or incremental innovation, is often very important as the initial product or process is rarely perfect. (Greenhalgh & Rogers, 2010)

For any single innovation, all of the stages 1–4 in this diagram are not always conducted in a single firm. In many sectors of the economy public research institutions and university departments will be contributors to the flow of new knowledge that can be translated by firms into innovations. Even where the relevant new knowledge is produced commercially there can be a separation of activity across firms. In fields such as biotechnology and pharmaceuticals, specialist firms exist to perform the R&D of stages 1 and 2, while other firms supply stage 3 testing services for potential new drugs. All of these activities can take place at arm's length from the final marketplace, under contract from the firms that will eventually bring successful new products to the market. This merely indicates that specialization and contracting-out can occur in any part of the innovation process, so long as suitable contracts can be written and enforced. (Greenhalgh & Rogers, 2010)

### **2.1.5. Innovation and long waves in economic thought**

The objective of this study is to evaluate the impact of innovation on economic growth. Hence, the concept of the long wave is the genesis of the association between innovation and growth this section is dedicated to show this particular relationship through discussion of the basic concept analysis and trend of the wave with relevant discussion of business cycle.

In literature, the term “long waves” is sometimes just referred to as “waves”, and is distinguished from the shorter cycles, like the business cycle (Tinbergen, 1984). Regarding the discovery of the wave (Tinbergen, 1984), argues that Van Gelderen, a Dutch economist, was the first economist who recognized these wave-like trends, similarly (Delbeke, 1984) added Parvus and De Wolff to the two former theorists, as economists who originally identified these wave-like trends but it was Kondratiev who is credited for the discovery of the wave and considered a pioneer after his publication of his seminal work “Long waves in economic life” in which he examined and confirmed using data of US, German, British and French economies through analyzing a price-time series (prices of consumer and capital goods) specifically variables such as prices of

raw materials, output products, interest rates, foreign trade, wages, bank deposits and other data reflecting supply and demand changes to assert the existence of extensive business cycles. Furthermore, it was evidenced that capitalist economies are constantly changing from spontaneous, recurrent depression to sustainable economic recovery (Narkus, 2012). Schumpeter built on the long wave theory of Kondratiev by explaining business cycle which gave a twist in understanding of the wave and entertain wide variety of scholarly debate.

Kondratiev lists four main characteristics of changes that lead to a new Kondratieff cycle:

1. Potential for further exploitation of an old basic innovation is exhausted (cycle of around 40-60 years)
2. High level of excess financial capital (versus physical capital)
3. Period of severe recession (period of radical change)
4. Social/institutional transformations.

He identified the growth and decay stages while employing a high number of years between the beginning and the end of the decline. Three long-waves are found by Kondratiev (Duijn, 1983)

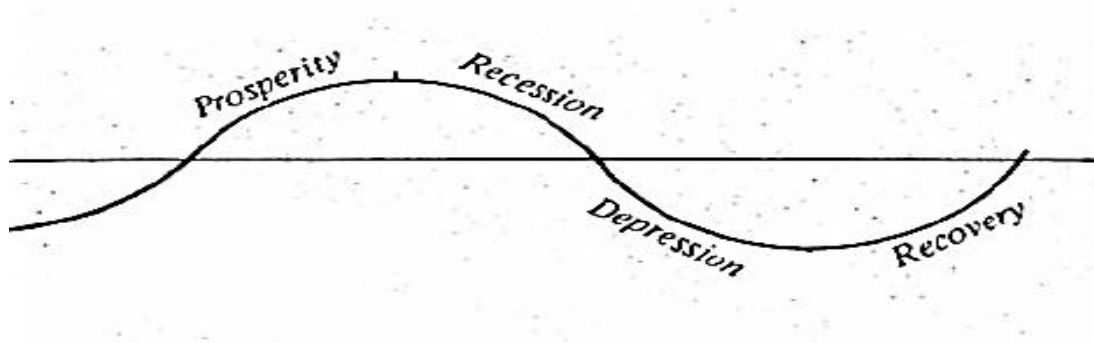
- ↳ The first cycle is identified to last from 1789 to 1849 (Length 60 years).
- ↳ The second cycle is approximated to continue in the period from 1849 to 1896 (Length 47 years).
- ↳ A third cycle started at 1896 and reached the peak in 1920. (Length 35 years).

There have been many discussions and critics of Kondratiev's theory. There is a debate on whether long waves actually exist; another concerning which indicators must be used to describe waves and still another on the lengths of the waves. Other indicators such as national product and national industrial production, investment figures, unemployment, and others were used to empirically long wave theory. (Sundbo, 1998)

(Van Duijn, 1983), empirically analyzed the wave through the analyzing the data of developed countries namely (United kingdom, United states, Italy, Germany, France and Sweden's) industrial production and total output as indicators and concluded that the long wave tendency in the various countries indeed exist, and added a fourth wave. Furthermore he identified and indicated upswing and downswing phases which were not previously mentioned by Kondratiev

that refined the waves by including Schumpeter's business cycle namely recession, depression, recovery and prosperity phases as depicted in figure 1 below.

Figure 3 Schumpeter's Four-Phase Cycle



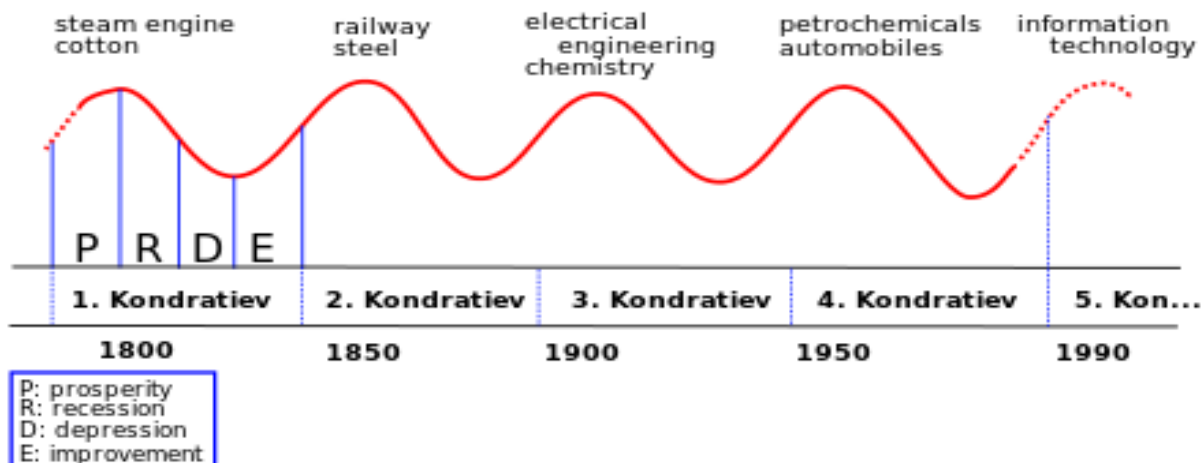
Source: (Narkus, 2012)

Sundbo (1998), concluded the long wave theory has reasonable empirical certainty and is useful for explaining the emergence of the current potential paradigms in innovation theory. The wave length presented by Kondratiev was confirmed empirically by Van Duijn (1983). Likewise, Sundbo (1998) similarly agrees with this view by referring to studies of Mager, Mandel, Glisman, Rodemer & Wolter and of Cleary & Hobbes. The cited studies show the length of the study with in an interval of 45-60 years (Eggink, 2011).

So far as depicted in figure 3 below five waves have been identified according to different authors. These cycles marked times of enormous change, in which technological networks transformed entire societies where

- Old industries were replaced by new ones,
- Corporate cultures and processes changed,
- New professions emerged,
- Extended periods of long-term economic growth resulted,
- Typically associated with rising equity markets.

Figure 4 Inventions in each cycle of the wave



Source: (Nefiodow, 2006)

The long waves have exhibited increasing human welfare levels as a feature for these cycles. The drawback of using an economic growth rate index is that it does not reliably stand for the progress levels or for the general situation in the countries. Long-cycles introduced and discussed by Kondratieff are exclusive as they combine consumption levels, demographic and technological changes in societies. (Narkus, 2012)

The magnitude of change in each of the five waves shown in figure 3 is further explained in Table 1 show the period, invention and area of application is discussed conveniently

Table 1 Trend and analysis of Kondratiev cycles

<i>Kondratiev cycles</i>	1 <sup>st</sup> <i>Kondratiev</i>	2 <sup>nd</sup> <i>Kondratiev</i>	3 <sup>rd</sup> <i>Kondratiev</i>	4 <sup>th</sup> <i>Kondratiev</i>	5 <sup>th</sup> <i>Kondratiev</i>
<i>Period</i>	1780–1830	1830–1880	1880–1930	1930–1970	1970 to today
<i>Invention</i>	Steam engine	Railway, steel	Electrification, chemicals	Automobiles, petrochemicals	Information technology, communications technology
<i>Area of application</i>	Clothing	Mass transportation	Mass production	Individual mobility	Information and communication

Source: (Nefiodow, 2006)

Since the financial crisis in 2008 the search for the drivers of the 6<sup>th</sup> Kondratieff cycle has been predicted by Allianz (2010) to be drawn between two sources:

1. Future megatrends, such as globalization and demographics, that lead to shifts in demand and
2. Trends and innovations that change the supply structure in the economy, such as environmental technology, biotechnology and nanotechnology or holistic health.

## **2.2. Economic growth and Innovation**

The term “economic growth” stands for the quantitative increase of the amount of available goods and services within a national economy which is described by the gross domestic/national income (GDI/GNI) or the gross domestic/ national product (GDP/GNP) per head of population or per head of the (potential) workforce population (labor productivity). (FRENKEL & HEMMER, 1999)

Study on the factors contributing to an economic growth has gained paramount interest as the modern epoch has been characterized by a population explosion, rising life expectancy, rapid urbanization, diversified patterns of employment and steadily rising income per capita for the world as a whole. However, because the Industrial Revolution and economic growth have spread unevenly across the world, the modern era of human history has also witnessed the emergence of unprecedented global inequality. Since sustained economic growth is the most important determinant of living standards, there is no more important issue challenging the research efforts of scholars than to understand the causes of economic growth. (Ucak, 2015)

One of the short comings of conventional economics is an extensive list of factors seen as exogenous or external to the model of the economy including technological change. Technology is viewed as an external factor which impacts the economy and moves it to the new level of equilibrium instinctively this feels unrealistic and a major criticism of conventional economics is that it excludes series consideration of the role of innovation as an endogenous or internal process and force within the economic system. Many economists over a long period of time however has been drawn to this question and have grappled to the concept of innovation and the central role it plays particularly in the capitalist economic system in driving economic growth and productivity.

The theory of innovation will be discussed using the following concepts as subject headings: equilibrium *versus* disequilibrium, innovation as an endogenous versus an exogenous factor of growth, the importance of the entrepreneur in innovation theory, and the concept of clusters of innovation (which will include a discussion on the “long waves” in the economy).

### **2.2.1. Equilibrium versus Disequilibrium**

The most fundamental difference between the classical, neoclassical theories and the Schumpeterian theory is the debate on an economy that tends towards an equilibrium position *versus* an economy that is continually changing and in disequilibrium. Although innovation (or technology, as some sources refers to the concept) has been recognized by some classical economists such as Marx and Adam Smith, the dominant neoclassical theory did not regard innovation or technology as a major category in its models. These models were based on economic equilibrium (Sundbo, 1998).

According to Sundbo (1998) *“The Neoclassical theory is based on an abstract theoretical assumption of general equilibrium in the economy, which would mean that there would normally be no change”*.

Although Keynes criticized certain aspects of the neoclassical school, the Keynesian school of thought itself arose from the neoclassical school and therefore included static equilibrium economics Brue (2000) where innovation seems to be the center of Schumpeter’s theory, Keynes treats it as a phenomenon outside of the economic scene. Another major difference between Schumpeter’s growth theory and that of Keynes is that Schumpeter focuses mainly on the supply side Schumpeter (1961) clarify his position by stating the producer who as a rule initiates economic change, and consumers are educated by him if necessary; they are, as it were, taught to want new things, or things which differ in some respect or other from those which they have been in the habit of using. Therefore, while it is permissible and even necessary to consider consumers’ wants as an independent and indeed the fundamental force in a theory of the circular flow, one must take a different attitude as soon as change is analyzed, on contrary; Keynes’ theory is based on the demand side. (Heertje, 2006)

Schumpeter saw the economy in evolutionary term arguing capitalism is by its very nature a form or method of economic change and capitalism never is and never can be stationary. He

memorably overturns the equilibrium model arguing that the essence of capitalism is a dynamic process of change where the economy is constantly driven by disruptive technological innovation. Schumpeter (1961) argue static analysis is not only unable to predict the consequences of discontinuous changes in the traditional way of doing things; it can neither explain the occurrence of such productive revolutions nor the phenomena which accompany them. It can only investigate the new equilibrium position after the changes have occurred.

The role of innovation in development thus can be explained neither by the classical, neoclassical nor by the Keynesian schools of thought, due to the static basis of their analysis, as well as the neglect of innovation in their theories. It is the Schumpeterian theory, with its explanation of the role of innovation in disturbing the equilibrium situation that is fundamental to the explanation of economic growth.

### **2.2.2. Innovation as an exogenous or endogenous factor**

In the theories of the classical economists, such as those of Adam Smith and Karl Marx, technological change and economic development formed an essential part. But during the late nineteenth and early twentieth centuries, technological change and economic development were neglected by the neoclassical theorists. Neoclassical theories dominated that era. (Verspagen, 2005) The interest in development theories only started flourishing again after 1945. (Brue, 2000). In some of these economic growth theories, innovation was either neglected or totally omitted. Even in those development theories where innovation is included, it is treated as an exogenous factor. According to Hanusch & Pyka (2007) “Neoclassical thinking focuses on the optimal allocation of resources and the adaptations following exogenous shocks such as demographic change, changing preferences, etc.” Thus in Schumpeter’s view innovation is not an external to the economy rather innovation is irrepressible internal driving force of the economy personified by the audacious entrepreneur. Nevertheless, the major work that considers innovation as an exogenous factor was considered by mainstream economist specifically by Solow (1956) who treated technological change as an exogenous factor, which implies that the growth that could not be explained by the variables endogenous to the model must be a result of exogenous technical change (Fagerberg, et al, 2005).

According to the model endogenous variables to growth are capital and labor whereas, technological change is treated exogenous variables in the production function. (Brue, 2000)

Summarized Solow's finding that increases in labor and capital inputs explain less than half of economic growth. The residual is the results from technological progress. Solow's model answers economic growth as it differentiates in investment rate and population growth rate and exogenous in technology to explain the inequality in per capita incomes. It postulates first, rich countries invest more and have lower population growth which allows them to accumulate more investment and more capital per worker and hence increase productivity. Secondly, it attributes the sustained growth to technological progress. Without technological progress, per capita growth will eventually cease as diminishing returns to capital set in. Technological progress, however, can offset the tendency for the marginal product of capital to fall, and in the long run, countries exhibit per capita growth rate of technological progress.

The model accounts for inequality in growth rate across countries through application of transitional dynamics. An economy with a capital-technology ratio below its long-run level will grow rapidly until the capital-technology ratio reaches its steady-state level. This reasoning may help explain why some countries such as Japan and Germany, which had their capital stocks wiped out by World War II, have grown more rapidly than the United States over the last fifty years. Or it may explain why an economy that increases its investment rate will grow rapidly as it makes the transition to a higher output-technology ratio. This explanation may work well for countries such as South Korea, Singapore, and Taiwan which increased their investment rates dramatically since 1950.

However Solow (2008) called technological change "neutral" and defined "neutral" stating, "Shifts in the production function are defined as neutral if they leave marginal rates of substitution untouched but simply increase or decrease the output attainable from given inputs"

Although Solow highlighted the importance of technological change in growth, his theory sharply contrasts with that of Schumpeter's.

Innovation as endogenous variable was first introduced by Romer (1986) developed a model to incorporate technological change as an endogenous factor. Although the model incorporates technological change as an endogenous factor in economic growth theories Romer's model remains another equilibrium model, one similar to the neoclassical growth models. (Eggink, 2011)

It was Schumpeter who developed a development theory with innovation as the major driver, endogenous to the economy and disturbing the equilibrium. He was little concerned with the

effect of the exogenous shocks to the economy, and he focused on the endogenous effect of innovation on the development process. (Hanusch & Pyka, 2007)

According to Schumpeter, innovation is not an external to the economy rather innovation is irrepressible internal driving force of the economy personified by the audacious entrepreneur. Schumpeter saw the economy in evolutionary term arguing capitalism is by its very nature a form or method of economic change and capitalism never is and never can be stationary. In Schumpeter's view the evolutionary character of capitalist process was due to productive change. To innovation that "incessantly revolutionizes the economic structure *from within*, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism." (Schumpeter, 1976)

The description of creative destruction powerfully encapsulate Schumpeter's believe innovation provided energy to the economy with in making economic growth possible and while some aspect of the growth of monopolistic corporation ultimately erode the environment for innovation and undermine capitalism do not enjoy a wide spread currency his memorable description and conception of creative destruction continues to resonate clearly today. Schumpeter (1939) saw that incessant process of innovation is being comprised of two stages. A discrete rush of innovation and a period of absorption of the results of that innovation with this process of stages together form business cycle.

Hanusch & Pyka (2007) Quoting Schumpeter state economic development has to be considered as a process generated within the economic system and there must be a *source of energy* within the economic system which endogenously destroys every equilibrium state which might be reachable. This "source of energy" Schumpeter refers to is innovation that functions as a catalyzer for disturbing equilibrium and generating development. Specifically Schumpeter (1939) called innovation *an internal factor of change*. In Schumpeter's view Innovation is an internal factor because the turning of existing factors of production to new uses is a purely economic process and, in capitalist society, purely a matter of business behavior. It is a distinct internal factor because it is not implied in, nor a mere consequence of, any other. The endogenous nature of innovation differs from that of the neoclassical economists in terms of the production function. Innovation does not vary the quantities of the factors of production in order to produce different quantities, as described by neoclassicism; innovation actually causes a

completely new production function (Schumpeter,1939). This new production function can represent the production of a totally new product, or the change of the inputs or method of production of an existing product, in order to produce something new.

### **2.3. Empirical Review**

In the economic analysis of innovation, patent statistics have been very widely analyzed as a proxy for innovation “output.” In contrast, trademarks and designs have not enjoyed broad coverage in the economic literature as innovation measures, even though they are registered in a wider range of sectors than are patents. The positive benefits of patents as indicators of innovation include the availability of data in many countries, patents indicate an invention that is often a predecessor to an innovation, it proves the inventions has a novelty, and lastly it provide information about changes in the directions of invention. (Greenhalgh & Rogers, 2010)

(Thompson & Rushing, 1996), examine the impact of patent on growth without any distinction between high income, using Panel data of 112 countries covering the period from 1970 to 1985, provide evidence to find a positive, though statistically insignificant relationship between patent and economic growth. Suggest that strong intellectual property rights laws and effective enforcement policies result in more rapid economic growth in countries with an initial level of GDP greater than or equal to \$3,400 (1980). This occurs presumably because protection from patents is the foundation for payoffs to entrepreneurs starting off the chain of events that leads to economic expansion. Furthermore Thompson & Rushing (1999), extend their previous work using panel data of 55 countries both from developing and developed and developing countries conclude that the ‘patent protection’ has a positive and significant impact on total factor productivity in more advance countries.

Janjua & Samad (2007) estimate an empirical relationship between protection of IPR and economic growth for 10 middle income developing countries with balanced and unbalanced data set of 1960-2005 and 1970-74 respectively. The result indicates a negative association between patent and growth. Falvey,*et al* (2006) investigate the impact of IPR protection on economic growth in a panel of 79 countries using threshold regression analysis show that the effect of IPR protection on growth depends upon the level of development, it is positively and significantly related to growth for low and high income countries, but not for middle income countries.This suggests that, although IPR protection encourages innovation in high-income countries, and

technology flows to low-income countries, middle-income countries may have offsetting losses from reduced scope for imitation. In these countries, intellectual property rights do not clearly affect economic growth and most of the industries rely on pirated and imitated technologies.

⇒ **HI:** *There is positive and significant relationship between patent and economic growth*

One of the methods traditionally used as a measurement of innovation in empirical studies is R&D expenditure by firms. This method is popular due to the comparability over time and across countries as it is measured in monetary values and so the R&D can be expressed as a ratio to GDP without the need for exchange rate adjustments when both R&D and GDP are expressed in national currencies. (Archibugi & Coco, 2005)

Yanyun & Mingqian (2004) analyzed the relationship between R&D expenditures and economic growth for 8 ASEAN (Association of South East Nations) countries and Korea, Japan and China for the period of 1994-2003 using panel data. The result conform there is an interactive relationship between R&D expenditures and economic growth. Thus, every country must aim to increase its competitive power and achieve sustainable economic growth, and increase its R&D expenditures.

Griffith, et al (2004) used the “two faces” concept of R&D to explore relationships between R&D and industrial productivity in twelve OECD countries. They find that countries behind the frontier increase their productivity growth by doing R&D.

Falk (2007), examined the effect of R&D expenditures on economic growth for OECD countries with panel data analysis method by using the data related to the period 1970-2004. According to the findings, both the ratio of company's R&D expenditures to GDP, and the share of R&D investments in advanced technology sectors, have strong positive effects on both per capita income and average hourly earnings per capita in the long term.

Peng (2010), analyzed the relationship between R&D expenditures and economic growth for China and reached the conclusion that GDP positively increased by approximately 0.92% if R&D expenditures increase by 1%.

Kim (2011), analyzed the effect of R&D activities on economic growth for Korea by using R&D based Cobb-Douglas production function and the data for the period between 1976-2009. According to empirical findings obtained as a result of the study, the contribution rate of R&D stocks on economic growth is approximately 35%. When analyzed in detail, it is seen that

approximate contribution of private and public R&D stocks on economic growth are 16% and 19% respectively.

⇒ **H2:** *There is positive and significant relationship between R&D expenditure and economic growth*

The idea of technological transfer through export of capital goods is credited to Veblen (1915) who provide the first concise analysis the prospect of Germany catching up with the United Kingdom who were technology leaders through technology catch-up process. Iyoboyi & Na-Allah(2014) states trade can make innovation through technology transfer possible through a variety of ways. One of these is importation into beneficiary country of machinery and equipment made in the innovator country. Innovation activities are often codified and embodied in capital goods such that export of such goods to other countries can imply export of new knowledge. Furthermore, Iyoboyi & Na-Allah (2014) empirically examines the impact of innovation through use of imported capital goods on economic growth in the Nigerian economy during the period 1970-2011 concluded there is a positive significant association of between imported capital goods on economic growth.

Likewise, Veeramani (2008) analyzed the impact through panel data of 90 countries during the period of 1995-2005 concluded with a country's imported capital goods leads to a faster growth rate of income per capita in the subsequent years. The results imply that a 10% increase in IMPY increases growth by about 1.3 to 1.9 Percent.

Cavallo & Landry (2009) examined the impact of imported capital goods and investment specific productivity on the growth of United States. The result indicated that imported capital goods have become an increasing source of growth for the U.S. economy. The result further showed that the U.S. could have lost more than 20 percent of its growth in output per hour without capital-goods imports technology over the past 20 years.

Arawomo (2014) examined (WAMZ) West Africa Monetary Zone i.e., Nigeria, Ghana, Gambia, Guinea, Liberia and Sierra Leone countries between 1970 and 2012. The results indicated that capital import has positive significant impact on economic growth in both short-run and long-run, although the magnitude of coefficient is higher in the long-run.

⇒ **H3:** *There is positive and significant relationship between imported capital good and economic growth*

## **2.4. Measures of innovation**

Innovation in the country as well as firm level has been measured using patent and research and development according to Greenhalgh & Rogers (2010) and the spillover using imported capital goods by (Derese,2016)

There are studies that measure the outcomes of innovation, and here, innovation surveys and innovation counts may be useful. Other studies focus on capabilities to innovate, and in these cases, the R&D expenditure and many of the indices (including indicators such as education, infrastructure, patents, etc.) may be more useful (MARIA, 2011).

In the economic analysis of innovation, patent statistics have been very widely analyzed as a proxy for innovation “output.” In contrast, trademarks and designs have not enjoyed broad coverage in the economic literature as innovation measures, even though they are registered in a wider range of sectors than are patents (Christine & Mark, 2010)

### **2.4.1. Patent**

According to Bronwyn (2007) patent is the legal right of an inventor to exclude others from making or using a particular invention. This right is sometimes termed an ‘intellectual property right’ and is viewed as an encouragement for innovation.

A patent is an exclusive right to exploit (make, use, sell, or import) an invention over a limited period of time (20 years from filing) within the country where the application is made. Patents are granted for inventions which are novel, inventive (non-obvious) and have an industrial application (useful). There are other types of exclusive rights over intangible assets, notably copyright, design protection and trademarks, but patents provide a broader protection that extends beyond the specific expression of an invention to the invention itself. Due to this control over the technology, the patent holder is in a position to set a higher-than-competitive price for the corresponding good or service, which allows recovery of innovation costs. In return, the applicant must disclose the invention in the text of the application, which is published 18 months after application (OECD, 2004)

Thompson & Rushing (1999) argued that intellectual property rights (IPRs) can act as an incentive resulting in the entrepreneurial actions that results in improvements in factor

productivity and in turn a more rapid advancement of economic growth. IPRs may encourage entrepreneurial activity at a variety of levels by: 1) encouraging development of a new product or process with some assurance of a return on resources invested in the effort; 2) creating an incentive to take an innovation from others and finding an application within the economy; or 3) creating an environment increasing the likelihood that an entrepreneur will recognize an opportunity not seen by others and market it in a creative way.

The positive benefits of patents as indicators of innovation are:

- Patents indicate an invention that is often a precursor to an innovation;
- They represent inventions with an expected value above the cost of patenting;
- The invention has been subjected to a test for novelty and non-obviousness;
- Patents are classified by technical fields providing information about changes in the directions of invention;
- Data are available for many countries and for long time periods

#### ***2.4.2. Research and Development***

Research and Development (R&D) is the term commonly used to describe the activities undertaken by firms and other entities such as individual entrepreneurs in order to create new or improved products and processes. The broadest meaning of the term covers activities from basic scientific research performed in universities and laboratories all the way to testing and refining products before commercial sale or use. The performance of, incentives for and the contributions of R&D are topics that are widely studied in management, economics, and other social science disciplines. Total spending on R&D activities is also one of the most widely used indicators of the innovative performance of firms, industries, and countries (Bronwyn, 2007 ).

This method is popular due to the comparability over time and across countries as it is measured in monetary values and so the R&D can be expressed as a ratio to GDP without the need for exchange rate adjustments when both R&D and GDP are expressed in national currencies. (Archibugi & Coco, 2005)

#### ***2.4.3. Imported capital goods***

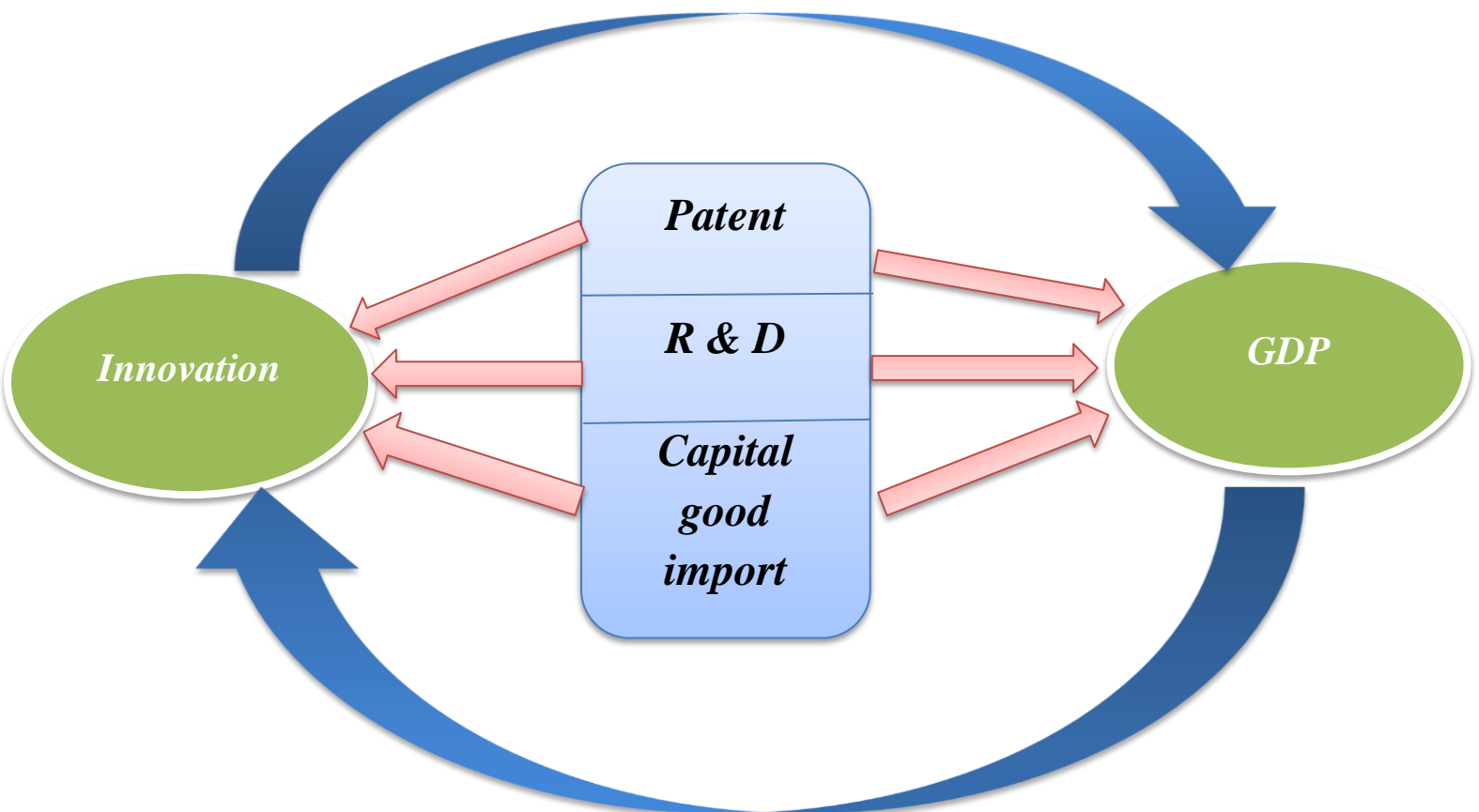
Accordingly Chuang (1998) state countries that use imported capital equipment derive benefits because these products embody foreign knowledge. Spillovers arise in this process of knowledge

diffusion to the extent the imported products cost less than its opportunity costs-including the R&D costs to develop the products. Further, import might facilitate learning about the products through reverse engineering, spurring imitation or innovation of competing products. Also, trade relationships stimulate personal interaction and other channels of communication leading to cross border learning of production methods, product design, organizational methods, and market conditions. Thus, countries import new goods first, then produce them by themselves, and eventually export them.

## 2.5. Conceptual Framework of the model

From the literature review, discussed above, the researcher constructed the following inclusive research frame work was constructed to summarize the main focus and scope of this study in terms of dependent and independent variables included.

*Figure 5 Conceptual Framework of the model*



*Source: Developed by the Author*

## Chapter three

### Research Methodology

In chapter three, the Research Design, Sampling Design, Data Collection Methods, model specification and Data Analysis are discussed in details. All the elements in this chapter are constructed based upon the purpose of the research which is assessing the nexus between innovation and economic growth in Ethiopia. Secondary data is used for this research. The Data is gathered from National bank of Ethiopia, and Ethiopian Intellectual Property Office covering the time period of 1996 to 2017.

#### 3.1 Research Approach

Research approach is to be selected based on the research purpose, the nature of the research, the problem area, and research questions (Alhamadni, et al, 2006). According to Creswell (2003) there are three basic types of research approaches including quantitative, qualitative, and mixed approach.

Creswell (2003) states quantitative research approach enables exploring and understanding the meaning individuals or groups ascribe to a social or human problem. It is particularly useful for data analysis that is inductive and build from specific themes. Consequently, the study in hand requires analyzing relationship between variables based on theories and hypothesis testing using statistical procedures due to the nature of the study the quantitative research approach is adopted.

#### 3.2 Research Design

The main objective of this study is to analyze the nexus between innovation and economic growth in Ethiopia for the period of year 1996 to year 2017.

Since the objective of the study is to examine relationship between variables explanatory research design is employed. The primary purpose of explanatory research design is to determine how events occur and which ones may influence particular outcomes ( Hancock & Algozzine, 2006). Explanatory studies are characterized by research hypotheses that specify the nature and direction of the relationships between or among variables being studied. Cooper & Schindler (2003) stated that explanatory studies unlike descriptive studies, go beyond observing and describing the condition and tries to explain the reasons of the phenomenon. Explanatory

research is devoted to finding causal relationships among dependent and independent variables. It does so from theory-based expectations on how and why variables should be related.

The rationalization for this method of study is it assists the researcher to explain the reasons behind the phenomenon of the relationship between innovation and economic growth in Ethiopia. Furthermore, since it goes beyond the description of variables that are found in major accepted economic theory the method is expected to allow the researcher to use theory-based expectations on how and why variables should be related.

### 3.3 Model Specification

The aim of this research was to investigate the nexus between innovation and economic growth in Ethiopia. The variables are taken from various papers discussed in the empirical literatures taking into consideration the availability of data and appropriateness of the variables in the country's context. Thus, the research is aimed to investigate the relationship between *Patent*, *Research and development (R&D)*, *Imported capital goods (Capital import)*, with *economic growth (GDP)*.

$$GDP = \beta_0 + \beta_1 Pat + \beta_2 R\&D + \beta_3 Capimp + \varepsilon$$

*Source:* Developed for the research

### 3.4 Operationalization of Variables

Table 2 sets down the exact definitions and measurement of each variable used in the study.

Table 2 operationalization and justification of variables

	<i>Notion</i>	<i>Variables</i>	<i>Measure</i>	<i>Empirical Source</i>
<i>Dependent</i>	<i>GDP</i>	Real Gross Domestic Product	Annual Real GDP in Birr	
<i>Independent</i>	<i>Pat</i>	Patent	Annual Number of patent	(Greenhalgh & Rogers, 2010), (Thompson & Rushing, 1999)
	<i>R&amp;D</i>	Research and development	Annual expenditure on R&D in birr	(Bronwyn, 2007 ) (Archibugi & Coco, 2005)
	<i>ImpCapG</i>	Imported capital good	Annual capital import in Birr	(Chuang, 1998) (Veblen, 1915)

*Source:* Developed by the Author

### 3.5. Data collection Method and sources

Data collection plays an important role in a research as it is the most essential information for a study. Moreover, the accuracy of a result is based on the precision of the data and this study used the data collected for analyzing purpose. Basically, data can be categorized into two which are primary data and secondary data. Data can be presented in term of words, numbers, figures or diagrams.

Primary data are information that has not been published. In other words, it is the first-hand-data. The methods for collecting primary data are surveying, experiment, testing or observations. Most of the researchers choose to use primary data instead of secondary data due to it more credibility as it is based on the target population. On the other hand, secondary data are information that has been published or available to public can be collected from Public bodies, Institutions, books, newspapers, journals, and electronic sources such as website, e-journals and etc. Secondary data are less time consuming and costly compared to primary data. This is because the information is collected from previous study by other researchers.

The objective of the study is to examine the association between innovation and economic growth in the Ethiopian through the use of time series data. Table 3 below briefly explain source of data in a convenient manner.

Table 3 Variables and source of data

	<i>Variables</i>	Sources
<i>Dependent</i>	Real Gross Domestic Product	National Plan commission
<i>Independent</i>	Patent	Ethiopian Intellectual Property Office
	Research and Development	National Plan commission
	Imported capital goods	National Bank of Ethiopia

Source: Developed by the Author

### 3.6. Estimation method

#### 3.6.1. Autoregressive Distributed Lag (ARDL) Model

To test the long run relationship between dependent variable and independent variable, the study applies Autoregressive Distributed Lag (ARDL) Model. It is proposed by (Pesaran and Shin, 1997; 1999) to investigate the existence of co-integration relationship among variables. This

approach has specific advantages over Johansen maximum Likelihood (1988) co-integration approaches: First it avoids the problem of the order of integration associated irrespective of  $I(0)$  or  $I(1)$ . Second unlike Johansen co-integration which is valid for large sample size, it is suitable for small sample size study (Pesaran *et al*, 2001). Furthermore, Kremers *et al*, (1992) stressed using long term tests using Eagle-Granger (1987) test, Johansen maximum likelihood test (1988, 1991) and Johansen – Juselius test to estimate long run relationship render unreliable result for small sample size. Third it provides unbiased estimates of the long run model and valid t-statistics even when some of the regressors are endogenous (Harris & Sollis, 2003). Fourth, the classical linear regression model results in spurious output with flawed interpretation of the adjusted  $R^2$ , Durbin-Watson test and t statistic (Granger & Newbold, 1974). Time series analysts were inclined to avoid the dilemma of stationarity by differencing data as much as necessary to make it stationary. As the continual differencing is basically a representation of the dependent variables own past values as well as current and past errors therefore it is deemed a theoretical Kennedy (1998) and Fabozzi, et al (2014) states that variables that are specified in the level or non-stationary form are likely to give spurious results. Using stationary or differenced variables is required in order to deal with this problem. Test for the existence of long-run relationships is required as in the process of using differenced variables the long run information can be lost and only short run information retained Hence, problems encountered through use other popular estimates stated earlier are effectively dealt with through the use of Autoregressive Distributed Lag (ARDL) Model.

### **3.6.2. Granger causality tests**

The dynamic relationship is the simplest technique to use to examine the cause and effect relationship between variables and it is applied in the context of the simple linear regression model. However, the simple linear regression model fails to capture the underlying dynamic causality between variables. Accordingly, in order to examine whether one variable is causally related to another, Granger (1969) introduced a concept of causality which is commonly known as, “Granger causality”. The concept is based on the idea that the future cannot affect the present or the past. In a bivariate framework, if current and lagged values of X improve the prediction of the future value of Y, then it is said that X “Granger causes” Y. The test shall be conducted after all the variables are stationary as recommended by Granger (1988) who argue that if two time series are cointegrated then they are necessarily causally related. It is therefore important to test

for stationary properties of variables before operationalizing the Granger causality tests. Hence, the first difference of variable in question shall be used to test the causality between the variables to have a deeper understanding of the association between them.

### **3.7. Unit Root Test**

In order to examine whether the time series variables are stationary Dickey-Fuller test, Augmented Dickey-Fuller test and/or Phillips-Perron test can be used. The null hypothesis for these tests is that the variables have a unit root and the alternative hypothesis being the variables do not have unit root. If a null hypothesis is rejected and determined that the variable is non-stationary, then the differenced variable is stationary. Dickey-Fuller test (statistics) and Augmented Dickey-Fuller tests (statistics) are deemed to be more reliable than Phillips-Perron test (Fabozzi et al, 2014).

Prior to the estimation the study first investigate the time series properties of the data by using Augmented Dickey-Fuller (ADF). The unit root tests will be used to check the stationarity of the variables and to check none of the variables are order two (I.e.  $I(2)$ ), which is precondition to apply ARDL model (Pesaran, *et al.*, 2001).

### **3.8. Cointegration Test**

Once unit root test is carried out and it assures us that the series is only of integration order of  $I(0)$  or  $I(1)$ . The next step is to carry out bounds test to check if long run relationship exists. The bounds test result shows that the F statistics for the joint significance of all lagged levels of variables and lower and upper critical bounds. If the F statistics is higher than both the lower and upper bounds then there is strong evidence that long-run relationship among variables exists (Jalil & Ma, 2008)

Pesaran, *et al* (2001) give two sets of critical values, one set assuming that all the variables are  $I(0)$ (i.e. lower critical bound which assumes all the variables are  $I(0)$ , meaning that there is no cointegration among the underlying variables) and another assuming that all the variables in the ARDL model are  $I(1)$ ( i.e. upper critical bound which assumes all the variables are  $I(1)$ , meaning that there is cointegration among the underlying variables). For each application, there is a band covering all the possible classifications of the variables into  $I(0)$  and  $I(1)$ . Narayan (2005) states

the existing critical values in Pesaran. et al., (2001) cannot be applied for small sample sizes as they are based on large sample sizes.

Hence Narayan (2005) provides a set of critical values for small sample sizes, ranging from 30 to 80 observations. The critical values are [2.496 - 3.346], [2.962 –3.910], and [4.068 – 5.250] at 90%, 95%, and 99%, respectively.

ARDL bounds test the existence of long run relationships should be assessed before estimating the main model. Nkoro & Uko (2016) the null of non-existence of the long-run relationship is defined by;

Ho:  $\delta_1 = \delta_2 = 0$  (null, i.e. the long run relationship does not exist)

H1:  $\delta_1 \neq \delta_2 \neq 0$  (Alternative, i.e. the long run relationship exists)

Decision rule: if the F-statistics is higher than the critical bounds at 5% level of significance both at I0 bound and I1 bound. The null hypothesis that states that no long run relationship exists is rejected.

### **3.9. Optimal lag selection**

Optimal lag length is calculated using different criterion. This includes final prediction error (FPE), Akaike information criteria (AIC), Schwartz information criteria (SIC), and Hannan-Quinn information criteria (HQIC) (Fabozzi, et al .2014).

The ARDL model specified in equation shall be tested using the appropriate lag-length selection criterion. According to (Pesaran & Shin 1999, as cited by Narayan , 2004) for the annual data a maximum of two lag lengths are recommended. From this, a lag length that minimize AIC is chosen. In addition to this, we have also used AIC to determine the optimal lag because it is a better choice for smaller sample size data as this study. Apart from this, AIC found to produce the least probability of under estimation among all criteria available (Liew & Khimsen , 2004).

### **3.10. Diagnostic Test**

Diagnostic test is done to test whether the sample is consistent with the following assumptions:

1. The long-term model stability test
2. There is no relationship among the error term at the period t and the error term at period before t (No autocorrelation problem)
3. The error term is constant across the number of observations (Homoscedasticity).

4. The error term is normally distributed.

If the above diagnostic tests have proven there is no violation in the data, the model estimated shall have an accurate and reliable. In order to, make the assumption clear the following section in explains briefly of each tests and their respective assumptions’.

### **3.10.1. Model Stability**

In order to check the stability of long-run coefficients that form the error-correction term in combination with short-run dynamics, cumulative sum of recursive residuals test (CUSUM test) and the cumulative sum of squares of recursive residuals test(CUSUMQ test) is applied to the residuals of the models. CUMSUM and CUSUMSQ statistics shall stay within 5% critical bound in order to infer that the stability of short run dynamics and long run parameters of the model (Brown *et al*, 1975)

### **3.10.2. Test for residual autocorrelation**

According to Fabozzi *et al*, (2014) one of the assumed properties of error term is that no statistically significant correlation between adjacent residuals exists. It is also assumed that the independent variables are not correlated with the residuals. A time series is said to be autocorrelated if each term is correlated with its predecessor so that the variance of each term is partially explained by regressing each term on its predecessor. Brook (2008) states in the case of autocorrelation problem, the estimated parameters can still remain unbiased and consistent, but it is inefficient. The result of T-test, F-test or the confidence interval will become invalid due to the variances of estimators tend to be underestimated or overestimated. Due to the invalid hypothesis testing, it may lead to misleading results on the significance of parameters in the model. In this study to test for the existence of autocorrelation, the popular Breusch-Godfrey Serial Correlation LM Test was employed.

H<sub>0</sub>: There is no autocorrelation problem in the model.

H<sub>1</sub>: There is autocorrelation problem in the model.

$\alpha = 0.05$

Decision Rule: Reject H<sub>0</sub> if p-value less than significance level. Otherwise, do not reject H<sub>0</sub>.

The incidence of auto correlation in time series makes hypothesis testing of regression coefficients questionable by way of significantly miscalculating variances.

### 3.10.3. Test for residual heteroscedasticity

According to Fabozzi *et al* (2014), states the variance of the error term is constant regardless of the level of the independent variable. If this assumption holds, the error terms are said to be homoscedastic. If this assumption is violated, the variance of the error term is said to be Heteroscedastic. Brook (2008) noted the presence of Heteroscedasticity makes the estimators of the inefficient and hypothesis testing is no longer reliable or valid as it will underestimate the variances and standard errors.

There are several tests to detect the Heteroscedasticity problem, which include Park Test, Glesjer Test, Breusch-Pagan-Goldfrey Test, White's Test and Autoregressive Conditional Heteroscedasticity (ARCH) test. In this study, Autoregressive Conditional Heteroscedasticity (ARCH) shall be employed to test for the presence of Heteroscedasticity. The hypothesis for the Heteroscedasticity test was formulated as follow:

H0: There is no Heteroscedasticity problem in the model.

H1: There is Heteroscedasticity problem in the model.

$\alpha = 0.05$

Decision Rule: Reject H0 if p-value is less than significance level. Otherwise, do not reject H0.

### 3.10.4. Test for Normality

Normality tests are used to determine if a data set is well-modeled by a normal distribution. Jarque-Bera test statistic, chi-square test statistics and analysis of standardized residuals are the methodologies employed to test for normality of error terms. (Fabozzi *et al.*, 2014). The null hypothesis in normality test is that the error terms are normally distributed. This study uses Jarque-Bera test statistic to This study used JarqueBera Test (JB test) to find out whether the error term is normally distributed or not. The hypothesis for the normality test was formulated as follow:

H0: Error term is normally distributed

H1: Error term is not normally distributed

$\alpha = 0.05$

Decision Rule: Reject  $H_0$  if p-value of JB test less than significance level. Otherwise, do not reject  $H_0$ . It is widely used in computer software packages

### **3.11. Conclusion**

Chapter three included the methodology used to perform data analysis in Chapter four. This study employed secondary quantitative data to measure the variables in question and Autoregressive Distributed Lag (ARDL) Model shall be used to test the hypothesis in question after the essential diagnostic tests have been performed in combination with pairwise Granger causality test to evaluate the nexus between innovation and economic growth in Ethiopia. Chapter four will in detail discuss the diagnostic tests carried out on the collected data consecutively the hypothesis tested will be represented in convenient manner

## CHAPTER FOUR

### DATA ANALYSIS AND INTERPRETATION

In the preceding chapter the research design employed in this study is presented and discussed in detail. The purpose of this chapter is to present results and analysis of data involved in this study. Accordingly, the results of hypothesis testing i.e. the estimated parameters of the regression equation, their significance, the connection between the independent and dependent variable according to the sign and the value of the parameters for the long run and short term ECM as well as causality test between the main source of innovation are presented and discussed in detail.

#### 4.1. Unit root test

The ARDL model allows us to precede with estimation regardless of whether the underlying variables are I (0) or I (1). Prior to the estimation the study first investigate the time series properties of the data by using Augmented Dickey-Fuller (ADF). The unit root tests will be used to check the stationarity of the variables and to check none of the variables are order two (I.e. I (2)), which is precondition to apply ARDL model (Pesaran, *et al.*, 2001). Accordingly The result in Table 4 shows that there is a mixture of I(0) and I(1)but not any order two.

Table 4: Unit Root result of the variables

Augmented Dickey-Fuller test statistic (ADF Test)							
R.no	Variable	With Intercept			Trend and Intercept		
		At Level	At First Difference	Order of [ ]	At Level	At First Difference	Order of [ ]
1	GDP	S	S	I[0]	S	S	I[0]
2	IMPORTED CAPITAL GOODS	S	S	I[0]	S	S	I[0]
3	PATENT	S	S	I[0]	S	S	I[0]
4	R&D	S	S	I[0]	S	S	I[0]

*S\** represents that the variable is stationary

*NS\** represents that the variable is non-stationary

Source: Authors computation of Eview 9 results

Form the above table 4 indicate that none of the variables entered in the regression are order two, which are not desire in applying ARDL model. So ARDL co-integration technique proposed by

Pesaran *et al.* (2001) is the most appropriate method for estimation or to check the long run and short run relationship among the variables.

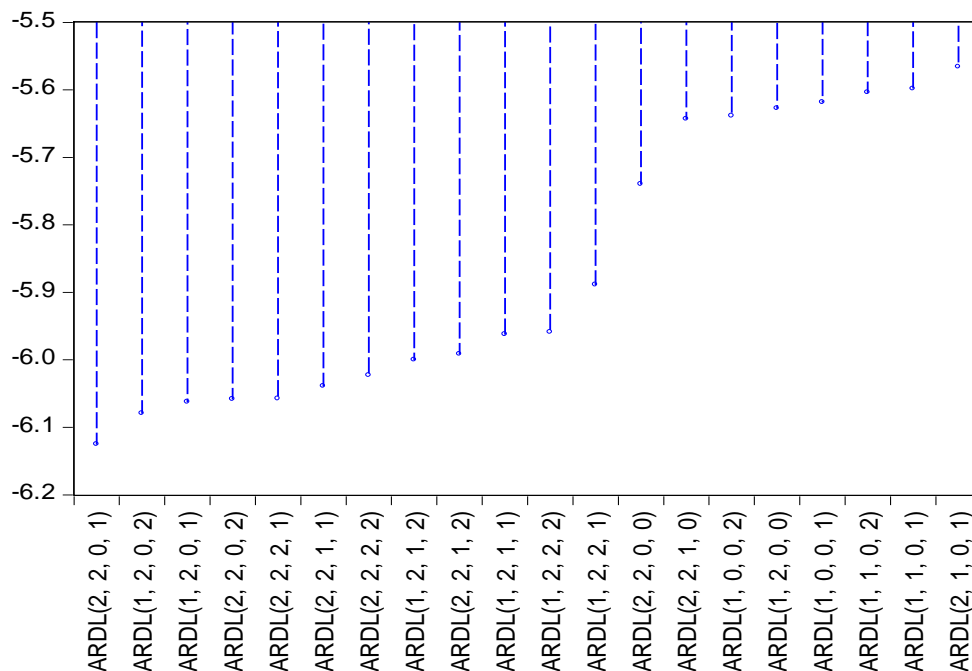
#### 4.2. Optimal lag selection

The ARDL model specified in this study was tested using the appropriate lag-length selection criterion. According to (Pesaran & Shin 1999 cited by Narayan 2004) for the annual data a maximum of two lag lengths are recommended.

From this, a lag length that minimize AIC is chosen. In addition to this, AIC was used to determine the optimal lag because it is a better choice for smaller sample size data as this study. Apart from this, AIC found to produce the least probability of under estimation among all criteria available (Liew & Khimsen , 2004). The estimation result in the appendix 1 indicate from 54 possible models, the top 20 model is selected and computed automatically through EViews 9 with the employment of AIC the final 20 top model summery is shown in Figure 4 how well some other specifications performed in terms of minimizing AIC.

**Figure 6 Akaike Information Criteria**

Akaike Information Criteria (top 20 models)



Source: Authors computation of Eview 9 results

### 4.3. Cointegration Test

Pesaran.*et al*, (2001), describe a methodology for testing whether the ARDL model contains a long-run relationship between the independent variable and the regressors. One of the steps in determining ARDL is the determination of long run relationship is testing a long term cointegration through use of ARDL bounds test before estimating the main model. (Nkoro & Uko, 2016)The null of non-existence of the long-run relationship is defined by;

Ho:  $\delta_1 = \delta_2 = 0$  (null, i.e. the long run relationship does not exist)

H1:  $\delta_1 \neq \delta_2 \neq 0$  (Alternative, i.e. the long run relationship exists)

Decision rule: if the F-statistics is higher than the critical bounds at 5% level of significance both at I0 bound and I1 bound. The null hypothesis that states that no long run relationship exists is rejected.

**Figure 7 Result of ARDL Bounds Test**

ARDL Bounds Test		
Sample: 1998 2017		
Included observations: 20		
Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	K
F-statistic	8.921733	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

Source: Authors computation of Eview 9 results

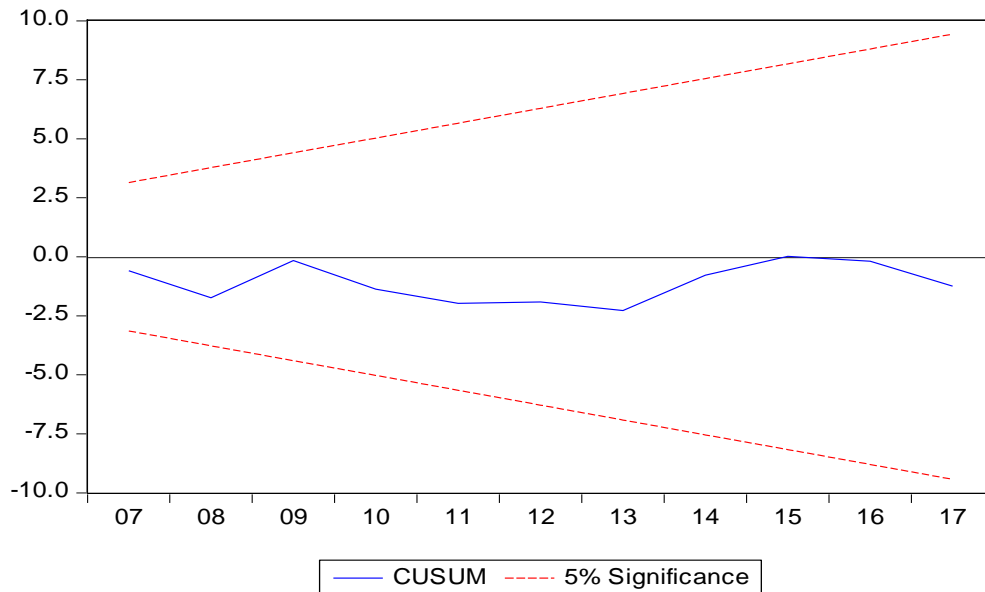
F-statistic for the Bounds Test is 8.92, and this clearly exceeds even the 1% critical value for the upper bound. Accordingly, we strongly reject the hypothesis of "No Long-Run Relationship" in Figure 7 .As a result, it can be concluded that long run relationship exists between the variables and can proceed to the next step to assess the basic diagnostic test.

#### 4.4. Diagnostic tests

##### 4.4.1. Model Stability

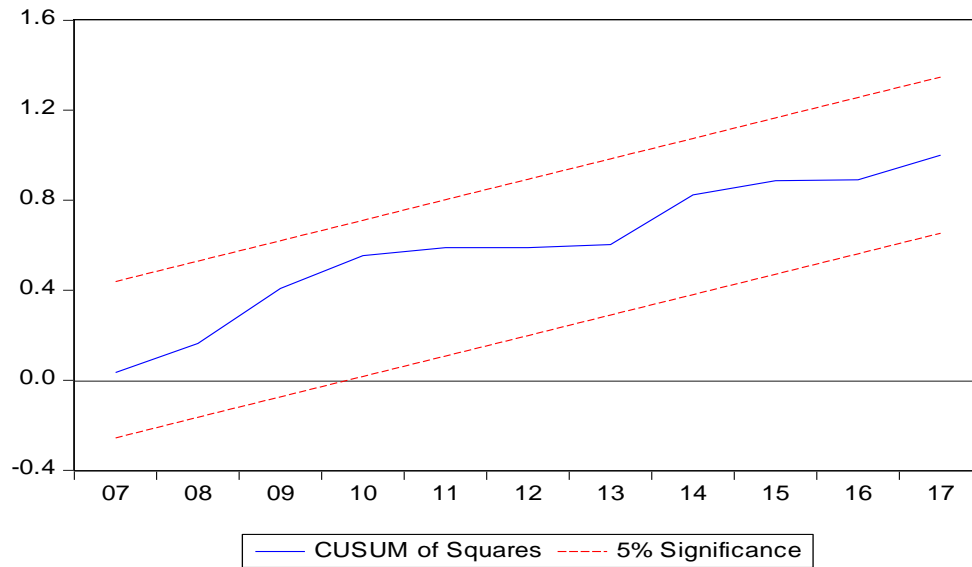
In order to check the stability of long-run coefficients that form the error-correction term in combination with short-run dynamics, cumulative sum of recursive residuals test (CUSUM test) and the cumulative sum of squares of recursive residuals test(CUSUMQ test) is applied to the residuals of the models. CUMSUM and CUSUMSQ statistics shall stay within 5% critical bound in order to infer that the stability of short run dynamics and long run parameters of the model (Brown *et al*, 1975).The CUSUM and CUSUMSQ tests are shown in Figures 4 and 5 respectively.

Figure 8 Cumulative sum of recursive residuals test (CUSUM test)



Source: Authors computation of Eview 9 results

Figure 9 Cumulative sum of squares of recursive residuals test (CUSUMQ test)



Source: Authors computation of Eview 9 results

From Figures 4 and 5, both the CUSUM and CUSUMSQ plots do not cross the 5% critical lines, implying that over the period of the study, the stability of the estimated coefficients exist, so that the regression coefficients are reliable and suitable for policy making.

#### 4.4.2. Test for residual autocorrelation

A time series is said to be autocorrelated if each term is correlated with its predecessor so that the variance of each term is partially explained by regressing each term on its predecessor. (Brook, 2008), states in the case of autocorrelation problem, the estimated parameters can still remain unbiased and consistent, but it is inefficient. The result of T-test, F-test or the confidence interval will become invalid due to the variances of estimators tend to be underestimated or overestimated. Due to the invalid hypothesis testing, it may lead to misleading results on the significance of parameters in the model. In this study to test for the existence of autocorrelation, the popular Breusch-Godfrey Serial Correlation LM Test was employed. The hypothesis for the Breusch-Godfrey Serial Correlation LM test was formulated as follow:

H<sub>0</sub>: There is no autocorrelation problem in the model.

H<sub>1</sub>: There is autocorrelation problem in the model.

$\alpha = 0.05$

Decision Rule: Reject H<sub>0</sub> if p-value less than significance level. Otherwise, do not reject H<sub>0</sub>.

Table 5 Breusch-Godfrey serial correlation LM test result

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.692256	Prob. F(2,9)	0.5252
Obs*R-squared	2.666495	Prob. Chi-Square(2)	0.2636

Source: Authors computation of Eview 9 results

As shown in table 5, all versions of the Breusch-Godfrey serial correlation LM test statistic (F-statistic, Chi-Square) gave the same conclusion that there was no evidence for the presence of autocorrelation in this particular study. Since the p-values of 0.5252 and 0.2636 for F-statistic and Chi-Square respectively were in excess of 0.05, the null hypothesis should not be rejected.

**4.4.3. Test for residual heteroscedasticity**

According to Fabozzi *et al*, (2014), states the variance of the error term is constant regardless of the level of the independent variable. If this assumption holds, the error terms are said to be homoscedastic. There are several tests to detect the Heteroscedasticity problem, which include Park Test, Glesjer Test, Breusch-Pagan-Godfrey Test, White’s Test and Autoregressive Conditional Heteroscedasticity (ARCH) test. In this study, Autoregressive Conditional Heteroscedasticity (ARCH) was used to test for the presence of Heteroscedasticity. The hypothesis for the Heteroscedasticity test was formulated as follow:

H0: There is no Heteroscedasticity problem in the model.

H1: There is Heteroscedasticity problem in the model.

$\alpha = 0.05$

The Decision Rule is Reject H0 if p-value is less than significance level. Otherwise, do not reject H0. Table 6 below present the result of Heteroskedasticity ARCH Test conducted in the study.

**Table 6 Result of Heteroskedasticity ARCH Test**

Heteroskedasticity Test: ARCH

F-statistic	1.683946	Prob. F(1,17)	0.2117
Obs*R-squared	1.712431	Prob. Chi-Square(1)	0.1907

Source: Authors computation of Eview 9 results

As shown in table 6, all versions of the white test statistic (F-statistic and Chi-Square) gave the same conclusion that there was no evidence for the presence of heteroscedasticity in this particular study. Since the p-values of 0.2117 and 0.1907 for F-statistic and Chi-Square respectively were in excess of 0.05, the null hypothesis should not be rejected.

#### 4.4.4. Test for Normality

Normality tests are used to determine if a data set is well-modeled by a normal distribution. Jarque-Bera test statistic, chi-square test statistics and analysis of standardized residuals are the methodologies employed to test for normality of error terms (Fabozzi *et al.*, 2014). The null hypothesis in normality test is that the error terms are normally distributed. This study used Jarque-Bera test statistic to This study used JarqueBera Test (JB test) to find out whether the error term is normally distributed or not. The hypothesis for the normality test was formulated as follow:

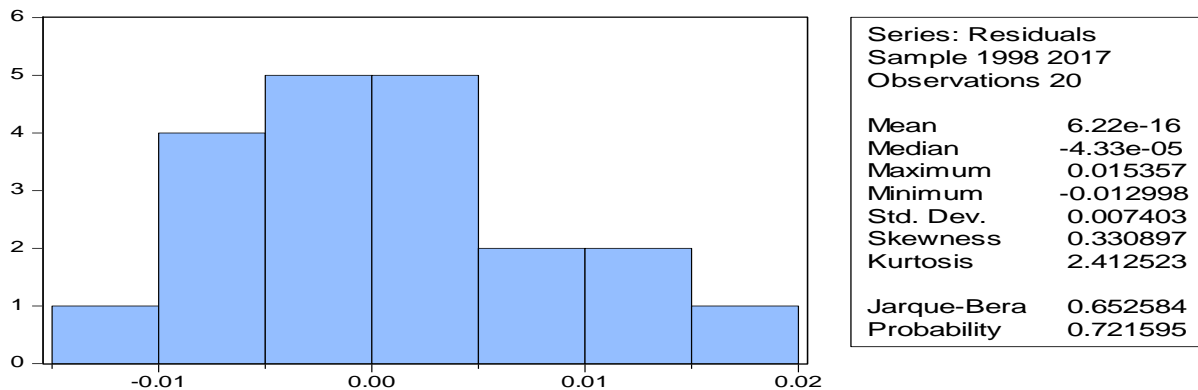
H0: Error term is normally distributed

H1: Error term is not normally distributed

$\alpha = 0.05$

The Decision Rule is Reject H0 if p-value of Bera-Jarque test is less than significance level. Otherwise, do not reject H0. Table 9 below present the result of Normality (Bera-Jarque test) conducted in the study.

**Figure 10 Result of Normality Test: Bera-Jarque test**



Source: Authors computation of Eview 9 results

Figure 9 indicate that distribution of the time series observation is symmetric about its mean. The Jarque-Bera statistic has a P-value of 0.7215 implies that the p-value for the Jarque-Bera test is greater than 0.05 which indicates that there was no evidence for the presence of abnormality in the data. Thus, the null hypothesis that the data is normally distributed should not be rejected since the p-value was considerably in excess of 0.05.

## 4.5. Discussion of result

The empirical evidence the effect of innovation on growth in Ethiopia is studied based on time series data for the time span that stretches from 1996-2017. To test the relationship between innovation and growth in the following autoregressive distributed lag (ARDL) regression model was developed.

$$GDP = \beta_0 + \beta_1 Pat + \beta_2 R\&D + \beta_3 Capimp + \varepsilon$$

The definition of all individual variables included in the above equation is discussed in the methodology part of the study.

**Table 7 Co-integrating and Long Run Result of ARDL model (2, 2, 0, 1)**

ARDL Cointegrating And Long Run Form  
 Dependent Variable: GDP  
 Selected Model: ARDL(2, 2, 0, 1)  
 Sample: 1996 2017  
 Included observations: 20

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	0.237108	0.170023	1.394568	0.1907
D(PATENT)	-0.109795	0.044255	-2.480958	0.0305
D(PATENT(-1))	0.062938	0.019646	3.203605	0.0084
D(R_D)	0.389650	0.105376	3.697717	0.0035
D(IMPCAPG)	-0.040664	0.040352	-1.007730	0.3352
CointEq(-1)	-0.716995	0.156285	-4.587728	0.0008

Cointeq = GDP - (-0.3144\*PATENT + 0.5434\*R\_D + 0.0864\*IMPCAPG + 4.1483 )

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
PATENT	-0.314371	0.045755	-6.870690	0.0000
R&D	0.543449	0.050321	10.799556	0.0000
IMPCAPG	0.086372	0.047723	1.809852	0.0977
C	4.148335	0.161710	25.652944	0.0000

Source: Authors computation of Eview 9 results

The dependent variable being regressed is economic growth of the country which is measured by

RGDP (Real Gross Domestic Product). Innovation proxies used as explanatory variables include number of patent, R&D investment in the country level are found to be significant regressors of economic growth in Ethiopia in the long run. On the other hand the findings revealed that, the imported capital good had no significant association with the growth of the country. The following section in detail demonstrates the effect of each explanatory variable's on economic growth of the country.

#### **4.5.1. The Association of Patent on Economic Growth**

Hypothesis testing of the relationship between Patent and economic growth in Ethiopia:

⇒ **H1:** *There is positive and significant relationship between patent and economic growth*

The estimation result of ARDL model in table 7 shows that in the long run holding other variables constant a unit increase in patent decrease the economic growth by 31.4% and statistically significant at one percent. Thus, the hypothesis of positive association between patent and economic growth is rejected. The possible reason for the finding mainly revolves around two factors. First, the country is at the transitional stage of it is economic development the cost of innovation is higher than the cost of imitation and additionally due to poor R&D activities with fewer inventions and weak protection of IPR most of the industries with in the economic system rely on pirated and imitated technologies. Secondly, due to lack of secured property rights, most of available assets cannot be turned into productive capital and tradable items, which result into less technological growth with high borrowing costs. This finding is also consistent with (Janjua & Samad, 2007 citing De Soto, 2000 and Falvey.et al, 2006)

Likewise Janjua & Samad (2007) by referring to World Bank (2002, 2003, 2005), World Intellectual Property Organization and UNCTD assert IPR can help in revenues generation, improve balance of payment (BoP), Provide access to international markets, create confidence to investors, and productivity. The absence of strong IPR on contrary obviously affects the economy in a loss of significant output and the possible cause of the study's finding.

Furthermore, the pairwise causality test shown in table 8 below indicates economic growth is causing a stronger IPR regime and has a unidirectional causality.

**Table 8** Pairwise Granger Causality Tests between Patent and GDP

Pairwise Granger Causality Tests  
Sample: 1996 2017  
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
DPATENT does not Granger Cause DGDP	20	0.00171	0.9675
DGDP does not Granger Cause DPATENT		5.44272	0.0322

Source: Authors computation of Eview 9 results

The result is consistent with empirical findings of (Sattar & Mahmood, 2011), that reveal the impact of IPR is found to be more significant in high income countries as compared to middle and low income countries. Similarly, the effect is stronger in case of upper middle income countries as compared to lower middle income and low income countries.

Likewise, Falvey.*et al*, (2006), Janjua & Samad, (2007) and Sattar & Mahmood, (2011) contend the effectiveness of IPR protection depends upon various stages of development and structure of the concerned economies the more the country's economy growth the better protection shall be given to the IPR. The structure of the economic growth in Ethiopia and the level of the economic development is the possible justification for the result of the causality.

The short run result of the study shown in table 7 also confirms negative statistically significant association between patent and economic growth indicating rampant counterfeit which cause a huge output loss in industries in the long run also contribute to a loss in productivity in short run of the country as well.

#### **4.5.2. The Association of R&D on Economic Growth**

Hypothesis testing of the relationship between R&D and economic growth in Ethiopia:

⇒ **H2:** *There is positive and significant relationship between R&D and economic growth*

The estimation result of ARDL model in table 7 shows that in the long run holding other variables constant a unit increase in R&D investment increase the economic growth by 54.3% and statistically significant at one percent. Thus, the hypothesis of positive association between patent and economic growth is accepted. The result is consistent with previous results of Falk (2007), Peng (2010) and Kim (2011).The possible explanation for the result is that due to the

country pledge to transfer from agriculture to industry without expenditure in the R&D sustainable growth in the last a few years was unthinkable . The countries progress is dependent on innovative activity mainly on the R&D. The pairwise causality test shown in table 9 indicates economic growth is causing R&D investment and has a unidirectional causality. The result is consistent with Bozkurt (2015) who suggested as real economic activities and growth rate increase, R&D must also increase for sustainability.

**Table 9** Pairwise Granger Causality Tests between R &D and GDP

Pairwise Granger Causality Tests  
 Sample: 1996 2017  
 Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
DR&D does not Granger Cause DGDP	20	2.39120	0.1404
DGDP does not Granger Cause DR&D		4.69719	0.0447

Source: Authors computation of Eview 9 results

The importance of technological development is an essential for increasing efficiency and competitiveness as part of technological development R&D is an essential for catching up with leading countries and reduce dependency. (Bozkurt, 2015)

The short run result of the study shown in table 7 also confirms positive statistically significant association between R&D and economic growth. STIC (2014) indicate Ethiopia R&D intensity in terms of the GDP account for 0.61% that is highly dependent on government expenditure as per the survey which accounts for 79.1% alone would be make it highly unlikely to meet target of the country reaching 1% in terms GDP that is set by Executive Council of the African Union on Science and Technology in 2006 for African countries to devote at least one percent of their GDP on R&D activities. Currently Ethiopian private company spending ranks (133<sup>rd</sup> out of 142) countries and without significant involvement of the private sector future innovative capacity to advance and develop new products compared to other countries would face a serious challenge. Hence, to encourage the private sector tax incentive as well as industry and university linkage must be maintained for sustainable growth of the country.

### 4.5.3. The Association of Imported capital good on Economic Growth

Hypothesis testing of the relationship between imported capital goods and economic growth in Ethiopia:

⇒ **H3:** *There is positive and significant relationship between imported capital goods and economic growth*

The estimation result of ARDL model in table 7 shows that in the long run holding other variables constant a unit increase in imported capital goods increase the economic growth by 8% but statistically insignificant. Thus, the hypothesis of positive association between imported capital goods and economic growth is rejected. The result is contrary to the previous results of (Veeramani , 2008) and (Arawomo, 2014).

The possible justification for the result is generally the volume of a country's imported capital goods is end product that is light duty which aimed to transfer the agricultural output to end product that doesn't cause significant impact on the level of output in the economy. Additionally, the chronic problem of gaining access to hard currency and depreciation of the national currency has had a large negative effect on both intermediate imports and economic growth as the time lag to procure the goods and actual initial production yield would entertain a devalued selling price of the product. This finding is also consistent with (Alemu & Jin-sang, 2014)

The short run result of the study shown in table 7 also confirms positive but statistically insignificant association between imported capital goods and economic growth. In line with the study Iyoboyi & Na-Allah (2014) suggests that innovation activities tend to take some time before its impact on growth is felt and given the huge expenditure on capital goods might not immediately translate into desired product. As the importation of technology-embodied capital goods would require time to improve current production levels, due inevitably to set up and associated costs. technological product innovation involves the implementation/adoption of new or significantly improved production or delivery method, which may involve changes in equipment, human resources, working methods or a combination of these, all of which are not likely to be achieved within a short period. Thus the sign of the current period coefficient of innovation is not out of place.

**Table 10 Pairwise Granger Causality Tests between imported capital goods and GDP**

Pairwise Granger Causality Tests

Sample: 1996 2017

Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
DGDP does not Granger Cause DCAPIMPG	20	2.35146	0.1436
DCAPIMPG does not Granger Cause DGDP		14.7202	0.0013

Source: Authors computation of Eview 9 results

Although the long term and short term result in table 7 show statistically insignificant association between imported capital goods and economic growth the pairwise causality test shown in table10 above indicate imported capital goods are causing economic growth and has a unidirectional causality. This implies the imported capital goods though have insignificant association the increase in output is causing the growth in the economy.

#### **4.5.4. Result of Error correction term**

Table 7 shows that the coefficient of the error correction term for profitability negative and statistically significant at one percent. The coefficient of the error correction term is -0.716995. This indicates that the adjustment process back to the long run equilibrium after a shock is 71% annually. The result shows that the short run innovation activity reaches is converging back to its long run equilibrium, it will converge back to its equilibrium. Hence, full adjustment requires one year and five month. The adjustment process explains the consistent growth of the country indicating innovation played a center role as one of the major factor for the success of the country.

## CHAPTER FIVE

### CONCLUSION AND RECOMMENDATION

In the preceding chapter the results and analysis of data was presented and discussed in detail. The purpose of this chapter is to give a conclusion based on the analysis of this study. Accordingly, the main conclusion, recommendation and future research direction shall be discussed.

#### 5.1. Conclusion

The broad objective of this research was to investigate the relationship between innovation and economic growth in Ethiopian. To achieve this broad objective, the study used quantitative research approach. The data used are collected from EIPO, NPC and NBE over the period of 1996 to 2017 were employed and analyzed using ARDL multiple regression analysis and Granger causality test.

The regression analyses were made in line with the specific research objectives and stated hypotheses formulated in the study. In doing so, previous studies on innovation and economic growth have been reviewed and as per the literature GDP of the country is usually expressed as a function of innovation proxy through Patent, R&D and imported capital goods. Consequently, the empirical findings of this particular study suggested the following conclusions.

First, in the long run as well as short term patent is has significant adverse association with economic growth. Since the country is in the transitionary stage of it is economic development the cost of innovation is higher in capital constrained economy making it easier to use imitated and pirated technologies and most of the industries rely on counterfitted products. The Pairwise Granger Causality tests confirm as the level of economy of the country progress the IPR regime also shall be improved as well.

Second, in the long run as well as short term investment in R&D has significant positive association with economic growth. The result is an indicative of the essential feature of R&D in the economy in a better utilization of resource and decency of other leading countries. The Pairwise Granger Causality tests confirm the real economic activities and growth rate increase

R&D investment have a unidirectional causality as economy increase the R&D also increase which is one of the factor of the sustainable economic growth.

Thirdly, in the long run as well as short term imported capital goods has insignificant positive association with economic growth. The long run result is due to the fact that the existence of chronic hard currency problem, depreciation in national currency in the time of procurement and initial production stage as well as the goods imported are mainly end product that is light duty which aimed to transfer the agricultural output to end product that doesn't cause significant impact on the level of output in the economy. While, in the short run the importation of technology-embodied capital goods would require time to improve current production levels, due inevitably to set up and associated costs. technological product innovation involves the implementation/adoption of new or significantly improved production or delivery method, which may involve changes in equipment, human resources, working methods or a combination of these, all of which are not likely to be achieved within a short period. The pairwise causality test shows imported capital goods are causing economic growth and has a unidirectional causality though statistically insignificant it is contributing to economic growth.

## **5.2. Recommendation**

The findings of the study showed that patent and R&D has a significant positive association with economic growth in Ethiopia during the study period. Hence, focusing and taking the necessary action on these indicators could have a significant impact on socio economic policy in Ethiopia in the coming years.

Based on the findings of the study the following possible recommendations are forwarded:

1. Enforcing a stronger IPR regime may cause an inflationary pressure, surging unemployment and exacerbate balance of payment. Hence, the government need to synchronize it is activity of becoming signatory of the world trade organization once it becomes a member it would face a serious challenge to meet the expected standard as the failure to meet the requirement isolate the country in an international market as well as erode the confidence of investors.
2. Sustainable economic growth requires an investment in R&D and the finding being clearly reflective of this scenario, Thus high dependence on government expenditure alone would make it unlikely to meet it is target of the country reaching 1% of it is target

.According to Company spending on R&D Ethiopian companies are the least spenders in the R&D which ranks (133<sup>rd</sup> out of 142) countries. This might limit Ethiopia's future innovative capacity to advance and develop new products compared to other countries. Hence, to encourage the private sector tax incentive as well as the linkage between university and industry should be evaluated periodically on their effectiveness of providing a useful innovation.

3. Spillovers usually take longer time to be reflected on the economic growth of the country. Hence, investment in R&D that specializes in reverse innovation particularly shall bring a significant impact on the long term growth and balance of payment of the country. The government should devise a policy to encourage a reverse innovation through creating awareness and collaborating with higher educational institutes', entrepreneurial incubators through holding competitions and fund such activity.

### **5.3. Future Research Direction**

This study examined the impact of innovation on economic growth in Ethiopia by using time series data that stretch to 22 years of using patent, R&D and imported capital goods as variables. However, there are variables such as human capital that is an essential part in innovation and entrepreneurial activity that have not been included due to the unavailability of data that stretch the time span of this study are not included in this study.

Additionally, the effect of transition from agriculture to industry in the next few years endogenously is expected to entertain a wide variety of innovations in the scope and number as well as the countries preparation to become signatory for world trade organization all change the landscape of innovation.

Thus, it is recommended for future researchers to further assess the impact of innovation and entrepreneurial activity in terms of economic development by incorporating additional micro and macro-economic factors. It is also recommended for future researchers to study the effect of innovation in specific economic sectors.

## References

- Alemu, A. M., & Jin-sang, L. (2014). Examining the Effects of Currency Depreciation on Trade Balance in Selected Asian Economies. *International Journal of Global Business*, 7(1), 59-76.
- Alhamadni, M., Aljaderi, A., Qandelji, A., Bani Hani, A., & Abu zeneh, F. (2006). *Research Methodology; First Book: The basics of scientific research*. (1ed, Ed.) Amman: Arab University for Graduate Studies.
- Allianz. (2010, January 3). *The sixth Kondratieff –long waves of prosperity:Analysis & Trends*. Retrieved December 3/12/2017, 2017, from [https://www.allianz.com/v\\_1339501901000/media/press/document/other/kondratieff\\_en.pdf](https://www.allianz.com/v_1339501901000/media/press/document/other/kondratieff_en.pdf)
- Arawomo, D. F. (2014). Nexus Of Capital Goods Import and Economic Growth:Evidence from Panel ARDL Model for WAMZ. *Arawomo, Journal of International and Global Economic Studies*, 7(2), 32-44.
- Archibugi, D., & Coco, A. (2005). Measuring technological capabilities at the country level: a survey and a menu for choice. *Research Policy*, 34, 175-194.
- Audretsch, D. B. (2004). Sustaining innovation and growth: public policy support for entrepreneurship. *Industry and Innovation*, 11(3), 167-191.
- Beroch , A. M. (2016). *Intermediate and Capital Goods Import and Economic Growth in Belarus*. Belarusian Research and Outreach Center (BEROC).
- Bloch, C. (2007). Assessing recent developments in innovation measurement: the third edition of the Oslo Manual. *Science and Public Policy*, 34(1), 23-34.
- Bozkurt, C. (2015). R&D Expenditures and Economic Growth Relationship in Turkey. *International Journal of Economics and Financial Issues*, 5(1), 188-198.
- Bronwyn, H. H. (2007 , February ). Contribution to The New Palgrave: A Dictionary of Economics, second edition.
- Brook, C. (2008). *Introductory Econometrics for Finance*. NewYork: Cambridge University Press.
- Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for testing the consistency of regression relations over time. *Journal of the Royal Statistical society*, 37, 149-163.
- Brue, L. S. (2000). *The evolution of economic thought* (Vol. 6). USA: Thomson.

- Cavallo, M., & Landry, A. (2009). Capital-Goods Imports, Investment-Specific Productivity, and U.S. Growth Working Paper of Federal Reserve Bank of Dallas . *Working Paper of Federal Reserve Bank of Dallas*.
- Christine, G., & Mark, R. (2010). *Innovation, Intellectual Property, and Economic Growth*. (P. a. Oxford, Trans.) Princeton University Press.
- Chuang, Y.-c. (1998). Learning by Doing, the Technology Gap and Growth. *International Economic Review*, 39(3), 679-721.
- Cooper , D. R., & Schindler , P. S. (2003). *Business Research Methods* (8th ed.). New York: McGraw-Hill:.
- Creswell, W. (2003). *Research Design: Qualitative, Quantitative and Mixed Approaches* (2nd ed.). California: Sage publication.
- De Soto, H. (2000). *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. Newyork: Basic Books.
- Delbeke, J. (1984). Recent long-wave theories: A critical survey. In C. Freeman, *Long waves in the world economy* (pp. 1-12). London: Frances Pinter.
- Duijn, J. J. (1983). *The Long Wave in Economic Life*. London: George Allen & Unwin Ltd.
- Eggink, M.-E. (2011). *THE ROLE OF INNOVATION IN ECONOMIC DEVELOPMENT*. Johansburg: UNIVERSITY OF SOUTH AFRICA.
- Fabozzi, F. J., Focardi, S. M., Rachev, S. T., & Arshanapalli, B. G. (2014). *The Basics of Econometrics:Tools, Concepts, and Asset*. New Jersey, Hoboken: John Wiley & Sons, Inc.
- Fagerberg, J., Mowery, D. C., & Nelson, R. R. (2005). *The Oxford handbook of innovation*. New York: Oxford University Press.
- Falk, M. (2007). R&D spending in the high-tech sector and economic growth. *Research in Economics*, 61(3), 140-147.
- Falvey, R., Foster, N., & Greenaway, D. (2006). Intellectual property rights and economic growth. *Review of Development Economics*, 10(4), 700-719.
- Freeman, C. (1982). *The economics of industrial innovation*. London: Frances Pinter.
- Freeman, C., Clark, J., & Soete, L. (1982). *Unemployment and technical innovation: A study of long waves and economic development*. London: Frances Pinter.

- FRENKEL, M., & HEMMER, H. R. (1999). Grundlagen der Wachstumstheorie. In O. Som, *Innovation without R&D Heterogeneous Innovation Patterns of Non-R&D-Performing Firms in the German Manufacturing Industry* (pp. 23-111). Karlsruhe: Springer Gabler.
- Gatignon, H., Tushman, M. L., Smith, W., & Anderson, P. (2002). A Structural Approach to Assessing Innovation: Construct Development of Innovation Locus, Type, and Characteristics. *Management Science*, 48 (9), 1103–1122.
- Goto, A. (2000). Japan's national innovation system: current status and problems. *Oxford Review of Economic Policy*, 16(2), 103-113.
- Granger, C. (1969). Investigating causal relations by econometric models and cross spectral methods', *Econometrica*, 37, pp. 424–38. 37, 424–438.
- Granger, C. (1988). Some recent developments in the concept of causality. *Journal of Econometrics*, 39, 199–211.
- Granger, C., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics*, 2(2), 111-120.
- Greenhalgh, C., & Rogers, M. (2010). *Innovation, Intellectual Property, and Economic Growth*. New Jersey: Princeton University Press.
- Greenhalgh, C., & Rogers, M. (2010). *Innovation, Intellectual Property, and Economic Growth*. New Jersey: Princeton University Press.
- Griffith, R., Redding, S., & Van Reenen, J. (2004). productivity growth in a panel of OECD industries. *Review of Economics and Statistics*, 86(4), 883–895.
- Hancock, D. R., & Algozzine, B. (2006). *Doing case study research: A practical guide for beginning researchers*. New York: Teachers college, Columbia University.
- Hanusch, H., & Pyka, A. (2007). Schumpeter, Joseph Alois (1883-1950). In H. Hanusch, & A. Pyka, *Elgar companion to neo-Schumpeterian economics* (pp. 19-26). Cheltenham: Edward Elgar.
- Harris, R., & Sollis, R. (2003). *Applied Time Series Modelling and Forecasting*. West Sussex: John Wiley and Sons Ltd.
- Hart, H. (1931). *The Technique of Social Progress*. New York: Henry Holt and Co.
- Heertje, A. (2006). *Schumpeter on the economics of innovation and the development of capitalism*. (C. J. Middendorp, Ed.) Edward Elgar.
- Herrick, B., & Kindleberger, C. P. (1983). *Economic development*. Singapore: McGraw-Hill.

- Iyoboyi, M., & Na-Allah, A. (2014). Innovation and economic growth: evidence from Nigeria. *EuroEconomica*, 1(33), 1582-8859.
- Jalil , A., & Ma, Y. (2008). Financial Development and Economic Growth: Time Series Evidence from Pakistan and China. *Journal of economic cooperation*, 29-68.
- Janjua, P. Z., & Samad, G. (2007). Intellectual property rights and economic growth: The case of middle income developing countries. *The Pakistan Development Review Volume* , 46(4), 711-722.
- Kennedy, P. (1998). *A Guide to Econometrics* (4th ed.). Massachusetts, Cambridge: MIT Press.
- Kim, L. W. (2011). The Economic Growth Effect of R&D Activity in Korea. *Korea and the World Economy*, 12(1), 25-44., 12(1), 25-44.
- Kotsemir, M. N., & Abroskin, A. S. (2013). INNOVATION CONCEPTS AND TYPOLOGY- AN EVOLUTIONARY DISCUSSION. *National Research University Higher School of Economics (HSE), WP BRP(05/STI/2013)*.
- Kremers, J. M., Ericsson, N. L., & Dolado , J. (1992). The power of co-integration tests. *The journal of Econometrics*, 52, 389-402.
- Liew , V., & Khimsen , A. (2004). Which lag length selection criteria should we employ. *Economic Bulletin*, 3(33), 1-9.
- Linton , J. (2002). Implementation Research: State of The Art and Future Directions. 22(2), 65–79.
- Maitena , D., & Banco , d. (2003, July 31). Definitions of Foreign Direct Investment (FDI): a methodological note.
- Mansfield, E. (1969). *The economics of technological change*. London: Longmans.
- Mansfield, E. (1969). *The economics of technological change*. London: Longmans. . London: Longmans.
- MARIA, E. E. (2011, NOVEMBER ). THE ROLE OF INNOVATION IN ECONOMIC DEVELOPMENT. *DOCTOR OF COMMERCE*.
- Masood, A. (2013, Septembe). Impact of Motivation on Employee Performance with Effect of Training: Specific to Education Sector of Pakistan. *International Journal of Scientific and Research Publications*, 3(9), 2.
- Narayan , K. (2004). Reformulating Critical Values for the Bounds F-statistics Approach to Cointegration: An Application to the Tourism Demand Model for Fiji. *Discussion Papers No 02, Monash University, Victoria, Australia*.

- Narayan, K. (2005). The Saving and Investment Nexus for China: Evidence from Cointegration Tests, *Applied Economics*, 37, 1979-1990.
- Narkus, S. (2012). *Kondratieff, N. and Schumpeter, Joseph A. long-waves theory :Analysis of long-cycles theory*. OSLO: UNIVERSITETET I OSLO.
- Nefiodow, L. A. (2006). The Sixth Kondratieff Wave. In *The Evolving Health Market* (Vol. 6th).
- Nelson, R. R. (1996). *The sources of economic growth*. London: Harvard University Press.
- Nkoro, E., & Uko, A. K. (2016). Autoregressive Distributed Lag (ARDL) cointegration technique: application and interpretation. *Journal of Statistical and Econometric Methods*, 5(4), 63-91.
- OECD. (2004). PATENTS AND INNOVATION:TRENDS AND POLICY CHALLENGES.
- Peng, L. (2010). Study on Relationship between R&D Expenditure and Economic Growth of China. *Proceedings of the 7th International Conference on Innovation & Management*, (pp. 1725-1728).
- Pesaran, H. M., & Pesaran , B. (1997). *Working with Microfit 4.0: Interactive Econometric Analysis*. Oxford: Oxford University Press.
- Pesaran, H. M., & Shin, Y. (1999). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. In S. Strom, A. Holly and P. Diamond (Eds.), *Econometrics and Economic Theory in the 20th Century: The Ranger Frisch Centennial*.
- Pesaran, H. M., Shin, Y., & Smith, R. J. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics*, 16(3), 289-326.
- Pesaran, H., Shin, Y., & Smith, R. (2001). Bound Testing approaches to the analysis of level relationship. *Journal of Applied Econometrics*, 16, 289–326.
- Petrack, J. I., & Juntiwarakij, S. (2011). The rise of the rest: hotbeds of innovation in emerging markets. *Research Technology Management*, 54(4), 24-29.
- Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). London: The Free Press.
- Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5), 1002–1037.
- Sattar, A., & Mahmood, T. (2011). INTELLECTUAL PROPERTY RIGHTS AND ECONOMIC GROWTH: EVIDENCES FROM HIGH, MIDDLE AND LOW INCOME COUNTRIES. *Pakistan Economic and Social Review*, 49(2 (Winter 2011)), 163-186.

- Schumpeter , J. A. (1934). *The Theory of Economic Development: An Inquiry Into Profits, Capital, Credit, Interests and The Business Cycle*. London: Oxford University Press.
- Schumpeter, J. A. (1911). *The theory of economic development*. Cambridge: Harvard University.
- Schumpeter, J. A. (1934). *The Theory of Economic Development*. Cambridge,MA: Harvard University Press.
- Schumpeter, J. A. (1939). *Business Cycles: A theoretical, historical and statistical analysis of the Capitalist process*. Newyork: McGraw-Hill Book company Inc.
- Schumpeter, J. A. (1961). *The theory of economic development: An inquiry into profits, capital, credit, interest and the business cycle*. (R. Opie, Trans.) USA: Harvard University Press.
- Schumpeter, J. A. (1976). *Capitalism, socialism and democracy* (Vol. 5). London: George Allen & Unwin.
- Sime, Z. (2013). *Economic Transformation and Sectoral Growth Option in Ethiopia: Considerations for achieving Middle Income Country Status*. (Vol. PhD Dessertation). Nairobi: University of Nairobi.
- Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations* (1904 ed., Vol. 5). London: Methuen & Co.
- Smith, K. (2005). Measuring innovation. In J. Fagerberg, D. C. Mowery, & R. R. Nelson, *The Oxford handbook of innovation* (pp. 148-177). New York: Oxford University Press.
- Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 70(1), 65-94.
- Solow, R. M. (2008). Technical change and the aggregate production function. In *The economic theory of invention and innovation* (In Link, AN. (ed.) ed., pp. 18-26). Cheltenham: Edward Elgar.
- STIC. (2014). *Science and Technology Indicators Report of 2014*. AddisAbaba: Science and Technology Information Center (STIC).
- Sundbo, J. (1998). *The theory of innovation: Entrepreneurs, technology and strategy*. Cheltenham: Edward Elgar.
- Teklie, D. K. (2016). *THE NEXUS BETWEEN INSTITUTION AND STOCHASTIC GROWTH IN SELECTED SUB- SAHARAN AFRICAN*. Addis Ababa: YOM INSTITUTE OF ECONOMIC DEVELOPMENT.
- Thompson , M. A., & Rushing, F. W. (1996). Intellectual Property Protection, Entrepreneurship. *Journal of Enterprising Culture*, 4(3), 267-285.

- Thompson , M. A., & Rushing, F. W. (1999). An Empirical Analysis of the Impact of Patent Protection on Economic Growth: An Extension. *JOURNAL OF ECONOMIC DEVELOPMENT* , 24(1), 67-76.
- Tinbergen, J. (1984). Kondratiev cycles and so-called long waves: the early research. In C. Freeman, *Long waves in the world economy* (pp. 13-18). London: Frances Pinter.
- Ucak, A. (2015). Adam Smith: The Inspirer of Modern Growth Theories. *Procedia - Social and Behavioral Sciences* . 195, pp. 663 – 672. Elsevier Ltd.
- UNDP. (2014). *Country Economic Brief:Ethiopia*. Analysis Issue No. 1.
- Van Duijn, J. J. (1983). *The long wave in economic life*. London: George Allen & Un.
- Veblen, T. (1915). *Imperial Germany and the Industrial Revolution*. New York: Macmillan.
- Veeramani , C. (2008). Impact of Imported Intermediate and Capital Goods on Economic Growth: A Cross Country Analysis. *The Working Paper of Indira Gandhi Institute of Development Research (IGIDR)*.
- Verspagen, B. (1992). Endogenous innovation in neo-classical growth models: a survey. *Journal of Macroeconomics*, 14(4), 631-662.
- Verspagen, B. (2005). Innovation and economic growth. In F. J. Mowery, & R. R. Nelson, *The Oxford handbook of innovation* (pp. 487-514). New York: Oxford University Press.
- Von Hippel, E. (2005). *Democratizing Innovation*. Cambridge: MIT Press.
- World Investment Report . (2007). DEFINITIONS AND SOURCES. *Transnational Corporations, Extractive Industries and Development*.
- Yanyun, Z., & Mingqian, Z. (2004). R&D and Economic Growth-Panel Data Analysis in ASEAN+3 Countries. *Seoul Conference 2004*. Seoul: Korea and the World Economy III.
- Zeng, M., & Williamson, P. J. (2007). *Dragons at Your Door: How Chinese Cost Innovation Is Disrupting Global Competition*. Boston, MA.: Harvard Business Review Press.



Seek Wisdom, Elevate your Intellect and Serve Humanity

Addis Ababa University

አዲስ አበባ ዩኒቨርሲቲ



# *Appendices*



## Appendix I Major innovations during 19th and 20th centuries

	Invention	Innovation	Innovator
Television	1907	1936	Electrical & Musical Ind. (GB)
Catalytic cracking	1927	1937	Sun Oil, Socony-Mobil (USA)
Electron microscope	1931	1937	Siemens-Halske (Germany) Metropolitan-Vickers (GB)
Nylon	1934	1938	DuPont (USA), I.G. Farben (Germany)
Fluorescent lamp	1896	1938	Westinghouse, Gen. Electric, Sylvania Electric (USA)
Helicopter	1907	1938	Focke-Wulf (Germany)
Polyethylene	1936	1939	ICI (GB)
jet airplane	1930	1942	Messerschmitt (Germany)
penicillin	1929	1942	Kemball, Bishop & Co. (GB)
continuous catalytic cracking	1942	1942	Standard Oil of New Jersey (USA)
DDT	1874	1942	Allied forces
guided missile	1903	1942	V2 (Germany)
silicones	1904	1943	Dow-Corning (USA)
aerosol spray	1862	1934	United States
high-energy accelerators	1929	1943	General Electric (USA)
ball-point pen	1938	1945	Eterpen Co. (Argentina)
streptomycin	1924	1946	Merck & Co. (USA)
phototype	1936	1946	American Intertype Corp. (USA)
orlon	1945	1948	DuPont (USA)
cortisone	1931	1948	Merck & Co. (USA)
long-playing record	1948	1948	CBS (USA)
automatic transmission (passenger cars)	1904	1948	Buick (USA)
Polaroid land camera	1937	1948	Polaroid (USA)
xerography	1937	1950	Haloid Corp.(USA)
terylene	1941	1950	ICI (GB)
radial tyre	1949	1950	Michelin (France)
sulzer loom	1928	1950	Warner & Swasey (USA)
transistor	1947	1951	Bell Telephone Labs (USA)
electronic computer	1944	1951	Remington Rand (USA)
power steering (passenger cars)	1926	1951	Chrysler (USA)
continuous casting of steel	1927	1952	Mannesmann (Germany)
oxygen steel making	1939	1953	Vöest (Austria)
colour television	1925	1953	RCA (USA)
gas chromatograph	1905	1954	Perkin-Elmer Corp. (USA)
remote control	1898	1954	Argonne National Lab. (USA)
silicon transistor	1947	1954	Texas Instruments (USA)
numerically controlled machine tools	1927	1955	United States
nuclear energy	1942	1956	Calder Hall, Great Britain
fuel cell	1885	1958	Union Carbide (USA)
polyacetates	1924	1959	DuPont (USA)
float glass	1952	1959	Pilkington bros. (GB)
polycarbonates	1935	1960	Bayer (Germany), General Electric (USA)
contraceptive pill	1954	1960	Searle Drug (USA)
hovercraft	1928	1960	Saunders-Roe (GB)
integrated circuit	1959	1961	Fairchild, Texas Instruments (USA)
communication satellite	1957	1962	USA, USSR
laser	1954	1967	Hughes Aircraft (USA)
Wankel-motor	1954	1967	NSU (Germany)
video cassette recorder	1956	1970	Philips (Netherlands)
micro-processor	1959	1971	Intel (USA)

Source: (Van Duijn, 1983)

## Appendix II. ARDL(2, 2, 0, 1)

Sample (adjusted): 1998 2017  
 Included observations: 20 after adjustments  
 Maximum dependent lags: 2 (Automatic selection)  
 Model selection method: Akaike info criterion (AIC)  
 Dynamic regressors (2 lags, automatic): PATENT R\_D IMPCAPG  
 Fixed regressors: C  
 Number of models evaluated: 54  
 Selected Model: ARDL(2, 2, 0, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDP(-1)	0.520113	0.191325	2.718487	0.0200
GDP(-2)	-0.237108	0.170023	-1.394568	0.1907
PATENT	-0.109795	0.044255	-2.480958	0.0305
PATENT(-1)	-0.052669	0.027031	-1.948488	0.0773
PATENT(-2)	-0.062938	0.019646	-3.203605	0.0084
R_D	0.389650	0.105376	3.697717	0.0035
IMPCAPG	-0.040664	0.040352	-1.007730	0.3352
IMPCAPG(-1)	0.102592	0.039141	2.621088	0.0238
C	2.974336	0.670281	4.437450	0.0010
R-squared	0.998899	Mean dependent var		8.531143
Adjusted R-squared	0.998098	S.D. dependent var		0.223093
S.E. of regression	0.009729	Akaike info criterion		-6.125151
Sum squared resid	0.001041	Schwarz criterion		-5.677071
Log likelihood	70.25151	Hannan-Quinn criter.		-6.037681
F-statistic	1247.321	Durbin-Watson stat		2.169004
Prob(F-statistic)	0.000000			

\*Note: p-values and any subsequent tests do not account for model selection.

### Appendix III ARDL Bounds Test

ARDL Bounds Test  
 Date: 01/17/18 Time: 11:03  
 Sample: 1998 2017  
 Included observations: 20  
 Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	8.921733	3

#### Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

Test Equation:  
 Dependent Variable: D(GDP)  
 Method: Least Squares  
 Date: 01/17/18 Time: 11:03  
 Sample: 1998 2017  
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	0.280696	0.180572	1.554483	0.1484
D(PATENT)	-0.099720	0.044227	-2.254722	0.0455
D(PATENT(-1))	0.059156	0.019829	2.983307	0.0124
D(IMPCAPG)	-0.041943	0.041681	-1.006285	0.3359
C	3.113783	0.749306	4.155556	0.0016
PATENT(-1)	-0.204399	0.071537	-2.857265	0.0156
R_D(-1)	0.366895	0.105499	3.477724	0.0052
IMPCAPG(-1)	0.067053	0.033480	2.002806	0.0705
GDP(-1)	-0.719511	0.166421	-4.323445	0.0012
R-squared	0.832911	Mean dependent var	0.033547	
Adjusted R-squared	0.711392	S.D. dependent var	0.018719	
S.E. of regression	0.010056	Akaike info criterion	-6.059034	
Sum squared resid	0.001112	Schwarz criterion	-5.610955	
Log likelihood	69.59034	Hannan-Quinn criter.	-5.971564	
F-statistic	6.854157	Durbin-Watson stat	2.362220	
Prob(F-statistic)	0.002332			

### Appendix III Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.692256	Prob. F(2,9)	0.5252
Obs*R-squared	2.666495	Prob. Chi-Square(2)	0.2636

Test Equation:

Dependent Variable: RESID

Method: ARDL

Sample: 1998 2017

Included observations: 20

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	0.138579	0.257252	0.538688	0.6032
GDP(-2)	0.098084	0.222377	0.441071	0.6696
PATENT	0.057561	0.067002	0.859090	0.4126
PATENT(-1)	0.026236	0.035653	0.735876	0.4805
PATENT(-2)	0.016643	0.024897	0.668466	0.5206
R_D	-0.140137	0.161115	-0.869791	0.4070
IMPCAPG	-0.023217	0.045979	-0.504941	0.6257
IMPCAPG(-1)	0.008862	0.041017	0.216048	0.8338
C	-0.992688	1.089971	-0.910747	0.3862
RESID(-1)	-0.432093	0.470182	-0.918991	0.3821
RESID(-2)	-0.515065	0.493784	-1.043099	0.3241
R-squared	0.133325	Mean dependent var		6.22E-16
Adjusted R-squared	-0.829648	S.D. dependent var		0.007403
S.E. of regression	0.010014	Akaike info criterion		-6.068242
Sum squared resid	0.000902	Schwarz criterion		-5.520589
Log likelihood	71.68242	Hannan-Quinn criter.		-5.961334
F-statistic	0.138451	Durbin-Watson stat		2.379186
Prob(F-statistic)	0.997611			

### Appendix III Heteroskedasticity Test: ARCH

Heteroskedasticity Test: ARCH

F-statistic	1.683946	Prob. F(1,17)	0.2117
Obs*R-squared	1.712431	Prob. Chi-Square(1)	0.1907

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 01/17/18 Time: 09:32

Sample (adjusted): 1999 2017

Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.98E-05	1.85E-05	3.773278	0.0015
RESID^2(-1)	-0.296023	0.228119	-1.297669	0.2117
R-squared	0.090128	Mean dependent var		5.48E-05
Adjusted R-squared	0.036606	S.D. dependent var		6.40E-05
S.E. of regression	6.29E-05	Akaike info criterion		-16.41207
Sum squared resid	6.72E-08	Schwarz criterion		-16.31266
Log likelihood	157.9147	Hannan-Quinn criter.		-16.39525
F-statistic	1.683946	Durbin-Watson stat		1.998823
Prob(F-statistic)	0.211734			