Addis Ababa University
አዲስ፡አበባ፡ዩኒቨርሲቲ
SEEK WISDOM, ELEVATE YOUR INTELLECT AND SERVE HUMANITY !

ADDIS ABABA UNVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

DEPARTMENT OF ECONOMICS

"FACTORS THAT AFFECT THE LEVEL OF GOLD RESOURCE MINING IN ETHIOPIA"

BY

SEYUM DEBEBE

A THESIS SUBMITTED TO THE DEPARTMENT OF ECONOMICS IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER SCIENCE IN ECONOMICS (NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS).

Advisor: Adane Tuffa (PHD

JULY, 2021

ADDIS ABABA, ETHIOPIA

“FACTORS THAT AFFECT THE LEVEL OF GOLD RESOURCE MINING IN ETHIOPIA”

BY SEYUM DEBEBE

A THESIS SUBMITTED TO THE DEPARTMENT OF ECONOMICS IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER SCIENCE IN ECONOMICS (NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS).

Advisor: AdaneTuffa (PHD)

JULY, 2021

ADDIS ABABA, ETHIOPIA

Approval Sheet

ADDIS ABABA UNIVERSITY
SCHOOL OF BUSINESS AND ECONOMICS
MSC IN ECONOMICS

FACTORS THAT AFFECT THE LEVEL OF GOLD RESOURCE MINING IN ETHIOPIA

By: SEYUM DEBEBE

APPROVED BY BOARD OF EXAMINERS

_______________________________ _______________________
Dean, graduate studies **Signature**

_______________________________ _______________________
Advisor **Signature**

_______________________________ _______________________
External Examiner **Signature**

_______________________________ _______________________
Internal Examiner Signature

DECLARATION

I, **Seyum Debebe**, declare that this research paper, entitled **"FACTORS THAT AFFECT THE LEVEL OF GOLD RESOURCE MINING IN ETHIOPIA"** is my original work submitted for the award of fulfillment of requirement for Masters of Science (MSC) Degree in Economics at the department of Economics, Addis Ababa University

It has not been presented for the award of any degree or other similar titles in any other institutions higher learning to the best of my knowledge, and the resource used have been dully acknowledged.

Addis Ababa University would guarantee to protect the property right of the writer and take full responsibility from its side after the submission of the thesis to the Department.

Declared by :

Name: SEYUM DEBEBE

Signature: ________________

Date: ____________________

Place and date of Submission: _________________________

CERTIFICATE

This is to certify that **SEYUM DEBEBE** has carried out his research work on the topic entitled **"FACTORS THAT AFFECT THE LEVEL OF GOLD RESOURCE MINING IN ETHIOPIA".** This work is original in nature and is suitable for submission to the award of MSC in Economics

Name of advisor: ADANE TUFFA(Dr.) Signature: ___________________

Place: Addis Ababa, Ethiopia Date: ___________________

ACKNOWLEDGMENT

First and foremost, I would like to thank the almighty God for all his blessing and for giving me the ability and strength to pursue my study and also to his mother saint virgin marry. I wouldlike to express my deepest gratitude to my advisor, Dr Adane Tuffa, for his unreserved support, encouragement and valuable comments throughout the course of this study. My special thanks also goes to my mother Endashu Urgie and my father Debebe Gashie, they encouraged me by providing moral and material supports. Thank you, I am deeply indebted for all deeds.Last but not the least I would like to express my gratitude to those who assist me through idea and data source, especially National Bank of Ethiopia and Ministry of mines workers.

ABSTRACT

Decade ago, gold constituted close to one-fifth of the total export earning of Ethiopia. Gold was the second largest foreign currency generator next to coffee. But the country has not been able to sustain this momentum. Export income dwindling continuously. The major objective of this paper is to investigate the magnitude of impact of selected economic variables on gold resource mining in Ethiopia using descriptive analysis and OLS time series econometric model for the period 1987-2017 collected from National Bank of Ethiopia (NBE). The study was motivated by the fact that the country is in deep need of a foreign currency earning and the means to earn could have been boosted given the current historical high prices of world gold due to uncertainties created as a result of recent pandemic.

Empirical result reveal that population and world price of gold have positive significant effect on level of annual gold extraction in the short run, while, inflation, population and world price of gold have positive significant effect on level of annual gold extraction in the long run. However, the study found out that GDP, Interest rate, Economic growth had statistically insignificant impact on gold resource extraction. This study also included important policy recommendation. The finding of this study implies that the need to develop a scheme or policy that controls gold mining in line with world gold price, as it is the main determining factor for movement in gold extraction level and also since it dictates the remaining gold export determinant variables.

Table of Contents

Contents --- ----------------------Pages

List of figures

List of Tables

ACRONYMS

ADLS:	Agricultural development led industrialization
Bn:	Billions
CSA:	Central statistics agency
ETB:	Ethiopian Birr
FDRE:	Federal Democratic Republic of Ethiopia
GDP:	Gross Domestic Product
GGP:	General Gold Price
GPT:	Gold per ton
IMF:	International Monetary fund
MOFED:	Ministry of finance and economic development
MOA:	Ministry of agriculture
OLS:	Ordinary least square
RRDC:	Resource rich developing countries
UNEP:	United Nations environment programe
US, U.S.A.:	United States of America
USD:	United States dollar
USDI:	The Dollar Index

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Gold have been the main foreign exchange means of the country for the last 30years. But, recently due to several factors gold mining contribution to the country's economy or foreign exchange gain is below average. Ethiopia has a huge potential of various mineral resources, but not yet well explored and exploited, and hence its contribution to the overall economy or GDP is low according to recent data. However, as reported by the World Bank Group (2014), its contribution to the foreign exchange earnings reached about 10% of which the artisan mining takes the lion's share of over 65%. The mining sector had a significant contribution to the Ethiopian economy. Production and export of gold was just US$ 5 million in 2001 and rose to US$ 23.8 million in 2015. The artisan mining also significantly contributes to the employment of at least 1.26 million people and supports the livelihood of over 7.5 million populations. The total population involved in gold mining (legal and illegal) is estimated at 1.24 million. Taking into account the number of artisan miners and average annual production, rough estimation shows that, in the major gold producing areas of the country, a total of about 18,000 kg of gold is produced per annum.

Recent report from Ministry of mining and petroleum shows huge drop in gold production over the last three years in gold in Ethiopia mainly due to large suppliers stopped operation. Although it's not a gold production site Kenticha Tantalum Factory also has been closed for two years by the Oromia Environmental protection authority for allegedly polluting the environment, which led the company loosing over half a billion Birr. In fact, the amount of foreign currency Ethiopia is earning from exports of gold is dwindling continuously. It plummeted to a shocking 32 million USD in 2018/19 down from 654 million in 2011/12. According to NBE's report, export earnings from gold plummeted significantly mainly due to 92.5% drop in volumes in past seven years, resulting from artisanal miners to sell their gold through the underground black market. With mining sector identified by Ethiopian government as a main reform program part to generate huge foreign currency and provide more than 3 million employment opportunity, the current status shows capital loss, international trade loss and less employment opportunity in gold mining sites in Ethiopia.

Economists give various determining factors behind the fluctuation or extraction determinant of gold resource. These factors could be micro, macro, political or technological. The research would explore these factors depending on their influence and data availability.

Economists have observed that gold extraction is related with price, inflation, population growth, economic level, technology and other economical factors. Prices are correlated with inflation. So they began to study how the price of gold was related to GDP, inflation, the US dollar index, gold market, gold price index and other economic variables (the study was specifically to USA market). Theoretical research shows that there should be a relationship between real economic variables, such as, real world GDP, real interest rates, inflation rates and the real U.S. dollar index, and the real gold price. Gold demand is mainly for consumption, deposit, and investment. Usually, the price of gold in determined by determines international economic development. When economy rises, the demands of gold increase too. A country's central bank's holdings of official gold reserves are used to guard against financial risks. For regular investors, gold is investment and is a used to hedge against inflation. A rise in macroeconomic factors leads to rise in international price for gold (Export price index of gold) which in turn immensely increases the level of gold extraction (Sun, 2018).

1.2. STATEMENT OF THE PROBLEM

For the last 30 years gold has been one of the main export earning items for Ethiopian economy. Gold used to constitute one of the highest foreign earnings; GDP and employment share in the nation's economy. But, lately the earnings from gold are decreasing tremendously due to several factors.

Gold export earnings reached record high 654 million USD in 2011/12. In 2013/14 GC the country managed to export record high 12.5 thousand kilogram of gold to foreign markets. But in 2018/19 the nation only managed to gain 49 million USD from gold exports (MoMaP, 2020)

Understanding the sources in the current decreasing trend in gold extraction requires closer look at worldwide phenomena that are related with gold extraction. Looking into the nation's major economic, mostly macro variables and worldwide gold price trend could help in dictating the reasons behind lower gold extraction and also help us to create scenarios on how to obtain the maximum gains from gold extraction in environmentally plausible manner.

Continuous demand for gold in the jewelry and the electronics industries, as well as for investment (it being one of the most tradable commodities in the world), has fuelled mine production worldwide. Many developing countries have been advised by donors to open up their gold mining industries to foreign investment which, they maintain, could provide a much-needed catalyst for economic growth. The series of tax breaks and generous investment incentives now offered by a range of developing countries have, over the past two decades, attracted numerous foreign gold mining and mineral exploration companies to their shores (Hilson and Laing, 2017). The last two decades have witnessed an extraordinary expansion in global mining activity. A surge in commodity demand from industrializing countries pushed up the price of metals, minerals and oil. This in turn led to substantial new mining investment, an increasing share of which is concentrated in emerging markets (Humphreys, 2010).

The mining boom was also witnessed in Ethiopia over the last 10 years. But, the level of export and gain from sales is decreasing over the years.

Exhaustible resources have been associated with increases in total savings and smaller increases in investment, these changes tend to be driven by the private sector. Until recently resource rich developing countries had lower public investment rates than competitors Boombust cycles—the ramping up of sometimes inefficient spending after positive revenue shocks, and abrupt expenditure reductions after adverse shocks— have been the norm. This is consistent with the evidence that fiscal policies have been more pro-cyclical in resource rich developing countries. Better management of resource revenue volatility is clearly central: higher macroeconomic volatility is a main channel for the growth-damaging “resource curse,” and volatile government spending is less effective and productive. (IMF, 2012)

Gold has a function of building against inflation. Gold hedging function in inflation is expected or has occurred when investors reflect. A lot of investment funds from the bond stock market into the gold market, leading to gold rose. The reason gold and its derivatives is used the hedge inflation in that its price moves in opposite situation of the value of the dollar. Therefore, if inflation reduces the value of the dollar, the price of gold rises which in turn increase the gold extraction. The important factor affection on the price of gold is the real interest rate. The real interest rate is the nominal interest rate adjusted for inflation (Sun, 2017).

The inflation in turn brought about a ‘spending effect’, which occurs when resource booms increase prices in non-tradable sectors, causing an appreciation in the real exchange rate. This often leads to competiveness issues in sectors other than the ‘booming’ resource sector, in this case, gold mining. This has affected sectors such as agriculture and manufacturing, further retarding growth and exacerbating the economy’s reliance on gold (Hilson and Laing, 2017)

The researcher tried to investigate other local papers written on similar area or topic, unfortunately the researcher unable to find any local paper that focused in any study that links gold mining with any of the explanatory variables. Other studies found in the area from foreign papers focus on single explanatory variable relationship with gold mining. This paper is first of its kind locally linking macroeconomic variables with gold mining. This study will be a corner stone for anyone interested in working on gold mining and relationship between decisive controlling macro economic factors. Studies found locally so far only focus on gold resource base and geographical issues. This paper tries to capture the effects of economic variables on resource extraction level in general and gold resource in particular

These paper studies what factors determine gold resource extraction in Ethiopia and their level of impact on gold extraction and Ethiopian Economy.

1.3. OBJECTIVE OF THE STUDY

1.3.1 GENERAL OBJECTIVE

The main objective of this paper is to examine what factors determine the extraction of gold resource in Ethiopia

1.3.2 SPECIFIC OBJECTIVE

- ✓ To examine the which factors significantly affect the extraction of gold in Ethiopia
- ✓ To examine the magnitude of their effect on gold extraction
- ✓ To examine the root causes of the fluctuation (latest tremendous decrease in volume of gold mining)

- ✓ To recommend some policy measurements that helps to boost income from gold mining

1.4. SIGIFICANCE OF THE STUDY

The outcome of the study will provide information to the government in policy formulation regarding gold extraction and also it helps international organization and NGOs to learn the pattern of Ethiopian gold resource and extraction. This study will serve as a base for further investigation to be under taken in this area. In addition, the researcher's suggestion will help to take corrective actions for the problem.

1.5. SCOPE OF THE STUDY

Factors that determine gold mining in Ethiopia are the main focus of the researcher and for comparison and literature purposes the researcher includes world and African countries experience both on gold resource extraction and other factors related with gold mining

1.6. ORGANIZATION OF THE PAPER

This study was organized and comprises into six chapters. The first chapter consists of an introduction which consists of background of the study, statement of the problem, objectives of the study, significance of the study, scope of the study and definition of terms. The second chapter discusses about the review of related literature. The third chapter deals with methodology of the study. The fourth chapter deals trend analysis of each variable in the thesis. The fifth chapter deals with presentation, analysis and interpretation of the data. The last chapter deals with the summary of findings, conclusions and recommendations of the study. Finally, references, a set of appendices and questionnaire that used to collect primary data for this work were included

CHAPTER TWO

LITREATURE REVIEW

2.1. THEORETICAL LITERATURE REVIEW

2.1.1. ECONOMY AND RESOURCE EXTRACTION

The patterns of economic globalization have significantly intensified the relationship between economy and ecology in the past few decades. This correlation trend is stressed on a debate between ecologists and economists regarding the impacts of economic development upon the resources exploitation and vice versa. The ecologist's argument is based on immediate consequences of economic growth. In order to achieve economic growth, developing countries are abusing their resources on the grounds of economic interests. Whether it is in the form of air and water pollution, deforestation and erosion or the extraction of natural resources itself, the fact is that developing countries are currently accounting for remarkable environmental degradation. It seems clear that much of the economic growth activities enforced by governments, account for significant environmental damage. Additionally, developing countries remain largely dependent on exports of natural resources to generate economic dividends. Pulling raw material from forests to fulfill exportation needs is subject to enormous domestic and international pressure, causing overexploitation of the environmental resource base (Mittal and Gupta, 2014)

Mittal and Gupta, (2014) tried to show the pattern in resource consumption by dividing countries in to developing and developed based on their economic status. Accordingly, the pattern of resource consumption differs in economically developed and developing countries. The people in developed countries have higher demand for resources than necessary for reasonable living due to their aspirations for better quality of life. Therefore, they exploit the resources to the level that degrade the global environment seriously. On the other hand people in developing countries have lesser demand for resources due to their simpler quality of life. However, their increasing population, less environmental awareness and aspirations for rapid upgrading of their living conditions, causes reckless destruction of resources. The consumerism based pattern of resource use which is prevalent in developed countries, is also spreading fast in developing countries. Current patterns of energy and natural resource use, agricultural practices and urbanization appear to be largely unsustainable and require urgent remediation. Left unchecked, these patterns will lead to dangerous climate change and reduced economic growth, as a result of increased economic, social, and environmental costs and decreased productivity

The relationship between natural resource abundance and economic performance has been the subject of a long and rich tradition in the literature. Some of early pioneers of modern economics such as David Ricardo and Adam Smith were concerned by both the positive and negative potential of resource wealth. More recent scholars have revisited this topic and sought to understand the ways in which natural resources can positively and negatively impact on national economic performance (Auty, 2001; Sachs and Warner, 1995 and Ploeg, 2011). But there are few researches on macroeconomic movement effect on natural resource extraction. Most studies focus on natural resource impact on different economic variables, not the reverse. This study focuses on the reverse, effect of movement in macroeconomic variables on natural resource extraction specializing on gold resource extraction.

Cust and Poelhekke, (2015) used the term “The resource curse hypothesis “ to support their idea of abundance of recourse especially in Africa is a curse to the people and development and could result in negative macroeconomic effects to the nations. The resource curse hypothesis that resource abundance is negatively associated with long-term economic growth has been scrutinized in great detail and linked to a wide-range of economic and political phenomena. The literature has examined a range of potential mechanisms including appreciation of the real exchange rate and de-industrialization, volatility, and consequences related to institutions, such as deterioration in governance, corruption, rent-seeking and conflict (Ploeg, 2011). The final strand posits that resource rich countries are unable to convert their depleting resource into other productive assets for reasons of policy failure, myopia and time-inconsistency

The mining boom has also reinvigorated the debate about the impact of mining on economic activity and welfare. Some regard mines simply as stand-alone enclaves without any notable local impact (Hirschman, 1958). Others point to the potentially negative consequences of natural resource dependence such as real exchange rate appreciation, economic volatility, deindustrialization and corruption (Ploeg, 2011).

Economists generally think in terms of resources becoming scarce, rather than reaching limits. The usual mechanism for allocating scarce resources is price. On the supply side, price rises are driven by resources becoming harder to find and more costly to extract. On the demand side, price rises are driven by people wanting more. Increasing scarcity is inflationary – it puts upward pressure on production costs and prices, all else being equal. In response to upward pressure on prices, a complex set of responses on both the supply side and the demand side occurs. Suppliers may use lower quality resources, substitute other resources and implement technological innovations. Consumers may lower their consumption or switch to less expensive substitutes if they are available. If we can substitute, there will be costs in the short term as the economy adjusts, but then the inflationary pressure will ease (Wright, 2008)

The effect that increasing scarcity will have on non-inflationary growth is complicated. It will depend on the interaction between the demand and supply side responses. The effects of increasing resource scarcity on growth can only be predicted using macroeconomic models, and these are necessarily based on a variety of assumptions (Wright, 2008)

2.1.2 LITERATURE ON RELATIONSHIP BETWEEN ECONOMIC FACTORS AND RESOURCE EXTRACTION

In the study mining matters: Natural resource extraction and local business constraints Haas and Poelhekke (2016) mentioned that the last two decades have witnessed an extraordinary expansion in global mining activity. A surge in commodity demand from industrializing countries pushed up the price of metals, minerals and oil. This in turn led to substantial new mining investment, an increasing share of which is concentrated in emerging markets (Humphreys, 2010). This geographical shift reflects that many American and European mineral deposits have by now been depleted and that the long-distance transport of minerals by sea has become less costly. As a result, the world's largest mines can nowadays be found in Africa, Asia and Latin America.

The mining boom has also reinvigorated the debate about the impact of mining on economic activity and welfare. Some regard mines simply as stand-alone enclaves without any notable local impact (Hirschman, 1958). Others point to the potentially negative consequences of natural resource dependence such as real exchange rate appreciation, economic volatility, deindustrialization and corruption (Ploeg, 2011). Mines may also pollute and threaten the livelihoods of local food producers. They often require vast amounts of water, electricity, labor and infrastructure, for which they may compete with local manufacturers. Yet others stress the potential for positive spillovers to firms and households as mining operators may buy local inputs and hire local employees. Local wealth can also increase if governments use taxable mining profits to invest in regional infrastructure or to make transfers to the local population.

Sun (2018) in his research paper entitled “The Impact of Macroeconomic Factors on the Price of Gold” mentioned several factors that affect gold price in USA, which in turn affect the level of gold mining. The factors he mentioned are discussed below with adjustment made to them to fit Ethiopian and the paper context.

The economic situation of the country

Sun (2018) used the term The Dollar Index (USDI) for gold as an indicator. When we bring the concept to Ethiopia - The Birr Index (BIRRI) for gold is an indicator of the exchange rate of BIRR in the international foreign exchange market, which is negatively correlated with international gold price.

A fall in the BIRRI means the BIRR depreciates and the value of gold increases, investors buys gold and reduces the demand for BIRR. This will leads the rising demand for gold. At the same time, international dollar price of gold appreciate. At the same time the gold mining increases immensely.

Supply and demand of gold

Gold demand is mainly for consumption, deposit, and investment. Usually, the price of gold is determined by international economic development. When economy rises, the demands of gold increase too. A country’s central bank’s holdings of official gold reserves are used to guard against financial risks. For regular investors, gold is investment and is a used to hedge against inflation.

According to the World Gold Council, the demand for gold increased by 15% in the first half of 2016 to 2,335 tons and the investment demand soared by 16%. This is the peak since 2009. However, the supply of gold increased by only 1% in the first half of 2016, the slowest pace of supply growth since the first half of 2008. This supply growth is less than the demand growth and was one of the reasons gold prices rose sharply in 2016.

Monetary policy direction

The specific implementation of monetary policy includes increasing the deposit-reserve ratio, lifting the discount rate and so on. The implementation of monetary policy may also have an impact on the supply of money. Increasing the money supply can lead to a decline in the purchasing power of the currency. A decrease in the purchasing power of the currency will in turn can cause the price of gold to rise. Conversely, a decrease in the supply of money may result in the purchasing power to increase and the price of gold to fall.

On one hand, tightening monetary policy is usually reflected in the market interest rate increases. Interest rates increases make the cart holding gold rise. This should weaken the demand for inventory. On the other hand, the Federal Reserve rate hikes will increase the yield of USD assets. This will make international funds flow into dollar bonds and other assets, which will lead to a decline in gold prices.

On the contrary, loose monetary policy is manifested in lower market interest rates. This reduces cart of holding gold increase the demand for gold, leading to a rise in gold price.

Inflation

Gold has a function of building against inflation. Gold hedging function in inflation is expected or has occurred when investors reflect. A lot of investment funds from the bond stock market into the gold market, leading to gold to rise. The reason gold and its derivatives is used as the hedge against inflation is that its price moves in opposite situation of the value of the dollar. Therefore, if inflation reduces the value of the dollar, the price of gold rises.

The important factor affecting the price of gold is the real interest rate. The real interest rate is the nominal interest rate adjusted for inflation. In periods when real interest rates are low, people are more willing to hold gold.

Global economic situation

Economic development leads to increased need for global liquidity. Therefore, this increases the scale of investment in various derivatives, thus contributing to a rise in gold prices. During an economic crisis, global liquidity is reduced, but because gold is a safe-haven in a period of uncertainty , international gold prices will rise.

In addition, global economic development will increase the residents of gold consumption and investment needs. China and India have a tradition of gold consumption, as the two countries try to accelerate development of their economies, the demand for gold also increases. Because gold's consumer demand is relatively stable and safe-haven demand tends to lead to overshoot of the gold price, the overall effect is that when GGP is less than expected or is significantly slower than the previous period, gold prices will form short-term support, and vice versa.

Real interest rate

When the economy is overheated or inflation is rising, many central banks will raise interest rates and tighten credit. After the overheated economy and rising inflation are effectively controlled, the country will lower the interest rate. If the interest rate of a certain currency rises, then the interest income from holding such a currency will increase, attracting investors to buy the currency, so that the currency will be favorably supported. On the contrary, the return to holding the currency will be weakened if domestic interest rates fall.

The price of gold is affected by interest rates, but it is mostly affected by the real interest rate. The real interest rate after deducting inflation is the opportunity cost of holding gold. In times when the real interest rate is negative, people are more willing to hold gold.

Economic development leads to increased need for global liquidity. Therefore, this increases the scale of investment in various derivatives, thus contributing to a rise in gold prices. During an economic crisis, global liquidity is reduced, but because gold is a safe-haven in a period of uncertainty, international gold prices will rise. Because gold's consumer demand is relatively stable and safe-haven demand tends to lead to overshoot of the gold price, the overall effect is that when GGP (General Gold Price) is less than expected or is significantly slower than the previous period, gold prices will form short-term support which leads in an over exploitation of gold resource, and vice versa (Sun, 2018)

E. Abhyankar, A. and Ghosh (1994) which argues that gold lease rates are equivalent to world real interest rates. These papers assume that changes in gold extraction costs are driven by the general rate of inflation, and that in the long term the gold price will rise in order to compensate miners for their increasing costs which in turn could result in increased gold mining. This implies that a causal relationship exists: running from inflation to the cost of extraction to gold prices to gold extraction. The implicit assumption in this argument is that miners are not price takers, and have market power.

S. Papworth, Rao, Myint, Latt, Tizard, Pienkowski and L. Carrasco (2017) studied demographics effect on global natural resource extraction. The price of gold has more than quadrupled since 2001, leading to increased rates of global extraction. Even small-scale, artisanal gold mining can have negative environmental and social impacts such as deforestation. Generally speaking, as the human population grows, our consumption of natural resources increases. More humans consume more natural resource either for survival or luxury.

Pearson (2005) used interest rate relation (effect on natural resource extraction) using the oil extraction example. According to Pearson -The firms that own land with oil underneath it are holding a valuable resource. These firms have two alternatives. First, they can extract the oil now and sell it at the current market price. Second, they can leave the oil in the ground and extract it at some later date. The firms, naturally, will choose the alternative that gives them the highest return. Their choice will depend on two key variables—the interest rate and the expected rate of increase in the price of oil. To see how the firms' decisions are made, consider two cases.

Chari and Christiano (2014) used the Hotelling's theory to describe the relationship between interest rate and resource extraction. The Hotelling result is intuitive and well-known to economists. In addition, it has a clear and strong implication for prices of these resources over time. When all prices and interest rates are adjusted for inflation, and as long as these "real" interest rates tend to be positive (and setting aside extraction costs, for the moment), the price of an exhaustible resource should rise over time at roughly the same pace as interest rates which would result tremendous increase in resource extraction.

Economic growth typically refers to an increase in the level of goods and services produced by an economy, as estimated by measures such as Gross Domestic Product (GDP). While economic growth has produced many benefits – raising standards of living and improving quality of life across the world – it has also resulted in the depletion of natural resources. The benefits of economic growth have not been restricted to the one nation or other advanced economies. As global GDP has multiplied 21-fold over the last 100 years, it has helped improve quality of life and pull countless millions out of poverty at the expense of immense natural resource extraction including gold (Everett, Ishwaran, Ansaloni and Rubin, 2010)

Ericsson &Löf (2019) stated that most developing countries are mining extensively for international trade (export) to increase their foreign currency earning, increase revenue and close their balance of payment deficit. The export contribution to the MCI-Wr score in low- and middle-income economies is the single most important factor explaining their high ranks. Botswana has the highest share of minerals in its exports of 93% of total exports. Sierra Leone, DR Congo and Mongolia are all countries where non-fuel mineral exports account for more than 80% of total exports

Ruta and Venables, (2012), mentioned the effect of dramatic increase of international trade after 1900 which resulted in upward sloping supply of natural resources and immense extraction of resources especially oil and other non renewable resources especially in 1970's trigged by the Arab-Israeli war and resulted in high world prices of resources. They also mentioned the need for government policy that balances and creates equilibrium in resource export, world price and the nations' level of earning.

The UNEP (2015), report indicated a significant increase in international trade in recent decades, with global trade volumes increasing over six-fold in monetary terms, or more than doubling in physical terms, between 1980 and 2010 and the amount of global resource extraction and use has also increased.

Zambrano (2015) empirically analyzed the influences of natural resources on economic growth and the effect of their presence on social setup. It is argued that resource amassing in countries appreciates real exchange rates but there would be decline in non-resource export sectors, which might lead to high inequality, poor growth rates, particularly if institutional management, law maintenance and corruption are not properly managed. Especially capital intensive resources are more prone to conflicts. This curse is even severe in case of diamond and precious metals. But if institutions are developed, trade is open and there are high investments in exploration resources it might be beneficial

Ebeke and Etoundi (2017) examined the impact of natural resources abundance and its implications for standards of living and urbanization in Africa. The basic hypothesis was that exploitation of natural resources combined with bad governance, creates the situation of fast urban concentration and urbanization and decreases the standard of living in central or primal part of the city. For empirical analysis panel of different African cities were considered. The results suggested that rise in natural resources enhances urbanization drastically. They established a negative relationship between the standard of life in big cities, the resource abundance and other facilities raises urban concentration and urbanization. The findings of the study asserted that results inevitably hold in case of bad governance. Urbanization due to resource agglomeration in developing countries creates the problem of poor governance. The results suggested that African cities are experiencing a unique type of transformations.

2.1.3 GOLD PRICE AND GOLD EXTRACTION RELATION AS A BASE FOR ECONOMIC INTER-LINKAGE

In the end, like any other asset, gold is affected by its supply and demand characteristics. Thus studies, such as Bertus & Stanhouse (2001), discuss gold prices in terms of supply and demand factors. However, including gold supply, as a variable is more difficult than might be expected due to the previously mentioned issue of gold's stocks dwarfing new gold inflow from mining. The relationship between gold prices and mining activities is then a factor to be considered in any modeling.

Gold shares a negative short-run relationship between price and mining output with other exhaustible resources. As Keynes (1936) and others have pointed out, an increase in the price of an exhaustible resource like gold can, in the short term, lead to declines in its output now. The fixed nature of ore processing capacity in the short term and a higher price of gold will induce the mining of lower grades of ore, which reduces the total volume of output. Thus, while the amount of ore processed remains steady, the final output of gold declines, leading to a further price increase.

This inverse relationship between the gold price and mining output has been documented empirically both for the 1930s Keynes (1936), and for the 1970s Marsh (1983). Fortunately, it has been noted that the long-term relationships between price and output do seem to be positive and stabilizing, as ore processing capacity restrictions can be overcome in the long term. Rockoff (1984) study shows that the long run supply of gold is relatively elastic with respect to gold's price.

Selvanathan & Selvanathan (1999) provide recent evidence on this through an empirical test of whether Western Australian gold production between 1948 and 1994 had a positive relationship to price. They find that in the short term (one year) there is no real measurable response in production level to price changes. However over 5 years a 1% increase in the real price of gold results in a roughly 1% increases in the volume produced. Rockerbie (1999) provides a similar analysis for South African data between 1970 and 1995, with annual data.

He finds that the adjustment speed of production was slow, taking eight years to feed through, which is not unreasonable considering the large-scale capital investment involved. This is one of the few papers where production costs are considered, but they were found to be an insignificant factor in explaining production volume changes. Erb and Harvey (2013), however, suggest that gold mine production is not significantly affected by the rise of prices since 2000, from a visual inspection of data.

Many other studies argue that gold miners are price takers rather than price setters Blose and Shieh (1995). Borenstein & Farrell (2007) find no mention of supply shocks of any kind having an effect on gold price from a search of 28 years of the Wall Street Journal. Nor was it mentioned in interviews they held with mining executives. Another factor from mining affecting gold prices is the idea that the marginal costs of gold mining drive gold prices. Rockoff (1984) points to this having its roots in the idea from classic economics that under a stable and perfectly elastic supply curve the cost of extracting gold is the main cause of the gold price level. In analyzing the effect of the gold price on production, Rockerbie (1999) assumes this causality holds true. Paul Krugman stated, “Placing a ceiling on the value of gold s mining technology, and the prospect that if its price gets out of whack for long on the upside a great deal more of it will be created.” (New York Times, December 28, 2013).

The other possibility is that the causality runs from prices to production costs, as explained by Ricardo’s Law of Rent Ricardo (1817). At any given price it can be expected that mines will supply the market up to the point where marginal costs equal marginal benefits and the industry as a whole maximizes its economic profit. Ricardo notes that mines are of various qualities. As gold prices rises, marginal mines, which were previously unprofitable, will be brought (back) into production. These would be deeper mines or mines yielding a lower quality of ore. This means that the average cost of production for the industry as a whole would rise after prices do, and because of the rise, making low cost mines even more profitable and allowing overall production to expand to meet demand. Similarly, if gold prices fall, it would force high-cost mines to shut down and decrease supply. The opening and closing of mines conditional on the gold price is consistent with the “real option” characteristic embedded in gold mines as analyzed theoretically in Brennan & Schwartz (1985) and empirically in Krautkraemer (1989) and Moel & Tufano (2002). For example, Krautkraemer (1989) finds that as prices rise, miners tend to mine lower quality ore. O’Connor, Baur, and Lucey (2014) examine this in some detail. They find strong evidence for causality running from gold prices to gold production costs both at a firm and a national level. There is also some industry-based discussion that gold prices drive production costs and not the other way around. GFMS Gold Survey 2013 states that "*Over the last decade rising gold prices enabled producers to adjust mine plans to incorporate lower grade material, there by optimizing assets' lives, but this practice also served to push costs higher when expressed on a unit dollar per ounce basis*." In contrast, some analysis argues that production costs provide a price floor below which gold prices cannot fall, as reported in Barron's by Conway (2014).

The positive relation between gold price and gold mining explained by many research is the base of this paper. The micro economic gold price leads to movement to other macro-economic factors that leads to increase/decrease in gold resource extraction

2.1.4. LITERATURE ON ETHIOPIAN CONTEXT

INTRODUCTION TO THE COUNTRY AND STUDY

Ethiopia's natural resources base, its land, water, forests, wildlife and biodiversity are the foundation of any economic development, food security and other basic necessities of its people. Smallholder agriculture is the dominant sector that provides over 85 percent of the total employment and foreign exchange earnings and approximately 47 percent of the Gross Domestic Product (GDP) (EEA, 2005). Ethiopia, with a population of roughly 95 million, is the second most populous country in sub-Saharan Africa, and one of the fastest growing economies in the world. Ethiopia has registered impressive economic growth for several years, ranging between 8 percent and 12 percent. The World Bank and IMF forecast a growth of 8.1 percent in 2015/16 and an average of 7.5 percent over the next three years (Ethiopia - Mining Sector and Business Prospects, 2016). The rate of population growth is expected to decline close to 2 percent by 2030 when the country's population is estimated to reach anywhere between 120 million to 130 million, depending on the rate of urbanization. This has strong implication on the sustainability of the natural resources base and the efforts to attain national food security. (Tedla, 2007)

Natural resources (land, water, forest, wildlife and biodiversity) are key assets for rural economic growth and generating a livelihood for millions of communities living in the rural and resource for those living in peri-urban areas. As an important asset, it constitutes a main vehicle for investment, wealth accumulation and transfer between generations. In many areas of the world, appreciation of land with increased population density is also a source of corruption, land conflicts, and lack of transparency. For these reasons, the distribution of land and other productive assets will affect not only productive outcomes in rural areas but also the ability of the farming communities to make investments, and accumulate assets by improving productivity (Tedla, 2007)

Environmental sustainability is central to sustainable economic growth and efforts to reduce poverty and social inequality. The country relies heavily on the services provided by its forests, biodiversity, agricultural soils, and water resources. However, these services are also fragile and in an apparent state of deterioration, thus requiring the country's full attention to achieve long-term development goals. The country recognizes the importance of the environment and natural resources to social and economic well-being and has signed on to several environmental declarations beginning with the 1992 Rio Summit and extending to the Johannesburg Summit in 2002. It has also designed and enacted its own environmental and natural resources policies and legislations and established appropriate institutions to implement these policies. (Tedla, 2007)

Ethiopia has diverse agro-climatic Zones. It has 18 major agro-ecological zones (AEZs) and 49 sub-agro-ecological Zones that are grouped under six major categories (MoA, 2000). These agro-ecological classifications have important implications for strategies in development of appropriate technologies for agricultural and rural development and natural resources management (NRM). (Tedla, 2007)

Renewable natural resource degradation has become the most threatening problem in today's Ethiopia. The problem is even more compounded when one sees it in the face of Ethiopia's daunting challenge to reduce poverty down to half its current level by the year 2015 via recording fast growth, an annual average GDP growth rate of at least 7percent per annum (MoFED, 2006).

Naturally, policy analysis and decision making take place on three relatively distinct levels: the local or field or firm level; the sectoral or industry level; and the national (macroeconomic) level. Policy makers at national level are responsible for multi-sectoral strategic planning that requires setting national priorities and policies of all sectors based on weighing alternatives and trade-offs. The contribution of national resource account (NRA) is proved to be significant at national (macroeconomic) and sectoral levels. This is extremely important when allocating resources like water or land among competing needs like crops, livestock, and wildlife based tourism (Tedla, 2007). It is widely recognized that poverty and under development aggravate the problem of environmental degradation unless conscious action is taken to reconcile the quest for fast growth and sound environmental management being guided by the signals developed on the basis of information generated through the NRA process. The NRA are well placed as alternative approaches to efficient natural resource management while at the same time promoting growth by integrating environmental concerns in conventional economic policy analyses and decision making criteria. This will also facilitate the implementation of the Ethiopian Conservation Strategy through providing a macro-link to micro (sector/firm/local) level interventions by the Ethiopian Environmental Protection Authority (Tedla, 2007).

It is also recognized that macro-policies (tax policy, external trade policy, interest rate policy) have had impacts on the environment in general and degradation of renewable natural resources in particular and hence on sustainable development. Thus, the impact of macro policies on economic activity and the environment can be monitored based on information generated through the NRA framework. Analysis of rent recovery and of the beneficiaries of rent is also essential. In this regard, the ability of the economy to extract economic rents through taxation of natural resource based industries like timber harvesting, coffee, and water use for domestic, industry and irrigation could be identified (Tedla, 2007).

The allocation of these proceeds for optimal use in the economy in Ethiopia is largely the responsibilities of the Ministry of Finance and Economic Development (MoFED). The recommendations in natural resource rich countries in the main is that these proceeds be allocated on building the future productive capacity of the economy in general, and human resource development in particular, to ensure the revenues are being used in a manner that promotes sustainable development. For instance, the Sustainability Budget Index (SBI) has been used as a sustainability indicator in the allocation of resources in mineral resource rich countries like Botswana (Tedla, 2007).

Given the already existing wide saving-investment gap and the accumulation of foreign debt in Ethiopia, encouragement of foreign direct investment export promotion are top on the agenda of the Federal Democratic Republic of Ethiopia (FDRE). The impact of this policy orientation on sustainable development could be assessed within the NRA framework. The Ethiopian Investment Authority and the Export Promotion Agency within the Ministry of Trade and Industry (MoTI) are important actors whose activities have to be coordinated on the basis of information generated through the NRA (Tedla, 2007).

For developing countries that are experiencing a commodity boom, a tremendous continuous rise in international prices for commodities, an issue of paramount importance is the so-called "natural resource curse," in which the economic development of many natural resource-rich countries does not benefit from extraction, and indeed may even suffer outright. Whilst this curse is a multi-faceted phenomenon, this paper will focus solely on the macroeconomic aspect. Broadly speaking, there are three macroeconomic channels through which economic development may suffer from a commodity boom (Basu, Gottschalk, Schule, Vellodi and Yang, 2013)

- The first is an unproductive use of natural resource revenue inflows. With regards fiscal policy, this could be that the government uses revenue inflows only to boost government consumption without having any lasting productive effect on the economy, at the expense of saving these resources or using them for productive public investment

- The second is a loss in external competitiveness from the rise in government consumption that damages the tradable sector in the economy. In this event, the increase in government spending would result in a real appreciation of the currency that reduces profitability of the tradable sector relative to the non-tradable sector. This would account for a decline in the tradable sector but not necessarily imply a setback to overall economic development, given that the non-tradable sector would expand.

- For overall economic development to suffer in this transmission mechanism, a third channel is potentially significant: the tradable sector must play a special role for economic development. For example, it could be the main source of productivity growth in the economy, such that a diminished size of the tradable sector would lower overall productivity growth of the economy permanently, thereby lowering long-term growth prospects.

Basada; (2017) mentioned the macroeconomic driven late Ethiopian government policy of following ADSL and Investment enhanced regulation through extensive and government supported advanced agricultural practices that led to modernization in every perspective and even though its limited improvement of the nation's FDI, GDP and employment rate.

However, this policies and practices resulted in" LAND GAP'S" and they were not ecologically friendly and the writer recommended a need for a production of biofuel crops to mitigate the impact on natural environment.

Natural resources have direct and indirect impacts on social development. Communities that rely on natural resources for their livelihoods can see these livelihoods being directly threatened by large extractive activities, including pollution and destruction of arable land. An example of positive indirect impacts is the social benefits derived from government revenues (earned from natural resources) being invested in health, education, sanitation, social protection and rural development or in physical capital that generates jobs (UNECA, 2018)

Dejene, (2003) mentioned the severe mining method observed in most Ethiopian parts and also other environmental degrading practices attributed to poor conservation through which the nation was able to generate most of its GDP, employment opportunity and international trade relations as the only means for most of the nation's history. He also recommended policies that go beyond food production and consist in the broadening of the livelihood base and expanding opportunities through employment generation and income diversification in the non-farm sector will be crucial. Such policies will increase access to food, reduce the need for resettlement and the ominous threat of the expanding rural population on the natural resources base. Such an approach could stimulate and stabilize the demand for food (without directly increasing food supply) as would production-oriented agricultural intensification policies. It could also be a significant linkage area to reduce the enormous pressure exerted by the impact of the population structure on the rural economy and natural resources (leading to the "vicious cycle").

GOLD AND THE ETHIOPIAN ECONOMY

Ethiopia has a huge potential of various mineral resources, but not yet well explored and exploited, and hence its contribution to the overall economy or GDP is low. However, as reported by the World Bank Group (2014), its contribution to the foreign exchange earnings reached about 10% of which the artisan mining takes the lion's share of over 65%. The mining sector has a significant contribution to the Ethiopian economy. Production and export of gold was just US$ 5 million in 2001 and rose to US$ 23.8 million in 2015. The artisan mining also significantly contributes to the employment of at least 1.26 million people and supports the livelihood of over 7.5 million populations. The total population involved in gold mining (legal and illegal) is estimated at 1.24 million. Taking into account the number of artisan miners and average annual production, rough estimation shows that, in the major gold producing areas of the country, a total of about 18,000 kg of gold is produced per annum.

According to the results of this study, at regional level, SNNPR collected royalties close to 13 million birr and Oromia about 8 million birr whereas, the remaining regions were much weaker in collecting royalties. Nevertheless, rough estimation, based on secondary data and key informant interviews with experts/officials of concerned institutions, shows that only 36% of potential royalty was collected in 2014 and it is a huge loss to the government.

Strategic assessment of the Ethiopian mineral sector (2014) by ministry of mines shows that mining service contributed 1.5% to GDP in the fiscal year 2011/12(a total of USD 32 Billion). The sector accounted for USD 618 million (19%) of the country's exports with gold making up close to 100% of the mining sector exports.

Ethiopia's gold production was reported at 11, 000 kg in Dec 2017. This records an increase from the previous number of 8, 577 kg for Dec 2016. Ethiopia's gold production data is updated yearly, averaging 3, 940 kg from Dec 1990 to 2017, with 28 observations. The data reached an all-time high of 12, 581 kg in 2013 and a record low of 848 kg in 1990 (CEIC, 2018).

Latest reports from NBE and Ministry of mines show huge drop over the last three years in gold production in Ethiopia mainly due to large suppliers stopped operation. In fact, the amount of foreign currency Ethiopia is earning from exports of gold is dwindling continuously. It plummeted to a shocking USD 32 millions in 2018/19 down from 654 million in 2011/12. According to NBE's report, export earnings from gold plummeted significantly mainly due to 92.5% drop in volumes in past seven years, resulting from artisanal miners to sell their gold through the underground black market. One of the main reasons for the decline is the joining of mass youths into the sector without skill, capital and technology. With mining sector identified by Ethiopian government as a main reform program part to generate huge foreign currency and provide more than 3 million employment opportunity, the current status shows capital loss, international trade loss and less employment opportunity in gold mining sites in Ethiopia.

2.2. EMPERICAL LIRERATURE REVIEW

J. Levin and E.Wright (2006) study on USA economy finding shows there is a long-term relationship between the prices of gold and the US price level. Second, the US price level and the price of gold move together in a statistically significant long-run relationship supporting the view that a one percent increase in the general US price level leads to a one percent increase in the price of gold. This evidence substantiates the belief that gold is a long-term hedge against inflation. Third, in the wake of a shock that causes a deviation from this long-term relationship, there is a slow reversion back towards it. This in turn will result in more demand requirement for gold, which in turn leads to more gold production. The estimate of the error correction term is –0.019, which implies that each month's error is about 2 per cent smaller than the previous month. In effect, this means that, in the aftermath of a shock, it typically takes around five years to eliminate two-thirds of the deviation from the long-term relationship between the price of gold and the US price level. Short-run relationships between the following explanatory variables and changes in the gold price were found to be statistically significant. There was a positive relationship between gold price movements and changes in US inflation, US inflation volatility and credit risk. We found a negative relationship between changes in the gold price and changes in the US dollar trade-weighted exchange rate and the gold lease rate. The significant negative parameter on the "error correction mechanism"

A. Pandey (2020) study shows a tremendous increase in gold price rates due to recent world phenomena, which in turn sky rocketed gold production. Gold ETFs attracted inflows of 734 tons — equivalent to $39.5 billion or €33.7 billion — in the first half of this year, which pushed global holdings in these products to new all-time highs of 3,621 tons, World Gold Council data showed. Gold ETF inflows in the first six months have surpassed the largest annual gain of 646 tons seen in 2009.

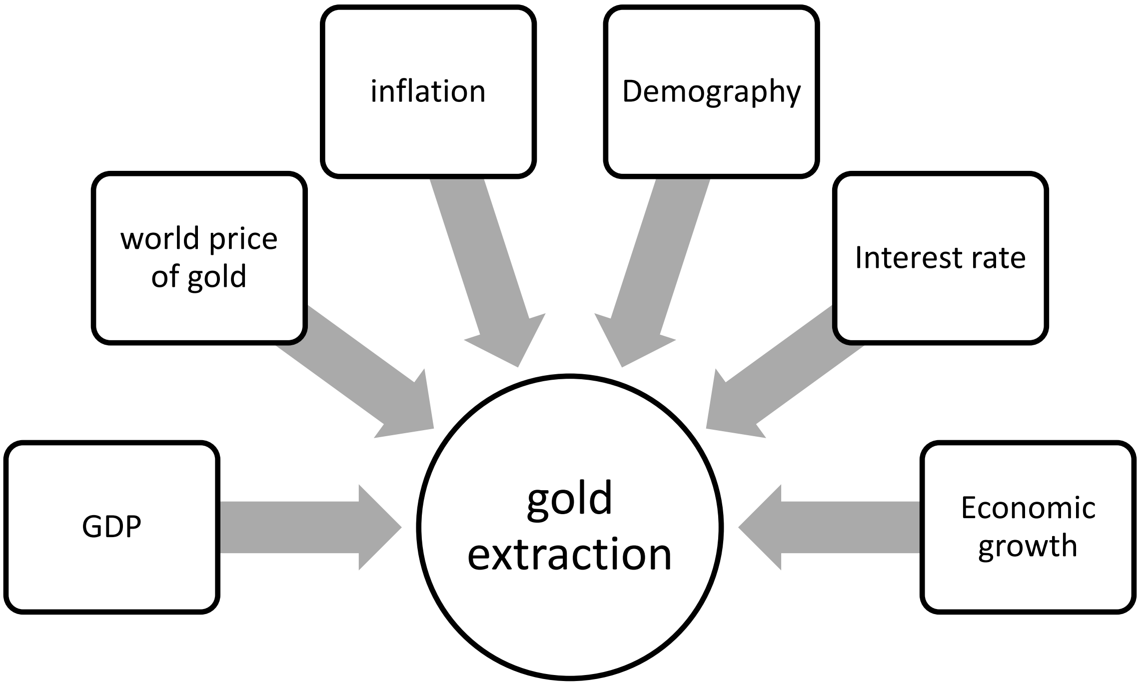
Oxford Economics used the Oxford global model scenario analysis shows that gold may be particularly strong in extreme economic situations, especially high inflation, a weak dollar and with rising financial pressure. However, in the case of deflation, gold performed well. The EU sovereign default caused by the high level of economic pressure led to the flight of security assets. Therefore, the potential role of gold in a balanced portfolio is "clear". In addition, our analysis shows that the optimization of gold and other assets, the lack of correlation means that even in the long term the actual return is negative, and the volatility of the portfolio may also play a role in reducing portfolio volatility.

The optimal portfolio allocation for gold in baseline scenario is 4-9%, depending on risk preference. These considerations may partly explain why the use of gold as an investment tool seems to be on the rise, driven by investment demand from less than15% to around 40% in 2010. With the central bank in 2010 as a net buyer of gold since the late 1980s, this is the first time it seems there is evidence that various types of investors are reassessing the value of gold

Sun (2018) empirical result shows that a 1 percent change in the real value of real GGP will result in the 0.01 percent change in real price of gold, holding constant the value for interest rate, and USDI. The estimated coefficient for the real interest rate indicates a one percentage decrease in real interest rate result in a 3.6 percentage increase in the 1st difference of price of gold, holding constant the value for GGP, and USDI. The estimated coefficient for the real trade weighted U.S. dollar index is that a one dollar percentage change in the 1^{st}difference of USDI will result in the 4.6 percentage decrease in the 1st difference of real price of gold, holding constant the value for GGP, interest rate and inflation rate. From Sun's initial hypotheses, price of gold is the major controlling factor of gold production and price of gold and production of gold are always positively related.

2.3. THEORITICAL FRAMEWORK

To show the effects of macroeconomic factors on gold resource extraction, the study developed a theoretical framework by combining theories that shows the effect of these factors on resource extraction in general and gold extraction in particular. According to this theoretical framework, annual gold extraction level can be dictated by macroeconomic variables that determine the level of market movement in an economy. The effects of these factors on a singular level on gold extraction have been presented by different theories on literature review. The theoretical framework combined these theories into one and created gold extraction function, where gold extraction is a function of different macroeconomic factors. This theoretical framework could be depicted as follows:


inflation
Demography
world price of gold
Interest rate
GDP
gold extraction
Economic growth

CHAPTER THREE

METHODOLOGY AND MODEL SPECIFICATION

3.1 Model specification

This section presents a simple model that attempts to capture some of the major economic factors affecting gold extraction level in Ethiopia. Studies have identified various economic factors that influence the gold extraction level. These factors include nation saving, economic growth rate, balance of payment, price real interest rate, inflation, investment, human capital, innovation, technology, economic policies, institutional framework, foreign direct investment, political factors, socio-cultural factors, geography, demography and many others. Understanding characteristics and determinants of gold extraction level requires an empirical framework that can be applied to a relatively long time frame. In order to examine the empirical evidence of the economic determinants of gold extraction level in Ethiopia, the study considers some of these factors.

In the theoretical literature review part, several possible economic parameters that effect natural resource extraction in general and gold mining in particular were thoroughly discussed. But given the data availability problem and the level of development of some parameters in Ethiopia, relatively fewer variables are considered for model specification shown below.

Literature discussed understatement of the problem and theoretical review part could be collected to determine the economic factors effect on gold resource extraction in Ethiopia. In this paper, the critical factors that determine the level of gold resource extraction with annual gold extraction level measured by kilograms being taken as dependent variable and vector of determining explanatory variables that affect annual gold mining; inflation rate, Real Interest Rate, population, national saving, price and export earnings from gold sales are used as explanatory variables in the model.

We specify the gold extraction level function for Ethiopia as follows: Annual gold extraction is a function of Real GDP, inflation, real interest rate, population, economic growth rate and world price of gold.

Therefore the mathematically relationship between annual gold extraction level and its major macroeconomic determinant are expressed as follows:

E = f (GDP, I, RI, G, P, PR) ……………………………………………………. 3.1

The researcher transformed some of the variables under study into Log data to avoid hetroscedasticity (Gujarati, 2004) and to show elasticity of the variables; the gold extraction function of equation [3.1] becomes:

E_t=Bo+$B1LnGDP_t$+$B2RI_t + B3I_t + B4LnP_t + B5G_t + B6PRt$ +U_t…………………. 3.2

Where $E_t$represents annual extraction per kilogram at a time t; GDP_trepresent real GDP at a time t; RI_t represents real rate of interest; I_t is the general inflation level; P_t is the level of population at a time t; G_t is annual economic growth and PRt is world gold price. U_t, assumed to be normally and independently distributed with zero mean and constant variance, is an error term which represents the variation in determining variables that is not explained by the above variables. It reflects the effect of other explicit and implicit variables which can affect the level of resource extraction but are not incorporated in the model may be because of absence of data, the qualitative nature of the data, and other reasons.

3.2. Data Source, Variable Description and trend analysis

ANNUAL EXTRACTION (E)

In my model, as a dependent variable, the annual gold extraction level is taken as a measure of gold resource extracted, which is measured by annual total gold production in kilograms in the nation reported to National Bank of Ethiopia (NBE). This means, change in annual extraction is proportional to change or depletion of gold resource (a 1% growth in extraction of resource investment, will result in an equal 1% change or increase in amount of gold resource depleted). Thus we will use the annual gold production level as a measure explained my major economic factors overtime.

Gross domestic product (GDP)

Gross Domestic Product measures the value of economic activity within a country. i.e. it is the sum of the market values of all final goods and services produced in an economy during a period of time, which includes the monetary value of all activities in the nation collected from

NBE. OECD(2001) mentioned the need for proper accounting of resources extracted to be included in national accounting and internalizing the environmental costs of natural resources extraction and use in the prices of resources is a powerful mechanism for creating incentives for sustainable natural resources management and consumption.The wealth embodied in natural resources makes up a significant proportion of the wealth of most nations, often more than the wealth embodied in produced capital, therefore, making natural resources management a key aspect of economic development (World Bank, 2006). Many countries have seen significant rises in revenues from natural resources due to the rise in commodity prices. Natural resources such as oil, gas, minerals and timber are expected to continue to play a significant role in resource abundant economies, as demand from rapidly growing economies increases, and as supplies of non-renewable resources decline and renewable resource harvests approach maximum sustained yield levels(OECD, 2011)It's expected that a rise in GDP will lead to an increase in level of gold resource extraction.

The most commonly used GDP formula, which is based on the money spent by various groups that participate in the economy is.

GDP=C+G+I+NX……………………………………………………………….3.3

C = consumption or all private consumer spending within a country's economy, including, durable goods (items with a lifespan greater than three years), non-durable goods (food & clothing), and services.

G = total government expenditures, including salaries of government employees, road construction/repair, public schools, and military expenditure.

I = sum of a country's investments spent on capital equipment, inventories, and housing.

NX = net exports or a country's total exports less total imports.

INFLATION (I)

Inflation is defined as an increase in the overall price level in a country and measured in percent. Inflation is a state of rising prices. It constitutes, thus, an overall increase in price level. It can, thus, be viewed as the devaluing of the worth of money. UNCTAD (2014) mentioned even though natural resource extraction contributed positively to economic development for countries like UK in 18^{th} and 19^{th} century, natural resources have sometimes been associated with the Dutch disease, a cascade of imbalances resulting in inflation and an appreciation of the real exchange rate. It’s expected that as the inflation rate rises, the annual extraction of a resource will increase

Real Interest Rate (RI)

Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator. Real interest rate: Bank lending rate minus inflation. Many studies link natural resource extraction to the existing level of real interest rate. Therefore to analyze its effect on gold extraction in Ethiopia, which is included in this study as an independent variable. The coefficient of this variable is expected to be positive sign.

Population (P)

Ethiopia’s population reached around 110 million in 2019. An ever increasing level of population is a threat to the environment and natural resource. The recent years low level export earnings and production in gold in Ethiopia is related to the wide spread artisanal mining and population pressure. Therefore to study if the actual total population rising have effect on gold production level in Ethiopia, population level is included in the study as an independent variable. The coefficient of this variable is expected to be positive sign.

Economic growth rate

Ethiopia’s economic growth has been remarkably rapid and stable over the past decade. Real GDP growth averaged 10.9 percent in 2004–2014, according to official data. By taking into consideration population growth of 2.4 percent per year, real GDP growth per capita averaged 8.0 percent per year. The country moved from being the 2nd poorest in the world by 2000 to the 11th poorest in 2014, according to GNI per capita, and came closer to its goal of reaching middle income status by 2025 (World Bank Group, 2004)

Economic growth rate is one of the main determining factors in natural resource extraction variable. To study if the actual increase in economic growth has effect on gold production level in Ethiopia, annual economic growth rate is included in the study as an independent variable. The coefficient of this variable is expected to be positive sign.

World gold price

The global economy is witnessing a rise in world gold price due to insecurities witnessed in the world economy in recent years. Individuals prefer to hold hard currency rather than money currency to avoid insecurities that follow unstable global market. This condition in turn could boost the mining companies drive to explore more gold and sell to global market.

To study if the actual increase in world gold price has effect on gold production level in Ethiopia, world annual average gold price is included in the study as an independent variable. The coefficient of this variable is expected to be positive sign

3.3 Method of data analysis

The paper mainly used econometric analysis using OLS estimation, while some descriptive analysis was also utilized. To analyze the Macroeconomic factors performance in Ethiopia during the study period, we used tools of descriptive statistical such as charts and trend graphs. On the other hand standard econometrical technique would apply to analyze the major determinants of gold extraction under the study period.

3.4. Time Series Econometrics Issues

To examine the short run and long run relationship between dependent variable (gold extraction) and independent variables (GDP, economic growth rate, inflation, population, world price of gold and interest rate), the study applies Autoregressive Distributed Lag (ARDL) Model. Before estimation of the final model, the different model diagnostics was conducted. These includes test of stationarity of the data, normality of the residuals, heteroscedasticty, selection of optimal lag length, existence of long run relationship or co-integration and model stability. First the stationarity of the time series data is investigated by using Augmented Dickey-Fuller (ADF) tests. The unit root tests will be used to check the stationary of the variables and to check none of the variables are not order two (I.e. I (2)), which is precondition to apple ARDL model (Pesaran et al., 2001).

3.4.1 The Autoregressive distributed lag Model (ARDL)

A large number of past studies have used the Johansen co-integration and Engle-Granger causality technique to determine the long-term relationships between variables of interest. In fact, this remains the technique of choice for many researchers who argue that this is the most accurate method to apply for I (1) variables. Recently, however, a series of studies by Pesaran et al. (1999, 2001); Narayan (2004); have introduced an alternative co-integration technique known as the 'Autoregressive Distributed Lag (ARDL)' bound test. There are numbers of advantages of using

ARDL model also called 'Bound Testing Approach' instead of the conventional Engle Granger two-step procedure (1987), Maximum likelihood methods of co-integration (Johansen, 1988) and Johansen and Juselius (1990).

First, the ARDL model is the more statistically significant approach to determine the co-integration relation in small samples as the case in this study (Pesaran et al., 2001; Narayan,2004), while the Johansen co-integration techniques require large data samples for validity. A second advantage of the ARDL approach is that while other co-integration techniques require all of the regressors to be integrated of the same order; the ARDL approach can be applied whether the regressors are purely order zero [I(0)], purely order one [I(1)], or mixture of both.

This means that the ARDL approach avoids the pre-testing problems associated with standard co-integration, which requires that the variables be already classified into I(1) or I(0) or mixture of both (Pessaran et al., 2001). Third, with the ARDL approach it is possible that different variables have different optimal numbers of lags, while in Johansen-type models this is not permitted. Forth, the other advantages of bound testing approach in the long run and short run parameters of the model in questions are determined simultaneously (Nasiru, 2012 as cited in Tsadkin, 2013). Finally, Appling the ARDL technique we can obtain unbiased and efficient estimators of the model (Narayan, 2004), (Harris and Sollis, 2003; Pesaran, 1995) as cited in Tsadkin 2013.

According to Pesaran et al. (2001), the ARDL modeling of unrestricted erro r correction model using Ordinary Least Square (OLS) can be represent as follows.

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta \Delta Y_{t-i} + \sum_{i=1}^{p} \alpha \Delta X_{t-i} + \delta_1 Y_{t-1} + \delta_2 X_{t-1} + U_t$$

Where denotes for first difference operation, is for a vector of dependent variables, is a vector of p determinants of regressors, is the residual term which is assumed to be white noise. Basically, the ARDL approach to cointegration (See Pesaran et al. 2001) involves estimating of the error correction model (ECM) version of ARDL model for the determinants of gold extraction

The orders of the lags in the ARDL Model is selected by either the Akaike Information criterion (AIC) or the Schwarz Bayesian criterion (SBC), before the selected model is estimated by ordinary least squares. We use the Akaike Information criterion (AIC) in la g selection because of its advantages for small sample size (Tsadkan, 2013) as it is the case in this study. Determination of the optimal lag length is so crucial in ARDL model, because of it helps us to address the issue of over parameterizations and to save the degree of freedom (Taban, 2010) as cited in Tsadkan (2013). For annual data, Pesaran and Shin (1999) recommend choosing a maximum of 2 lags. From this, the lag length that minimizes Akaike Information criterion (AIC) is selected. In the presence of cointegration, short-run elasticities can also be derived by Constructing an error correction model

3.4.1. Stationarity and testing for stationarity

In the analysis of time series data, the notion of Stationary process plays an important role. Strictly speaking, a stationary time series is one whose probability distribution is stable over time in the following sense: if we take collection of random variables in the sequence and shift the sequence h time period, the joint probability distribution must remain unchanged. Such a time series is called strictly stationary (Wooldridge, 2003; Madalla 1982). But Madalla (1982) pointed out that in practice this is a very strong assumption to make and it is useful to define Stationarity in less restrictive way, i.e. to define it in terms of first and second moments only.

Therefore, a stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap between the two time periods and not the actual time at which the covariance is computed. Such a time series is called weakly stationary (Gujarati, 2004).

A non-stationary time series on the other hand has a time varying mean or a time varying variance or both and using the classical ordinary least square (OLS) estimate technique on non-stationary time series data will result in what is called "spurious" or "non-sense" regression, i.e. a situation where the estimated regression has a high R^2 and significant t values without any economic relationship between the variables (Gujarati, 2004; Patterson, 2002).

Testing for Stationarity

We have discussed that a standard regression analysis requires a time series to be stationary and hence the next issue will be how to find that a time series is stationary. Although there are several tests for Stationarity, in this paper we will use one of them which is mostly used by different researchers.

Unit root test

A test of Stationarity (or non-stationarity) that has been become popular over the past several years is the unit root test. The Dickey-Fuller (DF) and the augmented Dickey-Fuller (ADF) tests are the most usually used tests for unit root (Gujarati, 2004).

It is fundamental to test for the statistical properties of variables when dealing with time series data. Time series data are rarely stationary level forms. Regression involving non-stationary (I.e., variables that have no clear tendency to return to a constant value or linear trend) time series often lead to the problem of spurious regression. This occurs when the regression results reveal a high and significant relationship among variables when in fact, no relationship exist. Moreover, Stock and Watson (1988) have also shown that the usual test statistics (t, F, DW, and R square) will not possess standard distributions if some of the variables in the model have unit roots.

The other necessary condition for testing unit root test when we applying ARDL model is to check whether the variables enter in the regression are not order two (I.e. I(2)), which is precondition in ARDL model. Therefore, it is necessary to test for time series variables before running any sort of regression analysis.

Non-stationarity can be tested using Augmented Dickey-Fuller (ADF) test, Phillips Perron (PP) test and Kwiatkowski- Phillips-Schmidt-Shin (KPSS) test. However, to ensure reliable result of test for stationarity, the study employs both Augmented Dickey-Fuller (ADF) .

The testing procedure for the ADF unit root test is specified as follows:

$$\Delta Y_t = \alpha + \delta t + \gamma Y_{t-1} + \sum_{i=1}^{\rho} \lambda \Delta Y_{t-i} + \epsilon_t$$

Where is a time series variables under consideration in this model at time t, t is a time trend

variable; Δ denotes the first difference operator; is the error term; p is the optimal lag length of each variable chosen such that first -differenced terms make a white noise. Thus, the ADF test the null hypothesis of no unit root (stationary).

That is: $H_0: \gamma = 0$; $H_1: \gamma \neq 0$

If the t value or t -statistic is more negative than the critical values, the null hypothesis (I.e. H0) is rejected and the conclusion is that the series is stationary. Conversely, if the t - statistic is less negative than the critical values, the null hypothesis is accepted and the conclusion is that the series is non-stationary.

The actual procedure of conducting the DF test involves three important equations which are derived from the following basic equation:

$Yt = \rho Yt\text{-}1 + ut$ …………………….. (3.4)

In literatures equation (3.4) is known as autoregressive process of order one (AR(1)) model.

In conducting the DF test, to allow for various possibilities of non-stationary time series, the test is estimated in three different forms:

$\Delta Yt = \delta Yt\text{-}1 + ut$ …………….. (3.4.1)

$\Delta Yt = \beta 1 + \delta Yt\text{-}1 + ut$ ……….. (3.4.2)

$\Delta Yt = \beta 1 + \beta 2t + \delta Yt\text{-}1 + ut$ ……. (3.4.3)

Where Δ is the first difference operator ($\Delta Yt = Yt - Yt\text{-}1$), $\delta = \rho - 1$, t = time or trend variable and ut is the white noise error term. In each case, the null hypothesis is that $\delta = 0$, that is, there is a unit root – the time series is non stationary. The alternative hypothesis is that δ is less than zero; that is, the time series is stationary.

The extended version of the DF test is usually called the augmented Dickey-fuller test (ADF) because the regression has been augmented with lagged changes, $\Delta Yt\text{-}h$. The inclusion of the lagged changes in the above three equations is intended to clean up any serial correlation in error term. The test is conducted by 'augmenting' the preceding three equations by adding the lagged values

of the dependent variable Yt. For example if we take equation (3.4.3) and augmentation it up to 'm' lags, the ADF takes the form:

$\Delta Yt = \beta 1 + \beta 2t + \delta Yt\text{-}1 + \Sigma.mh{=}1\ t\text{-}h + ut$ ……………. (3.4.4)

Where, ut is a white noise error term and $\Delta Yt\text{-}1 = (Yt\text{-}1 - Yt\text{-}2)$, $\Delta Yt\text{-}2 = (Yt\text{-}2 - Yt\text{-}3)$ etc.

Wooldridge (2003), mentioned that the lag length is often dictated by frequency of data (as well as the sample size). For annual data, one or two lags are usually sufficient and for monthly data we might include twelve lags, but there is no hard rule to follow in any case. On the other hand Gujarati (2004), points out that the number of lagged difference terms to be included is often determined empirically.

In our analysis, since the ADF test is important in avoiding serial correlation in the error term we use this test for unit root.

The rejection rule for both DF and ADF test is that, we reject the null hypothesis that $\delta=0$, if the absolute value of the computed tau statistic exceeds the DF or Mackinnon critical value in which case the time series is stationary. On the other hand if the absolute value of the computed tau statistic is less than the critical tau value, we fail to reject the null hypothesis; i.e. time series is non stationary.

CHAPTER FOUR

DESCRIPTIVE AND TREND ANALYSIS

This section of the paper will briefly discuss both descriptive and econometric analysis of factors that determine the extraction of gold resource. On the first part of this section, brief overviews of the overall factors which are deemed important and thus influence the gold extraction are discussed. In the second part of this section, econometric results are presented.

4.1. Gold resource extraction in Ethiopia

Artisanal miners have mined gold in Ethiopia for thousands of years, and gold deposits are widespread across the country. Southern Ethiopia's greenbelt already hosts two gold mines, with MIDROC Ethiopia mining at LegaDembi, and production having started at Sakaroin in the Oromia region. MIDROC has also been granted a large-scale gold mining license and is under development at Metekel in the Benishangul Gumuz region. In addition several local and international large-scale gold mining companies have been granted licenses (MoME, 2018)

Artisanal mining is extensive and primarily focused on gold. The gold is mined mostly from alluvial deposits in the 0roterozoic terrains in the south west and north of the country, and is being mined by numerous artisanal and small scale miners. In the south, there is also a small state owned mine called Adola, where alluvial gold has been mined for over half a century. Concerning the large scale sector, there is only one operating mine in Ethiopia, Midroc's LegaDembi Gold Mine, and ranked number 170 in the world in terms of value of production in 2012. A fairly mature gold project at Tulu Kapi, which has IFC (international finance corporation) involvement, was on hold during the second half of 2013 but changes in ownership and additional financing has now allowed for exploration activities to continue (Ministry of Mines, 2014)

Assessment by ministry of mines (2014), shows that mining service contributed 1.5% to GDP in the fiscal year 2011/12(a total of USD 32 Billion). The sector accounted for USD 618 million (19%) of the country's exports with gold making up close to 100% of the mining sector exports. In a probable scenario it is proposed that the mineral sector could generate revenues of up to USD 1.53 billion by 2024 and in an optimistic scenario some USD 2

BILLION. In the probable scenario the revenue corresponds to about 70% of the current export value of gold in Tanzania (2.2 Billion USD in 2012), an emerging mining economy dominated by gold production. In Ghana, which has a long mining history where gold accounts for more than 90% of the total mined value, gold exports were worth almost USD 5 billion in 2012. The current policy framework envisions the mineral sector to be the 'back bone' of the industry by 2020-2013, with an increase in the contribution to the GDP from the current 1.1% to 10% and a 10-fold increase in its contribution to foreign currency earnings. In 2012, gold accounted for 19% of the value of global mine production (excluding coal). However, between 2015 to 2021 gold ore production is expected to decrease by 0.7%. Ore grades for gold are also likely to fall from 1.6 gpt (grams per ton) in 2012 to 1.43 gpt by 2020. In general, gold mines have experienced considerable increase in costs and have had difficulties meeting output targets.

The foreign currency Ethiopia is earning from exports of gold is dwindling continuously. It plummeted to a shocking USD 32 millions in 2018/19 down from 654 million in 2011/12. According to NBE's report, export earnings from gold plummeted significantly mainly due to 92.5% drop in volumes in past seven years (EBR, 2019). Figure 4,1 presents gold production from 1990 to 2017 in Ethiopia.

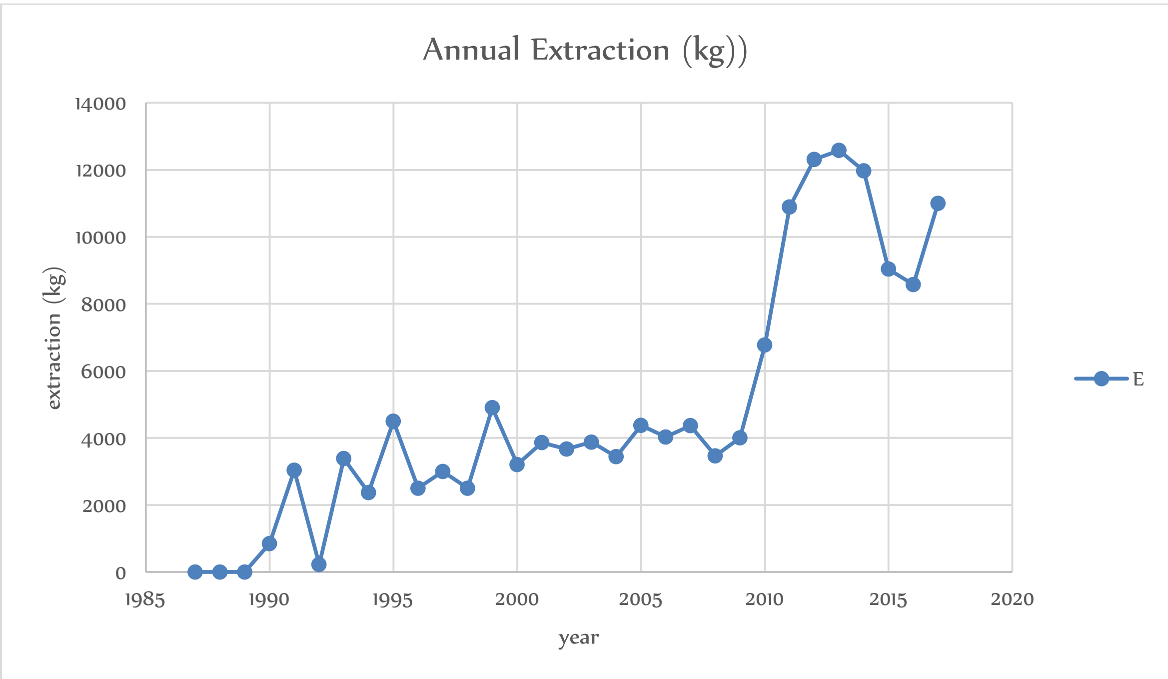


Figure 4.1: Gold production trend in Ethiopia from 1990 to 2017 (Source: NBE)

4.2. DETERMINANTS OF GOLD RESOURCE EXTRACTION

4.2.1. GDP

Ethiopia is one of the largest least developed countries (LDCs) in Sub-Saharan Africa, with a population of about 94 million people in 2012. After suffering economic stagnation for most of the 1970s and 1980s, its economy began to grow in the mid-1990s. During the last decade it has become one of the fastest growing economies in the world with an average gross domestic product (GDP) growth rate of about 10% per annum. According to the ambitious fiveyear Growth and Transformation Plan (GTP) the Ethiopian government rolled out in 2010, Ethiopia aims to attain a lower-middle-income status by 2020 (Shiferaw, 2017)

Ethiopia is among the fastest growing non-oil economies in the world as the government reforms undertaken in recent years have succeeded in opening the economy to foreign direct investments and resulted in expansion of commercial agriculture and manufacturing industry . The gross domestic product (GDP) in Ethiopia expanded 9 percent in 2018 from the previous year. The gross domestic product (GDP) in Ethiopia was worth 94 billion US dollars in 2019, according to official data from the World Bank and projections from Trading Economics. The GDP value of Ethiopia represents 0.08 percent of the world economy (Trading Economics, 2018-19).

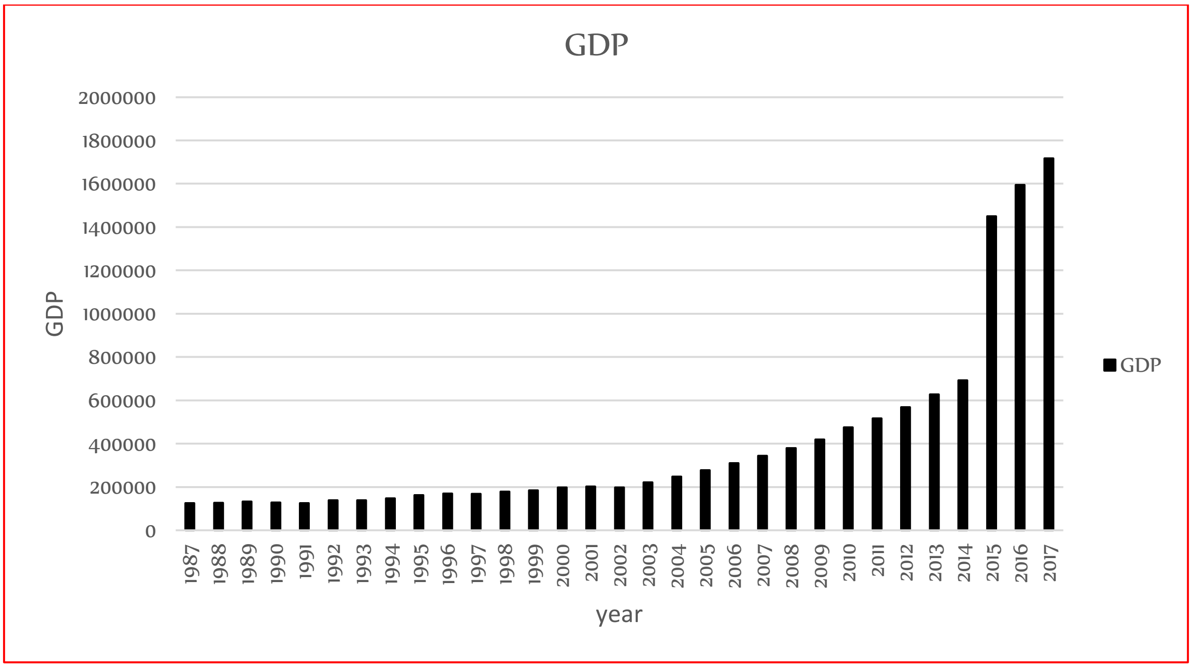


Figure 4.2: GDP trend in Ethiopia from 1995 to 2019 (Source: NBE)

4.2.1.1. The Impact of GDP on Gold resource extraction.

Quite a lot of papers have been done on natural resource extraction effect on GDP, though little has been done on gold resource. The intention of this part is the reverse, showing the impact of GDP growth on gold resource extraction. Sun (2018) mentioned macroeconomic factors effect on gold price, which in turn affects gold resource extraction. His paper was focused on USA's economy and the relationship between macroeconomic factors and gold price.

The Dollar Index (USDI), which shows the economic situation (GDP) of the country, for gold is an indicator of the exchange rate of USD in the international foreign exchange market, which is negatively correlated with international gold price. A fall in the USDI means the US dollar depreciates and the value of gold increases, investors buy gold and reduce the demand for USD. This will lead to the rising demand for gold. At the same time, international dollar price of gold appreciate which in turn increases the extraction level of gold (Sun, 2018)

Economic development leads to increased need for global liquidity. Therefore, this increases the scale of investment in various derivatives, thus contributing to a rise in gold prices. During an economic crisis, global liquidity is reduced, but because gold is a safe-haven in a period of uncertainty, international gold prices will rise. Because gold's consumer demand is relatively stable and safe-haven demand tends to lead to overshoot of the gold price, the overall effect is that when GGP is less than expected or is significantly slower than the previous period, gold prices will form short-term support which leads to an over exploitation of gold resource, and vice versa (Sun, 2018)

4.2.2. INFLATION

Currently, inflation is a major problem of the world. It is a monster that threatens all economies because of its undesirable effect on economies of both developed and developing countries. (Asmamaw, 2011). According to classical theories inflation occurs in an economy when the overall price level increases and the demand of goods and service increases. Based on the Keynesian theories inflation occurs when demand exceeds the potential output of the economy. Inflation is defined as an increase in the overall price level in a country and is measured in percent. In Ethiopian history inflation was not a problem of economic growth. However, starting 2008 it has become a serious problem. (Gebru, 2019)

The official headline inflation during 2008 stood at about 33 percent with food inflation being about 49 percent. This was huge macroeconomic shock in the history of Ethiopia for the last five decades and until 2003, was below 5 percent per annum (Ibid). This high rate of inflation continued until 2011/12. The 12 month moving average general inflation rate, which shows a longer inflation situation, was 18 percent for June 2010/11 and 33.7 percent in June 2011/12 (Gebru, 2019). According to MoFED (2012/13) the high inflation rate, particularly in the year 2011/12 adversely affected the wellbeing of people and the effort to promote private investment.

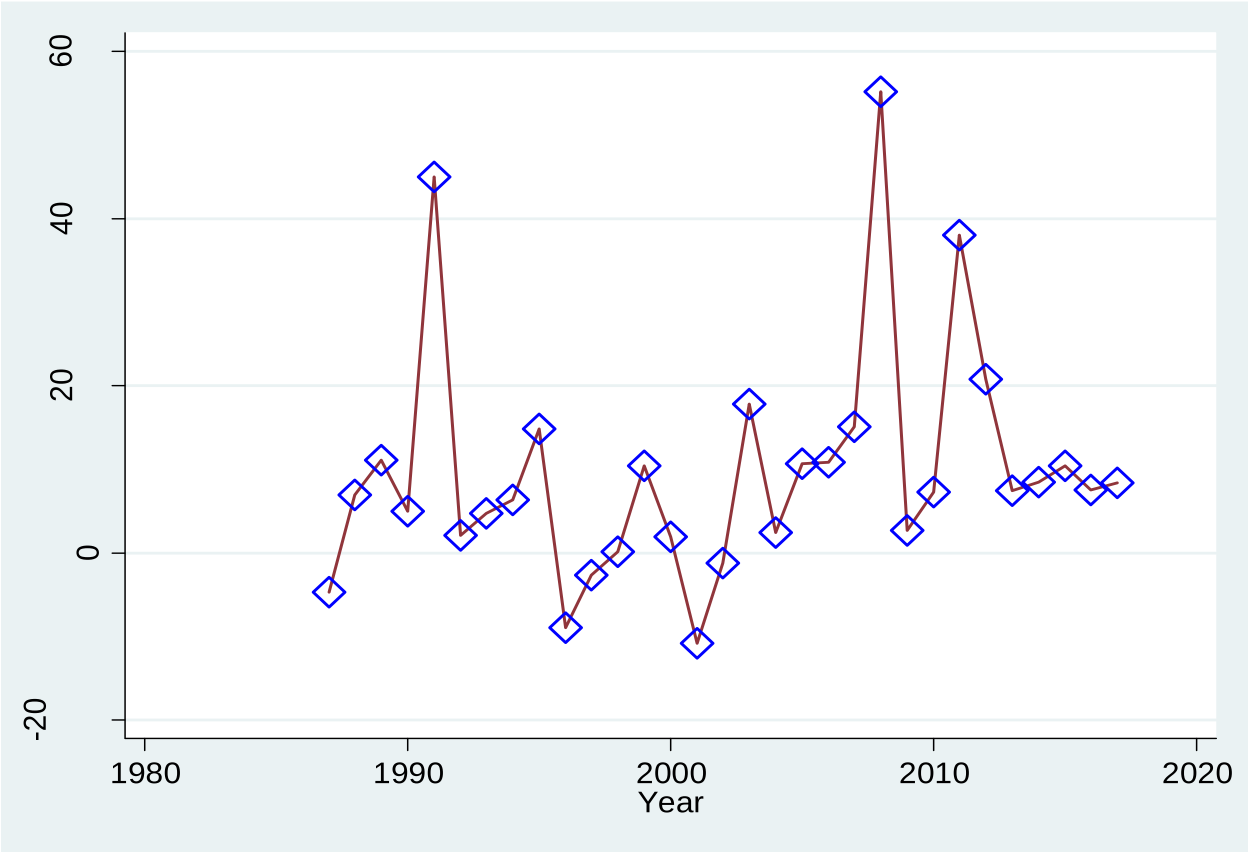


Fig 4.3: Trends of Inflation in Ethiopia from 1987 to 2017 G.C (Source: NBE)

4.2.2.1. The Impact of Inflation on Gold resource extraction

Mcmahon (2018), after studying the USA economy since 1970, the relationship between inflation and gold, mentioned that inflation rates in the 1990's continued to trend downward starting the decade at 5.39% in 1990 and averaging 1.55% in 1998 before rebounding to 3.38% in 2000. Even with fairly low annual inflation the dollar lost 1/3 of its purchasing power. Cumulative inflation from 1990-1999 was much lower than previous decades totaling “only” 33.47% but despite that loss gold also lost value which led to deprivation in gold production. Mcmahon concluded his study with a statement “So, does gold tend to follow the inflation rate? Yes, it appears it does” i.e. as the inflation rate is rising gold tends to rise and as the inflation rate is falling gold tends to fall. However, gold doesn’t always outperform the cumulative inflation over an individual decade. But it does appear to do well over longer periods of time. His statement describes both gold production and price.

Feldstein (1980)) looks at the theoretical reasons that expected inflation has a relationship with stores of value, such as gold. He argues that this relationship exists because gold is like a currency whose value cannot be diminished by sudden large increases in supply through printing, as is the case for fiat currencies such as the US Dollar or the Euro. He assumes that an increase in expected inflation will cause nominal interest rates to rise. Supposing investors are rational, this means that the required rate of return on holding gold will also increase, driving up the gold price, in order to compensate investors for the increased opportunity cost, which in turn increases the gold mining rates.

Fortune (1987) develops this by explicitly suggesting a channel through which inflation directly affects gold prices: a substitution effect. This calls for direct relationship between inflation and gold resource extraction. Feldstein (1980) stated that more specifically, the analysis here shows that in an economy with an income tax, an increase in the expected rate of inflation causes an immediate increase in the relative price of such "store of value" real assets. Abhyankar and Ghosh (1994) argue that gold lease rates are equivalent to world real interest rates. Abhyankar and Ghosh assumed that changes in gold extraction costs are driven by the general rate of inflation, and that in the long term the gold price will rise in order to compensate miners for their increasing costs which in turn could result in increased gold mining. This implies that a causal relationship exists: running from inflation to the cost of extraction to gold prices to gold extraction. The implicit assumption in this argument is that miners are not price takers, and have market power.

4.2.3 Demographics

Ethiopia’s population which is growing at a very rapid rate, of about 3 percent annually, has been clearing forests and vegetation to satisfy its increasing requirements of food and energy. The forest coverage of the country which was once 40 percent about a century ago is now reduced to only less than 4 percent, and the deforestation rate is estimated at 100,000 ha/year (EVDSA; 1990, 1991).

Ethiopia's natural resources base, its land, water, forests, wildlife and biodiversity are the foundation of any economic development, food security and other basic necessities of its people. Smallholder agriculture is the dominant sector that provides over 85 percent of the total employment and foreign exchange earnings and approximately 47 percent of the Gross Domestic Product (GDP) (EEA, 2005). Ethiopia, with a population of roughly 95 million, is the second most populous country in sub-Saharan Africa, and one of the fastest growing economies in the world with a growth rate of 2.73 percent between 2000-2005. The rate of population growth is expected to decline close to 2 percent by 2030 when the country's population is estimated to reach anywhere between 120 million to 130 million, depending on the rate of urbanization. This has strong implication on the sustainability of the natural resources base and the efforts to attain national food security. (Tedla, 2007)

The ever increasing population of Ethiopia is a big scare to the nation's natural resource. Most natural resource extraction in Ethiopia depends on artisan gold mining by ever increasing young artisan gold miners in gold mining sites.

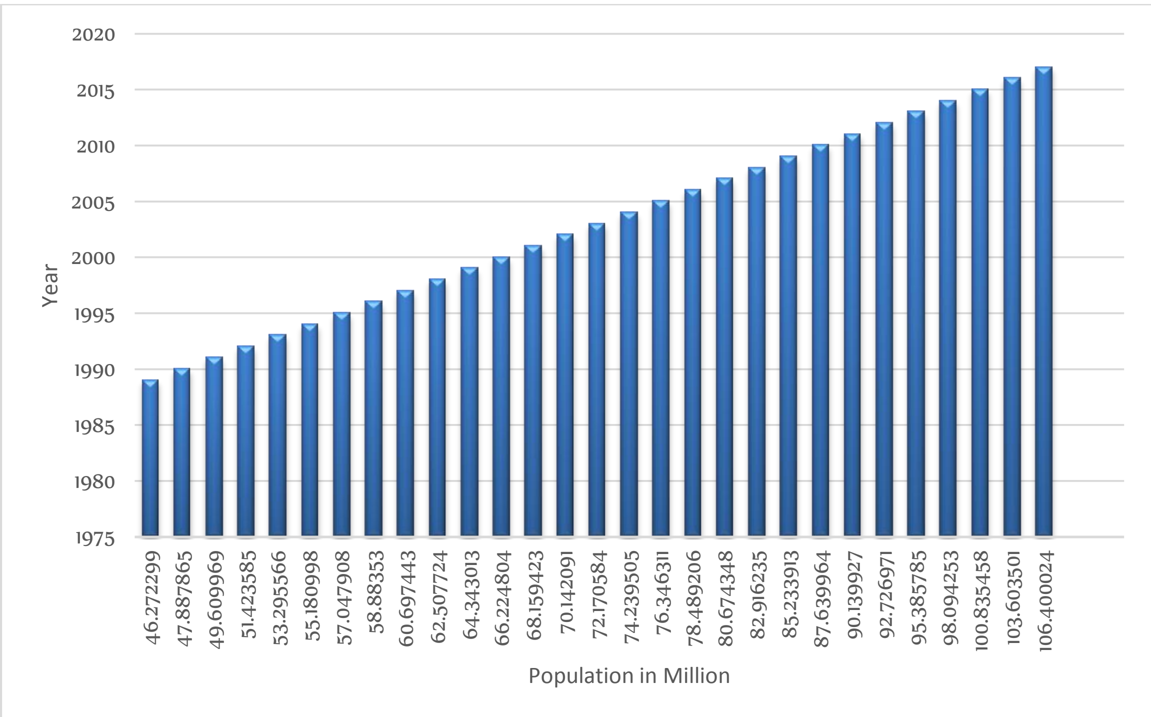


Fig 4.4: Trend of population level in Ethiopia from 1987- 2017 (Source: CSA and WB)

4.2.3.1. The impact of population growth on gold mining

The price of gold has more than quadrupled since 2001, leading to increased rates of global extraction. Even small-scale, artisan gold mining can have negative environmental and social impacts such as deforestation, water contamination, mass immigration and even the death of workers from metal poisoning. Yet gold mining is also an important source of revenue for local communities and governments, and there are methods for reducing, and even reversing, the negative impacts of gold mining. Although the impact of gold mining on local environmental quality is largely negative, the impacts on local communities are less clear-cut, with communities experiencing both costs (e.g. increased exposure to heavy metals) and benefits (e.g. increased income and livelihood opportunities) as mining expands (Myint, Tizard and Pienkowski, 2017)

Generally speaking, as the human population grows, our consumption of natural resources increases. More humans consume more freshwater, more land, more clothing, etc. The more people on the planet, the more food you need to feed those humans (more fishing, more farming, more deforestation to make room for agriculture and raising livestock, and so forth (Kate, 2016). Kate (2016) showed human population increase since 1900 with phosphate mineral extraction, which indicates population increase and phosphate extraction were proportionally growing since 1900.

4.2.4. Real interest rate

Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator. Real interest rate, Bank lending rate minus inflation, is one of the main macroeconomic determinants of an economy. The International Monetary Fund provides data for Ethiopia from 1985 to 2008. The average value for Ethiopia during that period was 2.11 percent with a minimum of -17.67 percent in 1985 and a maximum of 17.64 percent in 2001. The latest value from, from IMF, in 2008 is -17.12 percent. For comparison, the world average in 2008 based on 139 countries is 10.82 percent (IMF, 2008). In 2008, real interest rate for Ethiopia was -17.12 %. Though Ethiopia real interest rate fluctuated substantially in recent years, it tended to decrease through 1989 - 2008 period ending at 4.54 % in 2017.

Fig 4.5: Trend of real interest rate in Ethiopia from 1987 – 2017 (Source: NBE)

4.2.4.1 Real interest rate impact on gold mining

Pearson (2005) used interest rate relation (effect on natural resource extraction) using the oil extraction example. According to Pearson -The firms that own land with oil underneath it are holding a valuable resource. These firms have two alternatives. First, they can extract the oil now and sell it at the current market price. Second, they can leave the oil in the ground and extract it at some later date. The firms, naturally, will choose the alternative that gives them the highest return. Their choice will depend on two key variables—the interest rate and the expected rate of increase in the price of oil. To see how the firms' decisions are made, consider two cases.

First, suppose that the price of oil is expected to rise by less than the interest rate. For example, suppose the interest rate is 10 percent per year but the price of oil is expected to increase by only 5 percent per year. Oil extracted and sold now will in this case have a higher value than oil left in the ground, since revenues from current sales could be earning 10 percent in a bank account. Firms will therefore extract more oil this year. Because the demand curve for oil has a negative slope, raising the extraction rate (increasing the current supply) will reduce this year's price. Production will rise, and the current price will fall until the expected price increase between this year and next year is equal to the interest rate. The firms will then be indifferent between producing another barrel this year and holding it for production next year.

Second, suppose that the price is expected to rise by more than the interest rate. Firms will in this case prefer to leave more oil in the ground, where they earn a higher return than they could earn by selling the oil this year and investing the proceeds at the current interest rate. Thus, firms will cut their rate of production for this year, which will reduce the current supply and therefore raise this year's price. When the current price has risen so that the gap between the current price and next year's expected price is equal to the interest rate, firms will value equally a barrel of oil extracted and one left in the ground.In a competitive industry for a non-renewable resource, equilibrium occurs when the last unit currently produced earns just as much for each firm as it would if it had been left in the ground for future sales. From society's viewpoint, the optimal extraction pattern of a nonrenewable resource occurs when its price rises each year at a rate equal to the interest rate. If the price is prevented from rising, the resource is depleted too quickly. The rising price fulfills a number of useful functions. The shape of the demand curve (Interest rate level) determines the extraction pattern over time.

Chari and Christiano (2014) used the Hotelling's theory to describe the relationship between interest rate and resource extraction. The Hotelling result is intuitive and well-known to economists. In addition, it has a clear and strong implication for prices of these resources over time. When all prices and interest rates are adjusted for inflation, and as long as these "real" interest rates tend to be positive (and setting aside extraction costs, for the moment), the price of an exhaustible resource should rise over time at roughly the same pace as interest rates which would result tremendous increase in resource extraction.

It is often thought that a rise in the real rate of interest will not affect natural resource extraction if it has no effect on market prices. An increase in the real rate of interest will, however, cause the extractor to pump more in early periods and less in later ones. When the interest rate rises, the opportunity cost of extracting another barrel declines because the future profit (from the barrel that must be forgone) is worth less today (Salant, 1995)

4.2.5 Economic growth

Ethiopia's economic growth has been remarkably rapid and stable over the past decade. Real GDP growth averaged 10.9 percent in 2004–2014, according to official data. By taking into consideration population growth of 2.4 percent per year, real GDP growth per capita averaged 8.0 percent per year. The country moved from being the 2nd poorest in the world by 2000 to the 11th poorest in 2014, according to GNI per capita, and came closer to its goal of reaching middle income status by 2025 (World Bank Group, 2004)

Accelerated economic progress started in 1992 with a shift to an even higher gear in 2004. Econometric analysis supports a story of two growth accelerations as average growth increased from 0.5 percent in 1981–92 to 4.5 percent in 1993–2004 and to 10.9 percent in 2004–14.The recent growth acceleration was part of a broader and very successful development experience. Poverty declined substantially from 55.3 percent in 2000 to 33.5 percent in 2011, according to the international poverty line of US$1.90. Despite rapid growth, Ethiopia remained one of the most equal countries in the world with a Gini coefficient of consumption of 0.30 in 2011(World Bank Group, 2004)

Over the last ten years, the country has achieved double digit growth in real terms, averaging 10.6% per year, which is the second fastest in Africa after Angola and even surpasses that of China (10.2%). dependence on agriculture has decreased significantly since the 1980s, falling from 56% to 46% of GDP. This still makes the sector far more dominant than is usual elsewhere in Sub-Saharan Africa. The expansion of mining activity will also contribute to reducing Ethiopia's dependence on agriculture. In 2012 mining contributed 1.6% to GDP, and just fewer than 10% to export revenues (Deloitte, 2014)

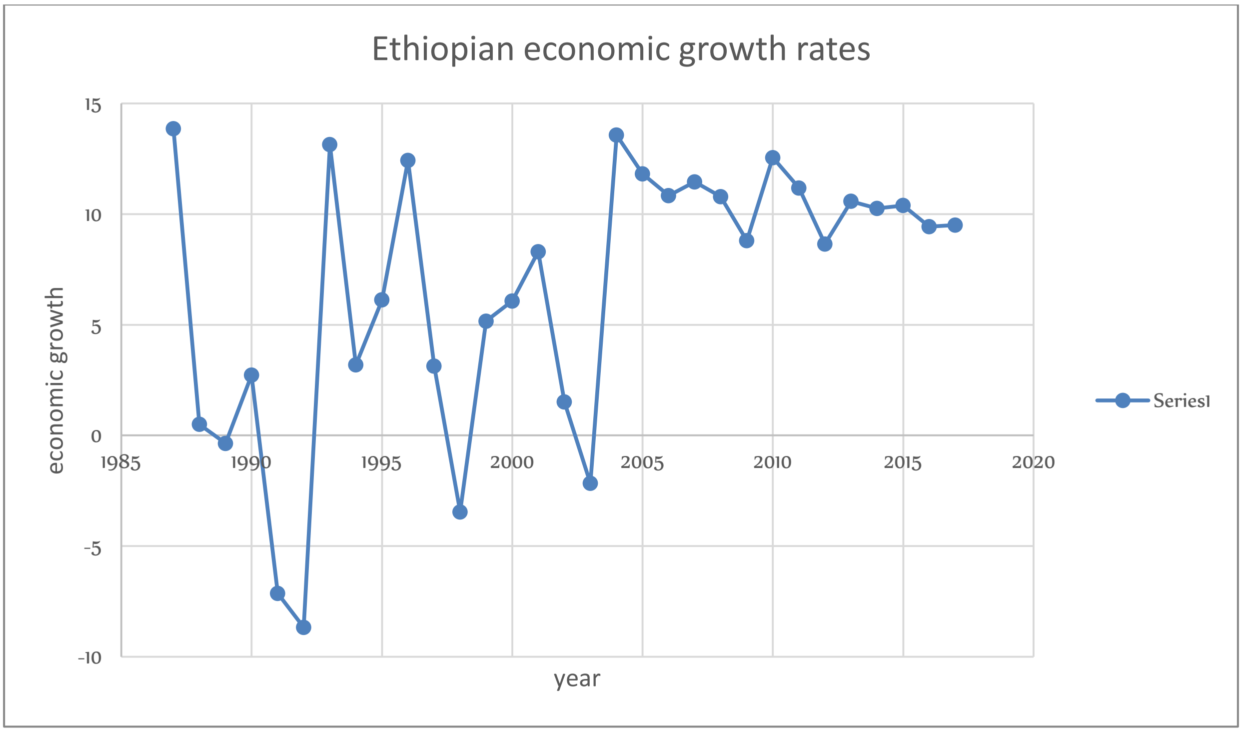


Fig 4.6: Trend of economic growth rate in Ethiopia from 1987 – 2017 (Source: NBE)

4.2.5.1 Economic growth and Gold extraction

A study made by world gold council (2013): shows that developed countries like china, Russia, Australia, and USA produce more gold products and generate huge direct value added to their economies. Even though this countries are not the top gold resource rich countries, their economic growth levels allowed them to produce and gain the maximum possible income from gold mining.

The six largest producers, China, Australia, the United States, Russia, Peru and South Africa, extracted more than half of the gold mined globally. The gold mines in the world's top 15 producing countries are estimated to have generated US$78.4 billion of direct GVA in 2012. This is equal to the entire national economic output of Ecuador or Azerbaijan or 30% of the estimated GDP of Shanghai.

Developing countries with good economic growth rates are ripping the benefit of gold production. China is estimated to derive the largest economic contribution directly from gold mining at US$12.6 billion. For some developing African countries gold mining constitutes the highest GDP share to the economy. Ghana and Tanzania's gold production contributes 8% and 6% to GDP respectively (world gold council, 2013)

Economic growth helps nations to build strong capacity to institutionalize gold extraction and control illegal/artisanal mining activities. Additionally it allows government to control foreign gold producers and capacity building to export in full and increases country's export gain from gold extraction

4.1.7. World price of gold

In 1833 the price of gold was $20.65 per ounce, about $415 in 2005 terms, while in2005 the actual price of gold was $445 – a very small change in the real price of gold over a period of one hundred and seventy two years. Despite this apparent constancy in real terms over the long run, it is also true that, outside of periods when the gold price was fixed through various iterations of the gold standard (A. Pandey, 2020).

In December 2005 the price of gold broke through the US$500 per ounce barrier for the first time since 1981. This price increase continued, reaching $548 by mid-January 2006.In April 2001, the price of gold was at a low of $260 (monthly average). Taking this data as a benchmark, the price of gold has effectively doubled in five years. Although this increase has without doubt been impressive, it was preceded by a long decline from an all-time monthly-average peak of $674 in September 1980 (A. Pandey, 2020).

Gold prices have risen more than 20% this year to touch all-time highs, as low yields and central bank stimulus drive investors toward the precious metal. The yellow metal soared to a record high of $1,944.71 per ounce in 2020, well above its previous record of $1,921.18 seen in 2011 — with demand also supported by worsening US-China relations and worries of delayed and uneven economic recovery amid rising Corona virus cases in several parts of the world, which have reinforced gold's safe-haven appeal. Gold has been the best-performing major asset class this year (A.Pandey, 2020)

Fig 4.7: Trend of world gold price from 1987 – 2017 (Source: NBE and WB)

4.1.7.1 Relationship between world price of gold and gold extraction

Increasing gold demand also supported by worsening US-China relations and worries of delayed and uneven economic recovery amid rising Corona virus cases in several parts of the world, which have reinforced gold's safe-haven appeal. Gold has been the best-performing major asset class this year. The collapse in interest rates and bond yields has made holding gold attractive. *"Rising inflation expectations"*, driven by unprecedented peacetime [fiscal] deficits plus central bank stimulus," make the precious metal, which is considered as a hedge against inflation, an appealing alternative to cash or credit investments (A.Pandey, 2020)

The demand for the precious metal has mainly been driven by record inflows in gold-backed exchange traded funds (ETFs) — investment funds that trade like stocks and replicate whole indices — which offset falling demand for physical gold in key markets such as China and India. Gold ETFs attracted inflows of 734 tons — equivalent to $39.5 billion or €33.7 billion — in the first half of this year, which pushed global holdings in these products to new all-time highs of 3,621 tons, World Gold Council data showed Gold ETF inflows in the first six months have surpassed the largest annual gain of 646 tons seen in 2009 (A.Pandey, 2020)

The surge in gold prices would allow gold miners to loosen their purse strings and spend on boosting production, possibly on the exploration of new mines, after years of cost cutting amid declining prices. Global exploration budgets have more than halved from their 2012 highs of around $10 billion In the past few years, gold miners have turned their focus away from growing production at any cost to focusing on economic metrics like free cash flow generation in the face of investor pressure. They have also struggled to discover new deposits to replace the lost production, prompting several experts and industry magnates to forecast a perpetual decline in gold production from its current peak. But lately economic uncertainty driving gold to record highs, which could allow for gold producing nations to invest more on gold production and benefit from rising gold prices (A.Pandey, 2020)

Sun (2018) suggested that gold price plays the big role in dictating other economic determinants of gold extraction. According to his study world gold price is the major factor that moves other economic variables like inflation, GDP and economic level to dictate the level of gold production the nations produces.

CHAPTER FIVE

ECONOMETRICS ANALYSIS

5.1 METHOD

To investigate factors determining gold extraction factors in Ethiopia, this paper has used ARDL method of econometric analysis and error correction model. It utilizes time series data for the period 1988-2017 to check the effect both in the long run and short run.

5.2 ECONOMETRIC RESULTS AND ANALYSIS

The result of the following table shows that the nature of each variables, such as mean of the value, median, maximum and minimum observation and others

	CI	E	G	GDP	P	I	PR
Mean	9.770968	4797.226	6.586784	399011.5	62.73882	1.730968	0.326484
Median	7.400000	3863.000	8.802553	201840.0	64.34301	2.810000	0.130000
Maximum	55.20000	12581.00	13.85933	1717794.	98.09425	17.64000	1.110000
Minimum	-10.80000	0.000000	-8.672480	125406.0	10.08355	-26.12000	0.026000
Std. Dev.	14.15938	3747.972	6.178825	427514.1	23.44819	9.496793	0.359174
Skewness	1.641944	0.845532	-0.931847	2.152702	-0.737144	-0.880948	1.015930
Kurtosis	5.881669	2.672181	2.913266	6.559453	3.203417	3.917360	2.419244
Sum	302.9000	148714.0	204.1903	12369358	1944.904	53.66000	10.12100
Sum Sq. Dev.	6014.644	4.21E+08	1145.336	5.48E+12	16494.53	2705.672	3.870186
Observations	31	31	31	31	31	31	31

5.2.1 Unit root test

A time series data is called stationary if its value tends to revert to its long-run average value and properties of data series are not affected by the change in time only. On the contrary, the non-stationary time series does not tend to return to its long-run average value, hence, its mean, variance and co-variance also change over time. Most of the macroeconomic variables such as volume of gross domestic product (GDP), consumption, consumer price index, etc. exhibit a strong upward or downward movement over time with no tendency to revert to a fixed mean. Hence, they are non-stationary series. If the time series is non-stationary, it is said to have a unit root. Therefore, in econometrics, the stationarity of a time series is examined by conducting unit root test (Shrestha and Bhatta, 2017).

Most of the modeling techniques applied in time series analysis are primarily concerned with stationarity of the data. The starting point is to examine the properties of series graphically and confirming it statistically. Graphs are the most preliminary tool to get the rough idea about the stationarity of the series. However, statistical tests are required for final decision. Unit root tests provide statistical evidence on the stationarity of a given series (Shrestha and Bhatta, 2017).

Since this study employs a time series data, it is mandatory to test stationary of data. A unit root test is conducted employing Augmented Dickey Fuller (ADF) test to prove whether the variables in the model are stationary or not. The calculated values are compared with the critical values at determined level of significance. If the calculated value is greater than any of the critical values, then we reject the null hypothesis, which actually means the variables are stationary. Otherwise, we do not reject the null hypothesis meaning that there is a unit root implying the variable is non-stationary.

In order to check the variability and the stability of the economic variables in the time series data analysis the first step is checking the stationarity of the variable or the unit root test. In this section the unit root test is done using both graphical method and test bases method. Both methods were applied data at level means at original raw data and after first differencing. The data was collected from 1987 to 2017

In analyzing time series data testing for stationarity is a vital condition. Unit root test is a very common practice in macro data analysis to handle the problem of non stationarity. This is because if such behavior of macro-variables is left uncorrected, it would lead to the problem of spurious regression when there is a need to model relationships among variables. Thus differencing variables may result in a stationary series thought this removes the long memory of the variable. Most economic variables are I (1) in which they become stationary after being differenced once.

Augmented Dickey –Fuller (ADF) test is often employed to determine degree of integration of variables, how many times a variable need to be differenced to achieve stationarity).

The stationary of the series is investigated by employing the Augmented Dickey-Fuller (ADF) unit root test. Unit root tests for each variable, is performed on both levels and first differences. The ADF test results show that the variables Inflation(I), real interest rate(RI), and population (LnP) (in levels) are stationary, whereas the remaining variables are non-stationary (contain a unit root). Furthermore, first differences of the remaining variables are investigated for a unit root and the test result proved that all of them are stationary (Table 4.1)

Unit root test using plots at level

From the result of the plot we observe that all variables *are upward trending* over time from month 1987 to 2017. Each graphs *shows* that the number of observations are stagnated that manse increasing and decreasing but not sharply from 1987 to 2017. From the plot we observe that *none* of the plots are stationary at level. If the variables are not stationary at level, we can convert in to first difference.

A. Graphical result of for stationarity of data

Figure 1: Graphical presentation for stationarity of data

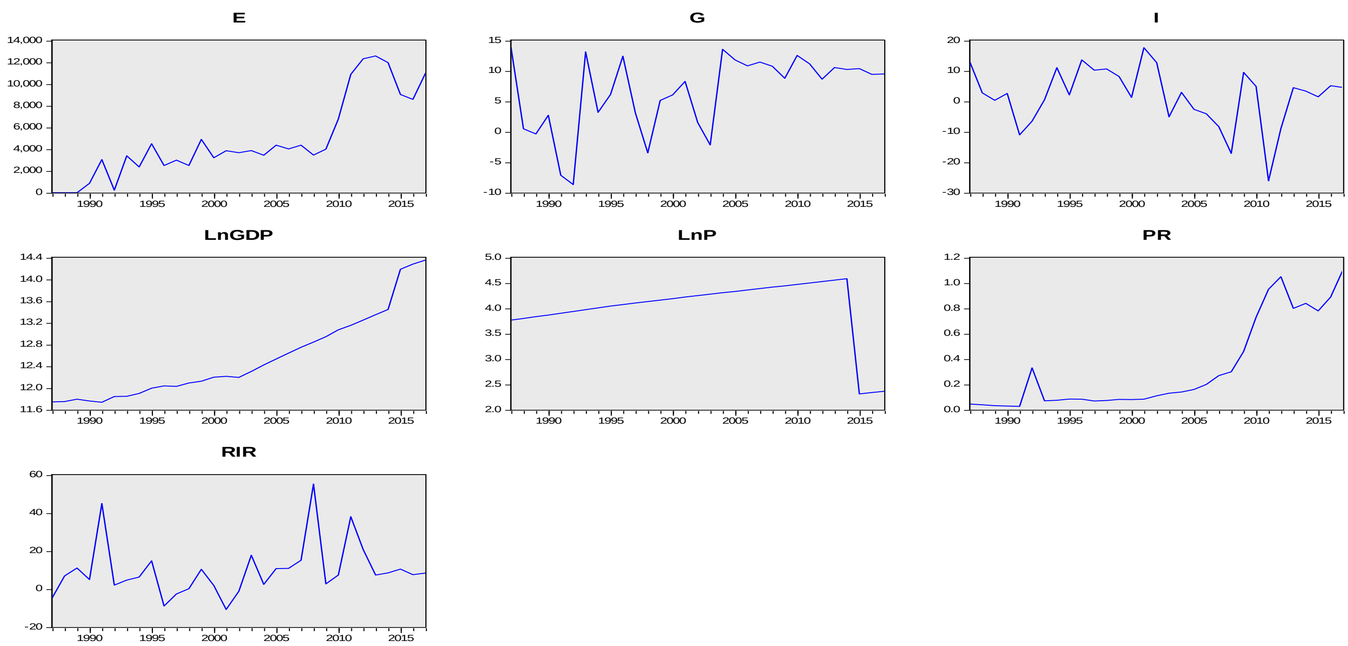


Fig 5.1 Unit root plot figure at level

The plotting of raw and difference data is used to visualize the nature of the data and stationarity properties in the series. There is also a formal method for checking stationarity in the series known as augmented Dickey-Fuller test (ADF) of stationarity. The Null Hypothesis ADF test states that individual series or observations have unit root or non-stationary.

The above graphs shows that the existence of non-stationarity in the data set. Therefore, there is a need to conduct the formal unit root test using ADF test. Hence, the summarized results of the ADF formal test result of the unit root test is presented as follows:

B. Unit root test

Table 1: ADF test results

Variable	Intercept				Trend and intercept			
	Level		First difference		Level		First difference	
	t-stat	p-value	t-stat	p-value	t-stat	p-value	t-stat	p-value
E	0.718273	0.9901	-4.104494	0.0038**	-1.720914	0.7139	-3.765893	0.0361**
G	-3.819133	0.0070***	-7.415164	0.0000***	-4.679270	0.0042***	-7.251999	0.0000***
I	-1.967468	0.2986	-7.348373	0.0000***	-4.002901	0.0196**	-7.226192	0.0000***
LNGDP	3.478605	1.0000	-4.716748	0.0007***	-0.440921	0.9810	-4.852182	0.0029***
LNP	-2.084341	0.2520	-5.373257	0.0001***	-0.984148	0.9314	-1.528944	0.7939
RIR	-2.435351	0.1432	-1.994867	0.2867	-1.589397	0.0933*	-3.281595	0.76410
PR	0.249536	0.9711	-4.931205	0.0004***	-1.465707	0.8182	-3.518028	0.0582*

*,** and *** shows significant at 10%, 5% and 1% level of significance respectively.

From the above ADF test result summary considering trend and intercept, it is observed that growth, LNGDP, and RIR are stationary at level at 1, 5 and 10% level of significance respectively while other variables are stationary at first difference at 1% level of significance except PR (price) which is stationary at 10 % level of significance.

Applying appropriate methodology for the time series data is most crucial part of the time series analysis as wrong specification of the model or using wrong method provides biased and unreliable estimates. Primarily, the method selection for time series analysis is based on the unit root test results which determine the stationarity of the variable. Methods commonly used to analyze the stationary time series cannot be used to analyze non-stationary series. If all the variables of interest are stationary, the methodology becomes simple. In such a case, ordinary least square (OLS) or vector autoregressive (VAR) models can provide unbiased estimates. If all the variables of interest are non-stationary, OLS or VAR models may not be appropriate to analyze the relationship. Similarly, additional problem arises when variables used in the analysis are of mixed type, i.e., some are stationary and others are non-stationary.

As mentioned above, a non-stationary time series can be converted into a stationary series by differencing. If a time series becomes stationary after differencing one time, then the series is said to be integrated of order one and denoted by I (1). Similarly, if a time series has to be differenced two times to make it stationary, then it is called integrated of order 2 and written as I (2). As the stationary time series need not to be differenced, it is denoted by I (0).

Johansen cointegration test cannot be applied directly if variables of interest are of mixed order of integration or all of them are not non-stationary, as this method requires all the variables to be I (1). An autoregressive distributed lag (ARDL) model is an ordinary least square (OLS) based model which is applicable for both non-stationary time series as well as for times series with mixed order of integration (Pesaran and Hasem., 1997; Pesaran *et al*., 1999). Hence, the data extracted for this study calls for ARDL model and the data is analyzed using this model.

A. Test for optimal lag length

VAR Lag Order Selection Criteria

Endogenous variables: E

Exogenous variables: C G I LNGDP LNP PR RIR

Sample: 1987-2017

Included observations: 29

Table 2: Test result for optimal lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-250.4262	NA	3033930.	17.75353	18.08357	17.85689
1	-244.0149	9.285247	2099340.	17.38034	17.75752	17.49847
2	-240.9941	4.166700*	1838126.*	17.24097*	17.66530*	17.37387*

* indicates lag order selected by the criterion (each test at 5% level)

LR: sequential modified LR test statistic

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

The analysis result indicates that all of the lag length selection criterion (LR, FPE, AIC, SC and HQ) supports selection of two lags as an optimal lag and hence the analysis is made using lag two as an optimal lag length.

B. Autoregressive Distributed Lag Model Results

Dependent Variable: E
Method: ARDL
Sample (adjusted): 1988- 2017
Included observations: 30 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Schwarz criterion (SIC)
Dynamic regressors (2 lags, automatic): G I LNGDP LNP PR RIR
Fixed regressors: C
Number of models evaluated: 1458
Selected Model: ARDL (1, 0, 1, 0, 0, 1, 0)

Table 3: First stage autoregressive Distributed Lag (ARDL) Model Results

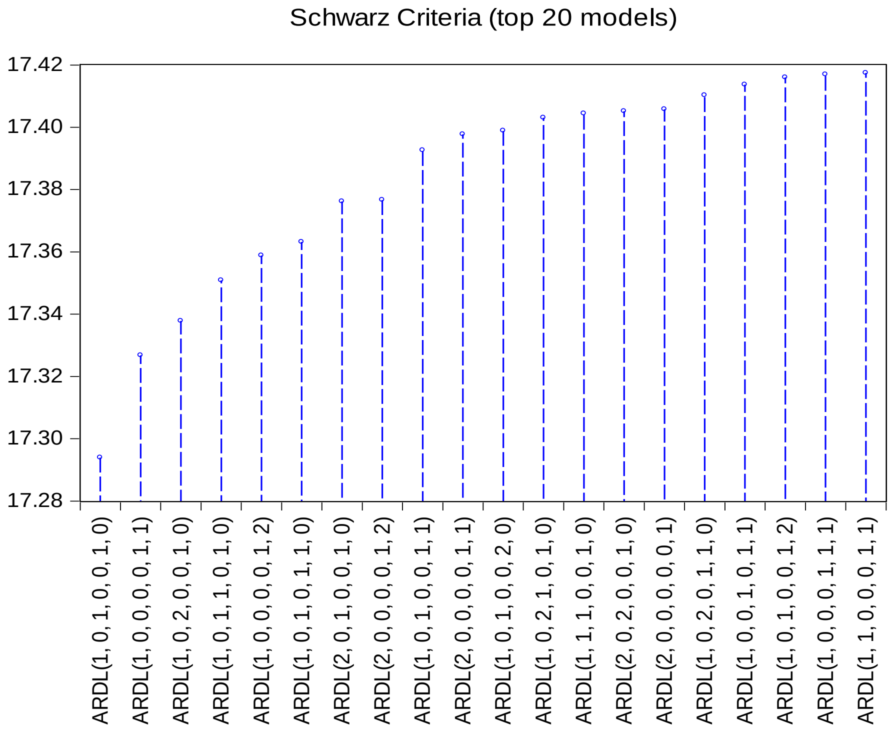
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
E (-1)	0.278833	0.145207	1.920247	0.0692*
G	51.82661	51.25794	1.011094	0.3240
I	39.35037	41.91449	0.938825	0.3590
I (-1)	61.79781	22.68809	2.723800	0.0131**
LNGDP	-459.7059	1027.276	-0.447500	0.6593
LNP	935.4526	510.9855	1.830683	0.0821*
PR	2543.951	2331.170	1.091276	0.2881
PR (-1)	6661.668	2362.919	2.819254	0.0106**
RIR	36.41337	27.62980	1.317902	0.02024**
C	1978.721	13448.99	0.147128	0.8845
R-squared	0.947621	Mean dependent var		4957.133
Adjusted R-squared	0.924050	S.D. dependent var		3702.926
S.E. of regression	1020.491	Akaike info criterion		16.95516
Sum squared residuals	20828049	Schwarz criterion		17.42222
Log likelihood	-244.3274	Hannan-Quinn criteria		17.10458
F-statistic	40.20328	Durbin-Watson stat		1.921493
Prob(F-statistic)	0.000000			

*and ** represents significant at 10 and 5% level of significance respectively.

NB: ARDL (1, 0, 1, 0, 0, 1, 0)indicates the optimal lag length for the dependent variable (E) which is 1 and the rest value (0, 1, 0, 0, 1, 0) represents the optimal lag length for the independent variables i.e., G, I LNGDP, LNP, PR, RIR) respectively. All the diagnostic tests and the final model is estimated based on this analyses output.

The following graph shows the model selection summary based on Schwarz Criteria (SC). As indicated on the graph, the shortest line on the graph represents the best model with the specified optimal lag length for both the dependent and independent variables which is (1, 0, 1, 0, 0, 1, 0).

Figure 2: Graphical model selection summary



C. Model diagnosis

Diagnostic tests tell us about the robustness of estimated coefficients. Diagnostic test statistics are generally not reported automatically by software and thus should be estimated separately. Type of the diagnostic test depends upon the modeling technique being utilized. However, the most common types of diagnostics tests are lag structure, coefficient diagnostics and residual diagnostics. Residual diagnostics is the most crucial part of diagnostic tests in economic modeling since the regression models try to minimize errors (or residuals). The error terms must be white noise (independently and identically distributed, i.i.d.). Therefore, the results of different model diagnostic results are presented below.

Serial correlation test

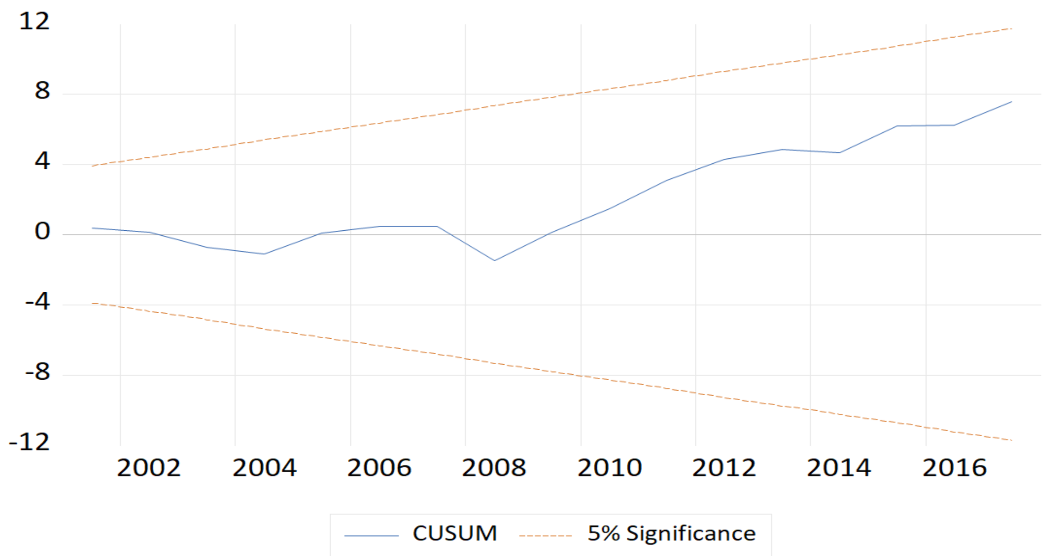
Table 4: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.167030	Prob. F (2,18)	0.8475
Observations*R-squared	0.546623	Prob. Chi-Square (2)	0.7609

As it can be observed in Table 4 above, the chi-square p-value (76.09%) indicates that there is no serial correlation in the model because we do not have evidence to reject the null hypothesis which states that there is no serial correlation in the data. i.e the p-value associated with both the LM version and the F version of the statistic was unable to reject the null hypothesis specified for each test

The null hypothesis of no serial correlation (Brush Cod fray LM test) is failed to reject for the reason that that the p-values associated with test statistic is greater than the standard significant level (I.e. 0.7609> 0.05). Here LM test for testing serial correlation is applied because unlike the traditional Durbin Watson test statistic which is totally inapplicable when the lagged dependent variable appear as a regressors, LM test avoid such limitation of DW test.

Model stability test result

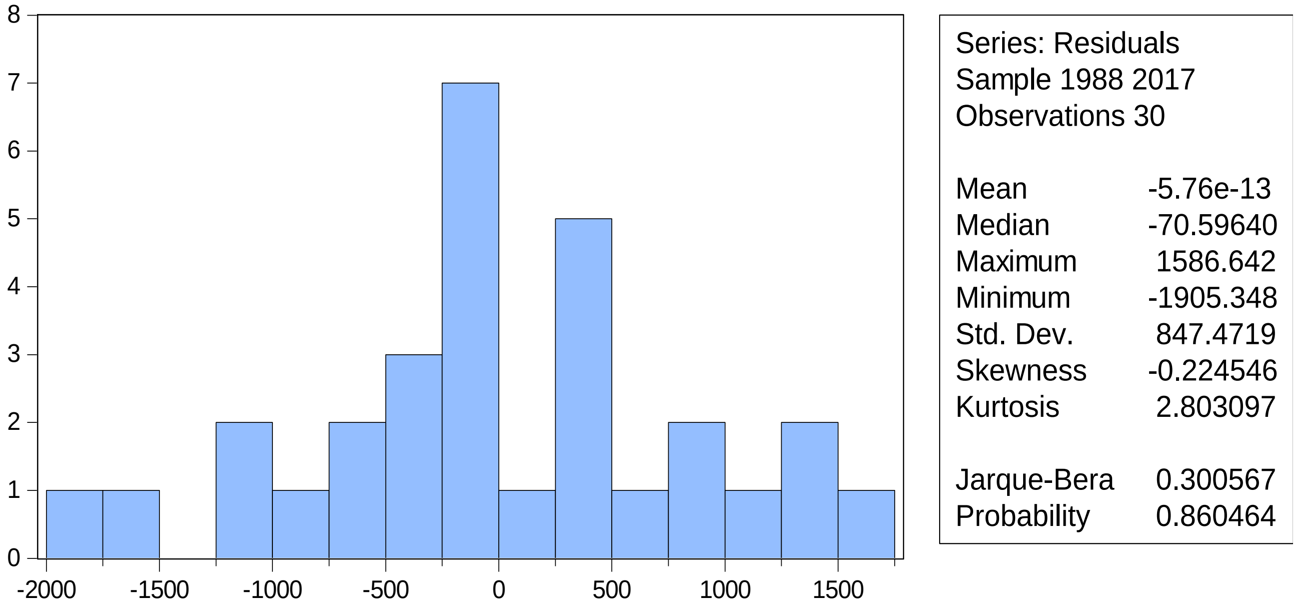


Since, the blue line lies inside the two redlines, the model is stable at 5% level of significance

Normality test result

As indicated in Figure 3 below, the residuals are normally distributed. The Jarque-Bera test of normality indicates that the residuals for the data are normally distributed and this is confirmed by the p- value (86%) showing Jarque-Bera statistical value (0.30) is not significant. The non-significancy of Jarque-Bera statistical value indicates the residuals of the data is normally distributed.

Figure 3: Normality test result



Heteroskedasticity test result

The ARCH test is one of the methods for testing whether there exist heteroskedasticity or not. Therefore, the test result indicates that there is no heteroskedasticity problem indicating that the variance of the residuals is constant or homoscedastic. This is assured by accepting the null hypothesis which states that there is no heteroskedasticity. The p-value (19.33%) indicates, absence of evidence to reject the null hypothesis i.e., the null hypothesis is accepted implying that there is no heteroskedasticity.

Table 5: ARCH heteroskedasticity test result

F-statistic	1.672850	Prob. F (1,27)	0.2068
Obs*R-squared	1.691937	Prob. Chi-Square (1)	0.1933
Test Equation:			
Dependent Variable: RESID^2			
Method: Least Squares			
Date: 06/03/21			
Sample (adjusted): 1989 2017			
Included observations: 29 after adjustments			

As we have seen from the above table, we can reject at 5% significant level due to its p-value associated with the test statistics are greater than the standard significance level(I.e. 0.1933> 0.05).

Long run relationship test results

The first ARDL result shows the short run effects of the dependent variable on the independent variable. Therefore, there is a need to test whether there exists a long run relationship between the dependent and the independent variable using bounds test which uses F-statistics for decision making. Hence, as presented in the table below the F-statistic value is higher than the lower (I (0)) and higher bound I (1)) value at 5% level of significance i.e., 4.74 is higher both 2.45 and 3.61 respectively. This shows the existence of long run relationship between the dependent and independent variable.

ARDL Bounds Test   Included observations: 30

Sample: 1988 2017   Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	4.741975	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Table 6: Bounds test result for long run relationship

Hence, once the existence of long run relationship (cointegration) is identified using bounds test, the ARDL cointegrating (short run) and long run form is specified as follows:

5.2.11. Results and Discussion of Regression Analysis

LONG RUN ANALYSIS

To examine the relationship between gold extraction level in Ethiopia and its explanatory variables, the following linear regression result was obtained

The result of the multiple linear regressions is given in the following tables.

The first table results on model diagnostics using F statistics and R-squared. The F statistics shows that the model is significant and the model fit the data well. Also the variations of independent variables are explained by 86.72% by the dependent variable.

ARDL Long Run Form

Dependent Variable: E

Selected Model: ARDL (1, 0, 1, 0, 0, 1, 0)

Sample: 1987- 2017

Included observations: 30

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
G	71.864915	78.445773	0.916109	0.3705
I	14.256242	6.702267	2.012219	0.0579*
LNGDP	-637.447105	1502.763484	-0.424183	0.6760
LNP	129.137203	61.215220	2.108428	0.0478**
PR	1276.890882	276.379992	4.609296	0.0002***
RIR	50.492274	42.249646	1.195093	0.2460
C	2743.775535	18975.830176	0.144593	0.8865

*, ** and *** represents significance at 10, 5 and 1% level of significance respectively

Table 5.7 Regression result

The result of Table 5.7 indicates that all the variables entered in the regression have the expected signs regardless of their significant level except GDP. As we have discussed in the theoretical and empirical literature parts, rate of inflation, interest rate, population, economic growth and price have positive impact on Ethiopian gold resource extraction level regardless of significant. .

When we came to our basic hypothesis, the null hypothesis is confirmed specifically in population, inflation, and world gold price. The estimated coefficients of the model presented in table 5.7 are consistent with our expectation regarding sign

Accordingly, the extraction of Gold is positively related to inflation, real interest rate, population level, economic growth and price and negatively related to GDP, but GDP, interest rate and economic growth are statistically insignificant

As the estimated result of the above table shows, Inflation appeared to have positive correlation with gold extraction on long run and found to be statistically significant. From table 5.7 the coefficient of Inflation (π) is 14.256242. This indicates that on average a 1 percent rise in inflation will result in 14.26 kg increases gold extraction level. This finding is in line Mcmahon (2018), which concluded in his study that gold extraction tends to follow the world gold price which is directly related to the level of inflation i.e a rise in inflation will lead to a rise in gold extraction and vice versa.

The other factor incorporated in the study is demographics. Population turns out to be affecting gold extraction positively and is statistically significant. This finding is in line with the findings of (Myint, Tizard and Pienkowski, 2017) and (Kate, 2016), who claimed that the ever increasing level of population will result in more resource extraction to satisfy their human needs. *"Generally speaking, as the human population grows, our consumption of natural resources increases. More humans consume more freshwater, more land, more clothing, etc. The more people on the planet, the more food you need to feed those humans (more fishing, more farming, and more deforestation to make room for agriculture and raising livestock, and so forth)"*. From table 5.7 the coefficient of Population (p) is 129.137203. This indicates that on average a 1 percent rise in population of the country will result in 129. 14 kg increases in gold extraction level

As A. Pandey (2020) and Sun (2018) found in their studies, world price of gold is the main determinant in gold extraction level and the econometric results supports their finding. The result is in line with the initial hypothesis and statistically significant. From table 5.7 the coefficient of price (pr) is 1276.890882. This indicates that on average a 1 percent rise in international world price of gold will result in 1276. 89 kg increases in gold extraction level

Increasing gold demand also supported by worsening US-China relations and worries of delayed and uneven economic recovery amid rising Corona virus cases in several parts of the world, which have reinforced gold's safe-haven appeal. Gold has been the best-performing major asset class this year. The collapse in interest rates and bond yields has made holding gold attractive. *"Rising inflation expectations"*, driven by unprecedented peacetime [fiscal] deficits plus central bank stimulus," make the precious metal, which is considered as a hedge against inflation, an appealing alternative to cash or credit investments. This phenomenon in the international market will allow gold producing companies to focus on more production of gold even with rising production cost (A.Pandey, 2020)

Economic growth affects gold extraction positively but, it's statistically insignificant. This could be due to the insignificant contribution of our economic growth to our gold extraction level. Our economic growth has been tremendously rising for the last 15 years, but its contribution for the rise in gold extraction is limited due to priority effects. i.e low priority in mineral sector backed by low budget.

GDP affects gold extraction level negatively but, it's statistically insignificant. This is against any of the studies mentioned in the literature. GDP usually affects gold extraction in positive relationship and one of the significant factors in doing so

Finally, Real interest level positively affects gold extraction level positively but, it's statistically insignificant. This could be due to the fact that local gold miners including artisanal miners consider real interest rate effect very minimal. Our real interest rate movement has very minimal/no effect on movement of gold price locally. Miners take other factors impact on their mining level rather than interest rates, since it has very minimal effect in shaping their extraction level. This result is against Hotelling theory, which stated interest rate has observable effect on resource extraction

SHORT RUN ANALYSIS

After the acceptance of long-run coefficients of the extraction equation, the short-run ECM model is estimated. The error correction term (ECM), as we discussed in chapter three, indicates the speed of adjustment to restore equilibrium in the dynamic model. It is a one lagged period residual obtained from the estimated dynamic long run model. The coefficient of the error correction term indicates how quickly variables converge to equilibrium. Moreover, it should have a negative sign and statistically significant at a standard significant level (i.e. p-value should be less than 0.05).

ARDL Cointegrating (short run) analysis

Dependent Variable: E

Selected Model: ARDL (1, 0, 1, 0, 0, 1, 0)

Sample: 1987- 2017

Included observations: 30

Table 5.8 Short run regression result

Cointegrating Form *(short run analysis)*				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(G)	51.826610	51.257942	1.011094	0.3240
D(I)	39.350369	41.914487	0.938825	0.3590
D(LNGDP)	-459.705862	1027.275677	-0.447500	0.6593
D(LNP)	93.452640	51.985460	1.830683	0.0821*
D(PR)	254.951146	233.170236	1.091276	0.02881**
D(RIR)	36.413365	27.629798	1.317902	0.2024
CointEq (-1)	-0.721167	0.145207	-4.966482	0.0001***

*, ** and *** represents significance at 10, 5 and 1% level of significance respectively

The error correction coefficient, estimated at -0.72116 is significant, has the correct negative sign, and imply a speedy adjustment to equilibrium. According to Bannerjee *et al*. (2003) as cited in Kidanemarim (2014), the highly significant error correction term further confirms the existence of a stable long-run relationship.

Moreover, the coefficient of the error term (ECM-1) implies that the deviation from long run equilibrium level of extraction level in the current period is corrected by 72 % in the next upcoming periods to bring back equilibrium when there is a shock to a steady state relationship.

From the cointegrating equation, the most important thing is the error correction term (ECT) (CointEq). The coefficient of this term must be negative and its coefficient should be significant. The error correction term indicates the speed of adjustment to equilibrium in a cointegrating relationship.

Therefore, as it can be observed in Table 5.8 above,the error correction term (ECT) has negative coefficient (-0.72) and the value of its coefficient is significant at 1% (that is, the ECT satisfies all the requirements). Hence, the value of the ECT indicates that, each year there is a need to adjust the previous year's discrepancy by 72% to achieve equilibrium and the value indicates the need for high speed of adjustment.

The coefficient of determination (R-squared) is high explaining that about 77 % of variation in the real GDP is attributed to variations in the explanatory variables in the model. In addition, the DW statistic does not suggest autocorrelation and the F-statistic is quite robust

In The regression result the sign of coefficient of all variables are positive, except GDP; then they have positive effect on gold extraction. The relationship between the independent variable GDP, real interest rate, inflation and growth rate are statistically insignificant because the p-value for these variables is greater than the significance level of 0.05.Reject H1. The relationship between inflation and interest rate and price with the dependent variables gold extraction is statistically significant at the significance level of 0.05. Then accept H1 and reject H0.

Similar to the long run analysis; Population and price have positive significant effect on level of gold extraction in the short run. On the other hand GDP, inflation, interest rate and growth are statistically insignificant in the short run analysis.

Similar to the long run analysis, demographics have significant positive effect on gold extraction in the long run . Population turns out to be affecting gold extraction positively and is statistically significant. This finding is in line with the findings of (Myint, Tizard and Pienkowski, 2017) and (Kate, 2016), who claimed that the ever increasing level of population will result in more resource extraction to satisfy their human needs. *"Generally speaking, as the human population grows, our consumption of natural resources increases. More humans consume more freshwater, more land, more clothing, etc. The more people on the planet, the more food you need to feed those humans (more fishing, more farming, and more deforestation to make room for agriculture and raising livestock, and so forth)"*. From table

5.8 the coefficient of Population (p) is 93.452640. This indicates that on average a 1 percent rise in population of the country will result in 93. 45 kg increases in gold extraction level in the short run

As A. Pandey (2020) and Sun (2018) found in their studies, world price of gold is the main determinant in gold extraction level and the econometric results supports their finding. The result is in line with the initial hypothesis and statistically significant. From table 5.8 the coefficient of price (pr) is 254.951146. This indicates that a 1 percent rise in international world price of gold will result in 254.95 kg increases in gold extraction level in the short run.

GDP, inflation, real interest rate and growth rate are statistically insignificant in the short run analysis

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATION

6.1. Conclusion

The econometric analysis of factors effecting gold extraction found out that gold mining is positively related to rate of inflation, population and world gold price where, they are all significant. In contrast real interest rate, GDP and economic growth rate found out to be statistically insignificant

6.2 Policy Recommendation

The policy recommendation of the results obtained is that all the variables included in our factor model should be considered in conducting mining policies, since the policy lacks some macro base considerations in Ethiopian context, with special emphasis given to population pressure, rate of inflation, growth rate, national saving and real interest rate.

Since rate of inflation, world price of gold and population are important variables in explaining change in gold extraction, emphasis must be given to these variables in conducting mining policy, As we have mentioned earlier, in support of earlier empirical and theoretical works done in Ethiopian or world in natural resource mining, we found significant and positive effect of rate of inflation, world gold price and population on the static long run and short run model. Real interest rate, GDP and growth rate effect is found to be insignificant. This could be due to our the following distinctive factors

1. Economic growth is not contributing much to our gold mining sector. Our Economy is characterized by tremendous increase in economic growth over the last 15 years, but our gold extraction is not flowing at constant rate in line with our increasing economic growth. Gold extraction level in Ethiopia is marked with tremendous decrease in amount over the last 5 years, but it was marked with increase in amount before that. Studies in other countries show constant increase in resource extraction with the level of economic growth, but that is not the case for our country. The contribution of economic growth is insignificant to the level of resource extracted in Ethiopia
2. Ethiopia's GDP rise over the last decades is not calling for any foreign direct investment in gold. Currently there is a single start up foreign mining company and given the fact that the nations mining policy is open for foreign investors; it should

have attracted lot of foreign investors. But our rising GDP is contributing insignificantly to the extraction of gold in Ethiopia.

3. Real interest rate plays minimal/no role in affecting price of exportable items. Miners will not compare the local interest rate against the world price of items. local gold miners including artisanal miners consider real interest rate effect very minimal. Our real interest rate movement has very minimal/no effect on movement of gold price locally. Miners take other factors impact on their mining level rather than interest rates, since it has very minimal effect in shaping their extraction level

Gold is non-renewable natural resource with no maximum sustainable stock and efficient utilization means getting the maximum possible value out of it. But, the extraction of gold should be driven by the macroeconomic factors to attain the maximum earning value possible. Our gold extraction system is poor so that it is resulting in unfavorable effect to the environment. Until a system that out weights the unfavorable environmental effects created, our gold extraction should be limited by the available macroeconomic indicators. Export earnings from gold is the basic derive behind gold extraction anywhere in the world, so our mining should have to be based on earning the maximum export value possible. To decide that the amount of production permitted the governing body should check the related macroeconomic indicators like the rate of inflation, export price index and world price of gold

Export income from gold plummeted in an alarming rate. Export income from gold diminished from 654 million dollar in 2011/12 to 32 million dollar in 2018. This is largely due to population pressure, increase in artisanal mining and closure of major gold producers for allegedly polluting environment.

The current level of gold export and income is very low and the level of contraband gold mining level is increasing largely. In order to increase gold's export contribution in a sustainable manner the following measures should be taken.

Our gold exploration should have to be dictated by world price of gold, as it's the main determinant factor and also dictates other determining factors of gold extraction. Recently due to world socio-politico-economical instability, the price of gold is rising to hold for unfortunate events. But our gold export performance is diminishing even big gold exporters are leaving the market. The ministry of mines and petroleum should make necessary gold exploration investment to attract more gold producers in current rising world gold market

The measures recommended are collected from the finding from my paper as well as after careful literature study in the area

Generally, the following major policy recommendation are drawn from our findings

- Ethiopia has been experiencing a decline in foreign earning from gold sells in recent years. The production of gold diminishing immensely. The country should allow more production and investment to the gold mining by creating conducive environment both for local producers and foreign investors interested in the investment. The countries gold price index is low from the analysis. The world price of gold is rising over the years, but our export diminishing. Export price index is a measure of gain from export due to the rising world gold price. Since price of gold is the main determining factor for gold production, government should form a special scheme that controls the level of gold production with the respective change in world price of gold. If the world price of gold is rising, government should introduce schemes that allow gold production companies to invest more. These schemes could be tax rate reduction, lowering of royalty payments for government, export fee reduction and other similar methods that induce lower production cost for the firms. If the world price of gold is decreasing, government should introduce cost increasing schemes that lowers the level of production by firms

- A need for macro-economic stability characterized by low interest rates and inflation. Even though, stable macro economy will lead to lower gold production, it will encourage direct foreign investment. In order to encourage investment, a set of macro-economic challenges that are relevant to investors need to be addressed. In the long run with stable macroeconomic environment, we could produce huge amount of gold resource and widen the GDP base.

- Population level effect on gold extraction is significant from our econometric study, this calls for the government to introduce a scheme for artisan mining. Even though population rise is resulting in rise in gold production, it led to decrease in gold foreign income due to the fact that the incasing artisanal miners in gold production are using illegal routes to sell the gold. This called for more artisanal miners in the market and more illegal routes for gold sales. This resulted in huge decrease in volume of gold reported and sold to national bank of Ethiopia. The main reason for recent decrease in gold mining in Ethiopia is related to increased pressure from artisan miners. To study more about the artisan mining effect and numerical study of the population working in the areas, government should form a scheme by Ministry of mines and petroleum to study the artisan mining. Modernization in artisanal mining could be the perfect measure. Artisan mining is the biggest problem right now leading to contraband gold export and extraction dismantling. The Government should recognize that mineral deposits occur mostly in rural areas, which lack basic services and facilities. The Government should examine, jointly with the private sector and relevant stakeholders, possible options and mechanisms to ensure that an adequate share of benefits from the mineral sector is provided to the communities impacted by mineral activities.

- Government should adjust the rates of interest and other components of GDP to increase GDP's contribution for more gold extraction level. GDP constitutes the lower impact on gold extraction level, but its impact could be improved if the government introduces schemes that will increase aggregate demand. this includes

1. Lower interest rate: Reduces the cost of borrowing and increases spending and investment. New gold producing companies will join production with ease accessibility to fund with lower interest rate and this in turn will raise the level of investment and vice versa when the level of world gold price is lowering
2. Increased real wages: If nominal wages grow above inflation then consumers have more disposable to spend and vice versa
3. Expansionary fiscal and monetary policies: This will result in increased spending by consumers on goods and services through tax cuts, job programs, and interest rate. Consumers will hold more gold and spend money to buy gold bars, which in turn will increase the level of investment by gold producers

REFERENCES

- Abebe Bedassa (2016) "***Overview of mining sector in Ethiopia***" federal democratic republic of Ethiopia ministry of mines, petroleum & natural gas
- Alemayehu Geda and Addis Yimer. (2013). **"An Applied Macro-econometric Model for Rwanda"** .East Africa Research Papers in Economics and Finance, EARP-EF No. 2018:18, Jönköping International Business School (JIBS), Jönköping University, P.O. Box 1026, SE-551 11 Jönköping, Sweden,Web: http://www.ju.se/earp, E-mail: EARP@ju.se
- Ashenafi Endale (2020). ***"The gold exile".*** Ethiopian business review. no. 81 page 13-16
- CEIC (2017) ***"Ethiopia's gold production"***
- Dejene Aredo (1982). "***An analysis of household consumption pattern in Ethiopia"*** Addis Ababa University school of graduate studies
- David Andolfatto. (2008). "***MACROECONOMIC THEORY & POLICY"*** 2nd Edition, Simon Fraser University
- Ethiopia – "***Mining sector and business prospects"*** ke- september, 2016
- Fergal O'Connor, Brian M. Lucey, Jonathan A. Batten, Dirk Baur (2015). ***"The financial economics of gold – a survey".*** international review of financial analysis· July 2015doi: 10.1016/j.irfa.2015.07.005
- Hector Pollitt, Anthony Barker, Jennifer Barton (CE) ElkePirgmaier, Christine Polzin, Stephan Lutter, Friedrich Hinterberger, Andrea Stocker .(2010). ***"A Scoping Study on the Macroeconomic View of Sustainability".*** Final report for the European Commission, DG Environment, 29 July 2010, (Sustainable Europe Research Institute – SERI), Cambridge Econometrics, Covent Garden Cambridge,CB1 2HT

- Ibrahim Ahmed Elbadawi and Kabbashi Madani Suliman (2018). "The Macroeconomics of gold economy in Sudan" economic research forum, working paper no. 1203
- IMF. (2012). ***"Macroeconomic policy frameworks for resource-rich developing countries"***
- James Cust & Steven Poelhekke (2015) ***"The local economic impacts of natural resource extraction"*** Annual review of resource economics, vol. 7, forthcoming 2015, Department of Economics Oxcarre Oxford centre for the analysis of resource rich economies manor road building, manor road, Oxford ox1 3uq
- Jan Gottschalk. (2014). ***"Natural resource extraction and Dutch disease: application to Papua New Guinea"***. : https://www.researchgate.net/publication/280621802
- Martin Feldstein (1978). ***"The effect of inflation on the prices of land and gold".*** National bureau of economic research .1050 Massachusetts avenue cambridgema02138. Working paper no. 296
- Ministry of mines, federal democratic republic of Ethiopia and World Bank (2018) ***"Strategic assessment of the Ethiopian mineral sector"***
- Ministry of mines, petroleum and natural gas of Ethiopia, Addis Ababa, Ethiopia
- Naod Mekonnen Anega (2010) ***"The balance of payment-constrained economic growth in Ethiopia***" EJBE vol.1No.1/2010
- Pesaran, M. and Hasem, P.B. 1997. ***Working with Microfit 4.0: Interactive Econometric Analysis***. Oxford: Oxford University Press.
- Pesaran, M, Hasem, Shi, Y. 1999. ***An autoregressive distributed lag modelling approach to cointegration analysis. In: Strom S, Holly A, Diamond P, eds. Econometrics and Economic Theory in the 20th Century***: The Ranger Frisch Centennial Symposium. Cambridge: Cambridge University Press.

- Pearson Education Canada (2005) ***"Interest rates and the extraction of natural resources"***
- Raimund Bleischwitz (2010): "***International Economics of Resource Productivity - Relevance, Measurement, Empirical Trends, Innovation, and Resource Policies"*** In: International Economics and Economic Policy (7), 2 – 3, pp. 227 – 244.
- Ralph De Haas and Steven Poelhekke (2017) ***"Mining matters: natural resource extraction and firm-level constraints".*** journal of international economics 117 (2019) 109–124
- Robert M. Kunst. 2006. ***"Introduction to Macroeconomics".*** Lecture Notes
- Sarah Papworth, Madhu Rao, YintMyint, Kyaw Thinn Latt, Robert Tizard, Thomas Pienkowski, and Roman Carrasco (2017). ***"The impact of gold mining and agricultural concessions on the tree cover and local communities in northern Myanmar***". Scientific reports
- SERI (2009***). "Over consumption? Our use of the world´s natural resources"***
- Shibru Tedla. 2007. ***"Environment and Natural Resources as a Core Asset in Wealth Creation, Poverty Reduction, and Sustainable Development in Ethiopia"***
- Stephen W. Salant (1995) ***"The economics of natural resource extraction: a primer for development economists"***
- Tim McMahon (2018) ***"how does inflation affect the price of gold?"*** inflation.com
- Trading Economics (2020)
- Yunhao Sun (2018). "***The impact of macroeconomic f actors on the price of gold".*** State university of New York, College at Buffalo - Buffalo state college digital commons at Buffalo state.

- UNCTAD. (2014).”***Natural resources sector: review and identification of opportunities for commodity based trade and development”.*** Multi-year expert meeting on commodities and development sixth session geneva, 9–10 april 2014 item 4 of the provisional agenda
- UNEP (2015), ***“International trade in resources: A biophysical assessment”***, report of the international resource panel

APPENDIX

A. Extraction Data (E)

At level and intercept

Null Hypothesis: E has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.718273	0.9901
Test critical values:	1% level	-3.724070	
	5% level	-2.986225	
	10% level	-2.632604	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(E)
Method: Least Squares
Date: 04/09/21 Time: 19:51
Sample (adjusted): 1993 2017
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
E(-1)	0.100622	0.140089	0.718273	0.4818
D(E(-1))	-0.113377	0.240996	-0.470453	0.6437
D(E(-2))	0.009228	0.223418	0.041304	0.9675
D(E(-3))	-0.575399	0.234330	-2.455505	0.0245
D(E(-4))	-0.336068	0.278722	-1.205749	0.2435
D(E(-5))	-0.370717	0.262218	-1.413773	0.1745
C	541.6721	614.7795	0.881084	0.3899

R-squared	0.405566	Mean dependent var	431.0400
Adjusted R-squared	0.207421	S.D. dependent var	1692.703
S.E. of regression	1506.961	Akaike info criterion	17.70507
Sum squared resid	40876747	Schwarz criterion	18.04636
Log likelihood	-214.3134	Hannan-Quinn criter.	17.79973
F-statistic	2.046816	Durbin-Watson stat	1.324148
Prob(F-statistic)	0.111683		

At first difference and intercept

Null Hypothesis: D(E) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.104494	0.0038
Test critical values:	1% level	-3.699871	
	5% level	-2.976263	
	10% level	-2.627420	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(E,2)
Method: Least Squares
Date: 04/09/21 Time: 19:45
Sample (adjusted): 1991 2017
Included observations: 27 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(E(-1))	-1.419436	0.345825	-4.104494	0.0004
D(E(-1),2)	0.400256	0.312465	1.280966	0.2130
D(E(-2),2)	0.506758	0.215306	2.353661	0.0275
C	571.0971	341.3737	1.672938	0.1079

R-squared	0.673238	Mean dependent var	58.33333
Adjusted R-squared	0.630617	S.D. dependent var	2702.120
S.E. of regression	1642.266	Akaike info criterion	17.78149
Sum squared resid	62031829	Schwarz criterion	17.97347
Log likelihood	-236.0502	Hannan-Quinn criter.	17.83858
F-statistic	15.79586	Durbin-Watson stat	2.056067
Prob(F-statistic)	0.000009		

At level and trend and intercept

Null Hypothesis: E has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 3 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.720914	0.7139
Test critical values:	1% level	-4.339330	
	5% level	-3.587527	
	10% level	-3.229230	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(E)
Method: Least Squares
Date: 04/09/21 Time: 21:03
Sample (adjusted): 1991 2017
Included observations: 27 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
E(-1)	-0.393054	0.228398	-1.720914	0.1000
D(E(-1))	0.148112	0.212414	0.697277	0.4933
D(E(-2))	0.314553	0.222741	1.412191	0.1725
D(E(-3))	-0.264142	0.262382	-1.006706	0.3255
C	-348.4554	799.0322	-0.436097	0.6672
@TREND(1987)	158.4688	86.80218	1.825632	0.0822

R-squared	0.350857	Mean dependent var	376.0000
Adjusted R-squared	0.196300	S.D. dependent var	1779.242
S.E. of regression	1595.079	Akaike info criterion	17.78036
Sum squared resid	53429793	Schwarz criterion	18.06833
Log likelihood	-234.0349	Hannan-Quinn criter.	17.86599
F-statistic	2.270072	Durbin-Watson stat	1.884268
Prob(F-statistic)	0.084756		

At first difference and trend and intercept

Null Hypothesis: D(E) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.765893	0.0361
Test critical values:	1% level	-4.374307	
	5% level	-3.603202	
	10% level	-3.238054	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(E,2)
Method: Least Squares
Date: 04/09/21 Time: 21:05
Sample (adjusted): 1993 2017
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(E(-1))	-2.138329	0.567815	-3.765893	0.0014
D(E(-1),2)	1.078954	0.481791	2.239467	0.0380
D(E(-2),2)	1.143281	0.405374	2.820314	0.0113
D(E(-3),2)	0.629375	0.366993	1.714954	0.1035
D(E(-4),2)	0.338794	0.230733	1.468335	0.1593
C	176.8345	809.6671	0.218404	0.8296
@TREND(1987)	44.74488	45.07096	0.992765	0.3340

R-squared	0.753904	Mean dependent var	209.4800
Adjusted R-squared	0.671872	S.D. dependent var	2598.009
S.E. of regression	1488.204	Akaike info criterion	17.68002
Sum squared resid	39865536	Schwarz criterion	18.02131
Log likelihood	-214.0003	Hannan-Quinn criter.	17.77468
F-statistic	9.190354	Durbin-Watson stat	1.297323
Prob(F-statistic)	0.000110		

B. Growth Data (G)

At level and intercept

Null Hypothesis: G has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.819133	0.0070
Test critical values:	1% level	-3.670170	
	5% level	-2.963972	
	10% level	-2.621007	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(G)
Method: Least Squares
Date: 04/09/21 Time: 21:07
Sample (adjusted): 1988 2017
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
G(-1)	-0.664200	0.173914	-3.819133	0.0007
C	4.165173	1.555522	2.677669	0.0123

R-squared	0.342503	Mean dependent var	-0.145182
Adjusted R-squared	0.319021	S.D. dependent var	7.104936
S.E. of regression	5.863094	Akaike info criterion	6.439573
Sum squared resid	962.5245	Schwarz criterion	6.532986
Log likelihood	-94.59359	Hannan-Quinn criter.	6.469456
F-statistic	14.58577	Durbin-Watson stat	1.787252
Prob(F-statistic)	0.000681		

At first difference and intercept

Null Hypothesis: D(G) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.415164	0.0000
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(G,2)
Method: Least Squares
Date: 04/09/21 Time: 21:11
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(G(-1))	-1.952136	0.263263	-7.415164	0.0000
D(G(-1),2)	0.479465	0.158396	3.027000	0.0057
C	0.443697	1.096567	0.404624	0.6892

R-squared	0.752665	Mean dependent var	0.033396
Adjusted R-squared	0.732878	S.D. dependent var	11.21439
S.E. of regression	5.796024	Akaike info criterion	6.453179
Sum squared resid	839.8475	Schwarz criterion	6.595915
Log likelihood	-87.34450	Hannan-Quinn criter.	6.496814
F-statistic	38.03879	Durbin-Watson stat	1.919724
Prob(F-statistic)	0.000000		

At level and trend and intercept

Null Hypothesis: G has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.679270	0.0042
Test critical values:	1% level	-4.309824	
	5% level	-3.574244	
	10% level	-3.221728	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(G)
Method: Least Squares
Date: 04/09/21 Time: 21:12
Sample (adjusted): 1989 2017
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
G(-1)	-1.187340	0.253745	-4.679270	0.0001
D(G(-1))	0.249586	0.172361	1.448042	0.1600
C	-0.168012	2.015659	-0.083353	0.9342
@TREND(1987)	0.495001	0.153575	3.223186	0.0035

R-squared	0.512094	Mean dependent var	0.310351
Adjusted R-squared	0.453546	S.D. dependent var	6.770178
S.E. of regression	5.004688	Akaike info criterion	6.186069
Sum squared resid	626.1726	Schwarz criterion	6.374662
Log likelihood	-85.69801	Hannan-Quinn criter.	6.245134
F-statistic	8.746472	Durbin-Watson stat	1.896008
Prob(F-statistic)	0.000386		

At first difference and trend and intercept

Null Hypothesis: D(G) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.251999	0.0000
Test critical values:	1% level	-4.323979	
	5% level	-3.580623	
	10% level	-3.225334	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(G,2)
Method: Least Squares
Date: 04/09/21 Time: 21:13
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(G(-1))	-1.952488	0.269234	-7.251999	0.0000
D(G(-1),2)	0.479795	0.162461	2.953299	0.0069
C	0.396570	2.555275	0.155196	0.8780
@TREND(1987)	0.002854	0.139120	0.020516	0.9838

R-squared	0.752670	Mean dependent var	0.033396
Adjusted R-squared	0.721753	S.D. dependent var	11.21439
S.E. of regression	5.915491	Akaike info criterion	6.524590
Sum squared resid	839.8327	Schwarz criterion	6.714905
Log likelihood	-87.34425	Hannan-Quinn criter.	6.582771
F-statistic	24.34539	Durbin-Watson stat	1.919560
Prob(F-statistic)	0.000000		

C. Inflation (I)

At level and intercept

Null Hypothesis: I has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.967468	0.2986
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(I)
Method: Least Squares
Date: 04/09/21 Time: 22:04
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	-0.538273	0.273587	-1.967468	0.0608
D(I(-1))	-0.090114	0.228840	-0.393788	0.6972
D(I(-2))	-0.328110	0.188101	-1.744328	0.0939
C	0.663889	1.786198	0.371677	0.7134

R-squared	0.435775	Mean dependent var	0.148214
Adjusted R-squared	0.365247	S.D. dependent var	11.61953
S.E. of regression	9.257443	Akaike info criterion	7.420297
Sum squared resid	2056.806	Schwarz criterion	7.610611
Log likelihood	-99.88415	Hannan-Quinn criter.	7.478478
F-statistic	6.178744	Durbin-Watson stat	1.944899
Prob(F-statistic)	0.002901		

At first difference and intercept

Null Hypothesis: D(I) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.348373	0.0000
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(I,2)
Method: Least Squares
Date: 04/09/21 Time: 22:05
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(I(-1))	-1.946378	0.264872	-7.348373	0.0000
D(I(-1),2)	0.532020	0.165741	3.209952	0.0036
C	-0.034336	1.848374	-0.018576	0.9853

R-squared	0.742922	Mean dependent var	0.064643
Adjusted R-squared	0.722356	S.D. dependent var	18.55038
S.E. of regression	9.774551	Akaike info criterion	7.498398
Sum squared resid	2388.546	Schwarz criterion	7.641135
Log likelihood	-101.9776	Hannan-Quinn criter.	7.542034
F-statistic	36.12347	Durbin-Watson stat	2.073138
Prob(F-statistic)	0.000000		

At level and trend and intercept

Null Hypothesis: I has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.002901	0.0196
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(I)
Method: Least Squares
Date: 04/09/21 Time: 22:06
Sample (adjusted): 1988 2017
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	-0.739388	0.184713	-4.002901	0.0004
C	2.456470	3.643705	0.674168	0.5059
@TREND(1987)	-0.098377	0.202362	-0.486143	0.6308

R-squared	0.375931	Mean dependent var	-0.279000
Adjusted R-squared	0.329703	S.D. dependent var	11.37376
S.E. of regression	9.311887	Akaike info criterion	7.395100
Sum squared resid	2341.203	Schwarz criterion	7.535220
Log likelihood	-107.9265	Hannan-Quinn criter.	7.439926
F-statistic	8.132217	Durbin-Watson stat	1.885637
Prob(F-statistic)	0.001720		

At first difference and trend and intercept

Null Hypothesis: D(I) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.226192	0.0000
Test critical values:	1% level	-4.323979	
	5% level	-3.580623	
	10% level	-3.225334	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(I,2)
Method: Least Squares
Date: 04/09/21 Time: 22:07
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(I(-1))	-1.953950	0.270398	-7.226192	0.0000
D(I(-1),2)	0.536550	0.169156	3.171928	0.0041
C	-1.435485	4.291505	-0.334495	0.7409
@TREND(1987)	0.084822	0.233501	0.363260	0.7196

R-squared	0.744328	Mean dependent var	0.064643
Adjusted R-squared	0.712369	S.D. dependent var	18.55038
S.E. of regression	9.948796	Akaike info criterion	7.564344
Sum squared resid	2375.485	Schwarz criterion	7.754659
Log likelihood	-101.9008	Hannan-Quinn criter.	7.622525
F-statistic	23.29012	Durbin-Watson stat	2.078694
Prob(F-statistic)	0.000000		

D. Gross Domestic Product Data (LNGDP)

At level and intercept

Null Hypothesis: LNGDP has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		3.478605	1.0000
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNGDP)
Method: Least Squares
Date: 04/09/21 Time: 21:18
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP(-1)	0.207294	0.059591	3.478605	0.0019
D(LNGDP(-1))	-0.501575	0.237921	-2.108161	0.0456
D(LNGDP(-2))	-0.581695	0.244910	-2.375136	0.0259
C	-2.410748	0.716370	-3.365228	0.0026

R-squared	0.342935	Mean dependent var	0.091552
Adjusted R-squared	0.260802	S.D. dependent var	0.135569
S.E. of regression	0.116558	Akaike info criterion	-1.329299
Sum squared resid	0.326056	Schwarz criterion	-1.138984
Log likelihood	22.61018	Hannan-Quinn criter.	-1.271117
F-statistic	4.175352	Durbin-Watson stat	2.036526
Prob(F-statistic)	0.016342		

At first difference and intercept

Null Hypothesis: D(LNGDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.716748	0.0007
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNGDP,2)
Method: Least Squares
Date: 04/09/21 Time: 21:18
Sample (adjusted): 1989 2017
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGDP(-1))	-0.897123	0.190199	-4.716748	0.0001
C	0.080843	0.030121	2.683983	0.0123

R-squared	0.451751	Mean dependent var	0.002296
Adjusted R-squared	0.431446	S.D. dependent var	0.179250
S.E. of regression	0.135159	Akaike info criterion	-1.098252
Sum squared resid	0.493238	Schwarz criterion	-1.003955
Log likelihood	17.92465	Hannan-Quinn criter.	-1.068719
F-statistic	22.24771	Durbin-Watson stat	2.019338
Prob(F-statistic)	0.000065		

At level and trend and intercept

Null Hypothesis: LNGDP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.440921	0.9810
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNGDP)
Method: Least Squares
Date: 04/09/21 Time: 21:19
Sample (adjusted): 1988 2017
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP(-1)	-0.039690	0.090017	-0.440921	0.6628
C	0.427613	1.019195	0.419559	0.6781
@TREND(1987)	0.009995	0.007262	1.376364	0.1800

R-squared	0.223325	Mean dependent var	0.087101
Adjusted R-squared	0.165794	S.D. dependent var	0.131982
S.E. of regression	0.120546	Akaike info criterion	-1.298938
Sum squared resid	0.392343	Schwarz criterion	-1.158818
Log likelihood	22.48407	Hannan-Quinn criter.	-1.254113
F-statistic	3.881798	Durbin-Watson stat	2.204731
Prob(F-statistic)	0.032978		

At first difference and trend and intercept

Null Hypothesis: D(LNGDP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.852182	0.0029
Test critical values:	1% level	-4.323979	
	5% level	-3.580623	
	10% level	-3.225334	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNGDP,2)
Method: Least Squares
Date: 04/09/21 Time: 21:20
Sample (adjusted): 1990 2017
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGDP(-1))	-1.518814	0.313017	-4.852182	0.0001
D(LNGDP(-1),2)	0.292395	0.203334	1.438001	0.1633
C	-0.059311	0.054202	-1.094255	0.2847
@TREND(1987)	0.011930	0.003854	3.095225	0.0049

R-squared	0.609903	Mean dependent var	0.001134
Adjusted R-squared	0.561141	S.D. dependent var	0.182428
S.E. of regression	0.120852	Akaike info criterion	-1.256930
Sum squared resid	0.350527	Schwarz criterion	-1.066615
Log likelihood	21.59701	Hannan-Quinn criter.	-1.198748
F-statistic	12.50771	Durbin-Watson stat	2.015002
Prob(F-statistic)	0.000040		

E. Population (LNP)

At level and intercept

Null Hypothesis: LNP has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.084341	0.2520
Test critical values:	1% level	-3.699871	
	5% level	-2.976263	
	10% level	-2.627420	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNP)
Method: Least Squares
Date: 04/09/21 Time: 21:24
Sample (adjusted): 1991 2017
Included observations: 27 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNP(-1)	-1.694375	0.812907	-2.084341	0.0490
D(LNP(-1))	1.459257	0.754870	1.933123	0.0662
D(LNP(-2))	1.449101	0.751554	1.928139	0.0668
D(LNP(-3))	-84.83643	60.03255	-1.413174	0.1716
C	9.621082	5.073979	1.896161	0.0711

R-squared	0.187011	Mean dependent var	-0.055713
Adjusted R-squared	0.039195	S.D. dependent var	0.443543
S.E. of regression	0.434764	Akaike info criterion	1.337547
Sum squared resid	4.158426	Schwarz criterion	1.577517
Log likelihood	-13.05689	Hannan-Quinn criter.	1.408903
F-statistic	1.265161	Durbin-Watson stat	2.019618
Prob(F-statistic)	0.313504		

At first difference and intercept

Null Hypothesis: D(LNP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.373257	0.0001
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNP,2)
Method: Least Squares
Date: 04/09/21 Time: 21:24
Sample (adjusted): 1989 2017
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNP(-1))	-1.033414	0.192325	-5.373257	0.0000
C	-0.051188	0.081451	-0.628444	0.5350

R-squared	0.516752	Mean dependent var	-0.000200
Adjusted R-squared	0.498854	S.D. dependent var	0.615386
S.E. of regression	0.435643	Akaike info criterion	1.242483
Sum squared resid	5.124179	Schwarz criterion	1.336779
Log likelihood	-16.01600	Hannan-Quinn criter.	1.272015
F-statistic	28.87189	Durbin-Watson stat	2.002490
Prob(F-statistic)	0.000011		

At level and trend and intercept

Null Hypothesis: LNP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.984148	0.9314
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNP)
Method: Least Squares
Date: 04/09/21 Time: 21:25
Sample (adjusted): 1988 2017
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNP(-1)	-0.141838	0.144123	-0.984148	0.3338
C	0.731245	0.604417	1.209836	0.2368
@TREND(1987)	-0.012944	0.008695	-1.488632	0.1482

R-squared	0.107039	Mean dependent var	-0.046807
Adjusted R-squared	0.040894	S.D. dependent var	0.420853
S.E. of regression	0.412158	Akaike info criterion	1.159820
Sum squared resid	4.586604	Schwarz criterion	1.299939
Log likelihood	-14.39729	Hannan-Quinn criter.	1.204645
F-statistic	1.618249	Durbin-Watson stat	2.006641
Prob(F-statistic)	0.216888		

At first difference and trend and intercept

Null Hypothesis: D(LNP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.528944	0.7939
Test critical values:	1% level	-4.339330	
	5% level	-3.587527	
	10% level	-3.229230	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNP,2)
Method: Least Squares
Date: 04/09/21 Time: 21:26
Sample (adjusted): 1991 2017
Included observations: 27 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNP(-1))	-89.64201	58.63004	-1.528944	0.1405
D(LNP(-1),2)	88.38851	58.56893	1.509137	0.1455
D(LNP(-2),2)	88.12292	58.50605	1.506219	0.1462
C	3.478782	2.124237	1.637662	0.1157
@TREND(1987)	-0.052726	0.023808	-2.214588	0.0375

R-squared	0.615991	Mean dependent var	-0.000285
Adjusted R-squared	0.546171	S.D. dependent var	0.638617
S.E. of regression	0.430216	Akaike info criterion	1.316516
Sum squared resid	4.071882	Schwarz criterion	1.556486
Log likelihood	-12.77297	Hannan-Quinn criter.	1.387872
F-statistic	8.822579	Durbin-Watson stat	2.024902
Prob(F-statistic)	0.000208		

F. Real Interest Rate (RIR)

At level and intercept

Null Hypothesis: PI has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.435351	0.1432
Test critical values:	1% level	-3.737853	
	5% level	-2.991878	
	10% level	-2.635542	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PI)
Method: Least Squares
Date: 04/09/21 Time: 21:29
Sample (adjusted): 1994 2017
Included observations: 24 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PI(-1)	-0.943265	0.387322	-2.435351	0.0270
D(PI(-1))	-0.077469	0.368842	-0.210033	0.8363
D(PI(-2))	-0.024551	0.365043	-0.067254	0.9472
D(PI(-3))	0.338705	0.352788	0.960082	0.3513
D(PI(-4))	0.669912	0.334837	2.000711	0.0627
D(PI(-5))	0.681057	0.278067	2.449251	0.0262
D(PI(-6))	0.439061	0.200699	2.187657	0.0439
C	8.024659	4.648037	1.726462	0.1035

R-squared	0.649052	Mean dependent var	0.151979
Adjusted R-squared	0.495512	S.D. dependent var	18.21891
S.E. of regression	12.94041	Akaike info criterion	8.219789
Sum squared resid	2679.267	Schwarz criterion	8.612473
Log likelihood	-90.63746	Hannan-Quinn criter.	8.323968
F-statistic	4.227250	Durbin-Watson stat	2.010975
Prob(F-statistic)	0.008064		

At first difference and intercept

Null Hypothesis: D(PI) has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.994867	0.2867
Test critical values:	1% level	-3.769597	
	5% level	-3.004861	
	10% level	-2.642242	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PI,2)
Method: Least Squares
Date: 04/09/21 Time: 21:29
Sample (adjusted): 1996 2017
Included observations: 22 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PI(-1))	-2.613314	1.310019	-1.994867	0.0675
D(PI(-1),2)	0.709848	1.258021	0.564258	0.5822
D(PI(-2),2)	0.094146	1.196519	0.078684	0.9385
D(PI(-3),2)	0.218796	1.107824	0.197501	0.8465
D(PI(-4),2)	0.644264	0.935954	0.688350	0.5033
D(PI(-5),2)	1.012568	0.710898	1.424350	0.1779
D(PI(-6),2)	0.950612	0.447405	2.124723	0.0534
D(PI(-7),2)	0.404348	0.208882	1.935774	0.0749
C	0.564839	2.854234	0.197895	0.8462

R-squared	0.893106	Mean dependent var	-0.349278
Adjusted R-squared	0.827325	S.D. dependent var	31.77134
S.E. of regression	13.20234	Akaike info criterion	8.290753
Sum squared resid	2265.922	Schwarz criterion	8.737089
Log likelihood	-82.19829	Hannan-Quinn criter.	8.395897
F-statistic	13.57693	Durbin-Watson stat	2.021678
Prob(F-statistic)	0.000037		

At level and trend and intercept

Null Hypothesis: PI has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 6 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.281595	0.0933
Test critical values:	1% level	-4.394309	
	5% level	-3.612199	
	10% level	-3.243079	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PI)
Method: Least Squares
Date: 04/09/21 Time: 21:30
Sample (adjusted): 1994 2017
Included observations: 24 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PI(-1)	-1.431878	0.436336	-3.281595	0.0050
D(PI(-1))	0.286178	0.387954	0.737660	0.4721
D(PI(-2))	0.208072	0.357215	0.582485	0.5689
D(PI(-3))	0.514319	0.337640	1.523276	0.1485
D(PI(-4))	0.796522	0.315604	2.523798	0.0234
D(PI(-5))	0.773602	0.260844	2.965767	0.0096
D(PI(-6))	0.493778	0.187241	2.637132	0.0187
C	-3.049484	7.114315	-0.428641	0.6743
@TREND(1987)	0.856137	0.438909	1.950604	0.0700

R-squared	0.720060	Mean dependent var	0.151979
Adjusted R-squared	0.570759	S.D. dependent var	18.21891
S.E. of regression	11.93639	Akaike info criterion	8.077057
Sum squared resid	2137.161	Schwarz criterion	8.518827
Log likelihood	-87.92468	Hannan-Quinn criter.	8.194259
F-statistic	4.822870	Durbin-Watson stat	2.196344
Prob(F-statistic)	0.004321		

At first difference and trend and intercept

Null Hypothesis: D(PI) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 7 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.589397	0.7641
Test critical values:	1% level	-4.440739	
	5% level	-3.632896	
	10% level	-3.254671	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PI,2)
Method: Least Squares
Date: 04/09/21   Time: 21:31
Sample (adjusted): 1996 2017
Included observations: 22 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PI(-1))	-2.222009	1.398020	-1.589397	0.1380
D(PI(-1),2)	0.260820	1.372253	0.190067	0.8524
D(PI(-2),2)	-0.383145	1.328198	-0.288470	0.7779
D(PI(-3),2)	-0.234161	1.235097	-0.189589	0.8528
D(PI(-4),2)	0.319125	1.017082	0.313765	0.7591
D(PI(-5),2)	0.839153	0.745317	1.125901	0.2822
D(PI(-6),2)	0.912180	0.453970	2.009340	0.0675
D(PI(-7),2)	0.420000	0.211704	1.983902	0.0706
C	9.264247	10.45842	0.885817	0.3931
@TREND(1987)	-0.448613	0.518437	-0.865318	0.4038

R-squared	0.899384	Mean dependent var	-0.349278
Adjusted R-squared	0.823922	S.D. dependent var	31.77134
S.E. of regression	13.33178	Akaike info criterion	8.321134
Sum squared resid	2132.837	Schwarz criterion	8.817062
Log likelihood	-81.53247	Hannan-Quinn criter.	8.437960
F-statistic	11.91836	Durbin-Watson stat	2.055994
Prob(F-statistic)	0.000102		

G. Price (PR)

At level and intercept

Null Hypothesis: PR has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.249536	0.9711
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PR)
Method: Least Squares
Date: 04/09/21 Time: 21:34
Sample (adjusted): 1989 2017
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PR(-1)	0.018585	0.074479	0.249536	0.8049
D(PR(-1))	-0.006062	0.214592	-0.028249	0.9777
C	0.031362	0.032098	0.977070	0.3375

R-squared	0.002487	Mean dependent var	0.036931
Adjusted R-squared	-0.074244	S.D. dependent var	0.121757
S.E. of regression	0.126196	Akaike info criterion	-1.204263
Sum squared resid	0.414061	Schwarz criterion	-1.062819
Log likelihood	20.46182	Hannan-Quinn criter.	-1.159965
F-statistic	0.032417	Durbin-Watson stat	1.931248
Prob(F-statistic)	0.968142		

At first difference and intercept

Null Hypothesis: D(PR) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.931205	0.0004
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PR,2)
Method: Least Squares
Date: 04/09/21 Time: 21:35
Sample (adjusted): 1989 2017
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PR(-1))	-0.989655	0.200692	-4.931205	0.0000
C	0.036630	0.023755	1.542006	0.1347

R-squared	0.473856	Mean dependent var	0.007793
Adjusted R-squared	0.454370	S.D. dependent var	0.167850
S.E. of regression	0.123985	Akaike info criterion	-1.270837
Sum squared resid	0.415053	Schwarz criterion	-1.176540
Log likelihood	20.42713	Hannan-Quinn criter.	-1.241304
F-statistic	24.31679	Durbin-Watson stat	1.924959
Prob(F-statistic)	0.000037		

At level and trend and intercept

Null Hypothesis: PR has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.465707	0.8182
Test critical values:	1% level	-4.309824	
	5% level	-3.574244	
	10% level	-3.221728	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PR)
Method: Least Squares
Date: 04/09/21 Time: 21:36
Sample (adjusted): 1989 2017
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PR(-1)	-0.181493	0.123826	-1.465707	0.1552
D(PR(-1))	0.048179	0.205495	0.234455	0.8165
C	-0.057415	0.054434	-1.054775	0.3016
@TREND(1987)	0.009316	0.004734	1.967836	0.0603

R-squared	0.136274	Mean dependent var	0.036931
Adjusted R-squared	0.032627	S.D. dependent var	0.121757
S.E. of regression	0.119754	Akaike info criterion	-1.279307
Sum squared resid	0.358527	Schwarz criterion	-1.090715
Log likelihood	22.54996	Hannan-Quinn criter.	-1.220243
F-statistic	1.314792	Durbin-Watson stat	1.947031
Prob(F-statistic)	0.291697		

At first difference and trend and intercept

Null Hypothesis: D(PR) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 3 (Automatic - based on AIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.518028	0.0582
Test critical values:	1% level	-4.356068	
	5% level	-3.595026	
	10% level	-3.233456	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PR,2)
Method: Least Squares
Date: 04/09/21 Time: 21:37
Sample (adjusted): 1992 2017
Included observations: 26 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PR(-1))	-1.653265	0.469941	-3.518028	0.0022
D(PR(-1),2)	0.561486	0.387813	1.447828	0.1632
D(PR(-2),2)	0.552057	0.321795	1.715553	0.1017
D(PR(-3),2)	0.309853	0.225236	1.375682	0.1841
C	-0.038298	0.065458	-0.585084	0.5650
@TREND(1987)	0.005701	0.003647	1.562925	0.1338

R-squared	0.570438	Mean dependent var	0.008577
Adjusted R-squared	0.463047	S.D. dependent var	0.177616
S.E. of regression	0.130152	Akaike info criterion	-1.041051
Sum squared resid	0.338792	Schwarz criterion	-0.750721
Log likelihood	19.53366	Hannan-Quinn criter.	-0.957446
F-statistic	5.311804	Durbin-Watson stat	1.816302
Prob(F-statistic)	0.002891		

Lag length determination

VAR Lag Order Selection Criteria
Endogenous variables: E
Exogenous variables: C G I LNGDP LNP PR RIR
Date: 06/03/21 Time: 02:05
Sample: 1987 2017
Included observations: 29

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-250.4262	NA	3033930.	17.75353	18.08357	17.85689
1	-244.0149	9.285247	2099340.	17.38034	17.75752	17.49847
2	-240.9941	4.166700*	1838126.*	17.24097*	17.66530*	17.37387*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

ARDL Model output

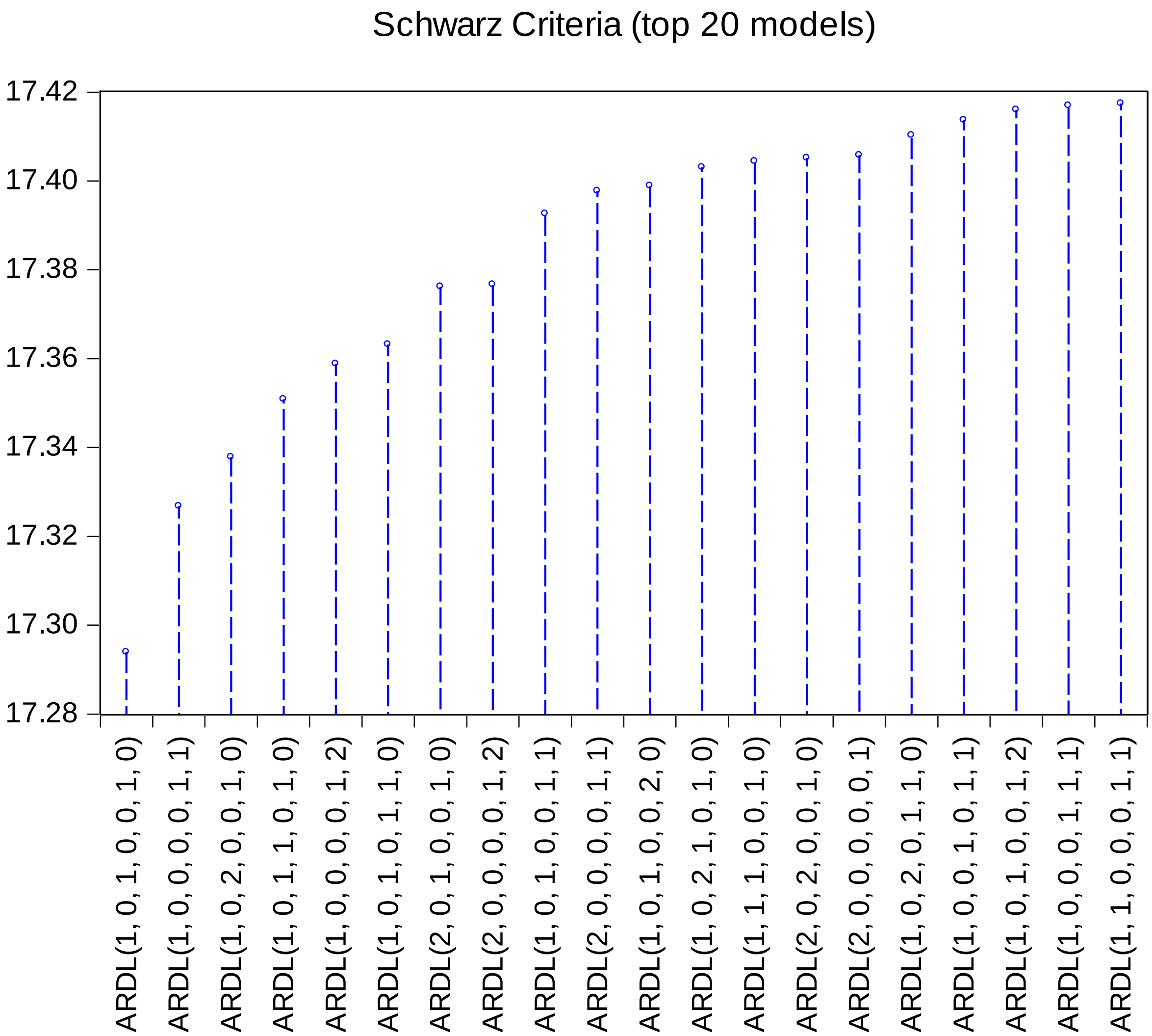
Dependent Variable: E
Method: ARDL
Date: 06/03/21 Time: 05:29
Sample (adjusted): 1988 2017
Included observations: 30 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Schwarz criterion (SIC)
Dynamic regressors (2 lags, automatic): G I LNGDP LNP PR RIR
Fixed regressors: C
Number of models evalulated: 1458
Selected Model: ARDL(1, 0, 1, 0, 0, 1, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
E(-1)	0.278833	0.145207	1.920247	0.0692
G	51.82661	51.25794	1.011094	0.3240
I	39.35037	41.91449	0.938825	0.3590
I(-1)	61.79781	22.68809	2.723800	0.0131
LNGDP	-459.7059	1027.276	-0.447500	0.6593
LNP	935.4526	510.9855	1.830683	0.0821
PR	2543.951	2331.170	1.091276	0.2881
PR(-1)	6661.668	2362.919	2.819254	0.0106
RIR	36.41337	27.62980	1.317902	0.2024
C	1978.721	13448.99	0.147128	0.8845

R-squared	0.947621	Mean dependent var	4957.133
Adjusted R-squared	0.924050	S.D. dependent var	3702.926
S.E. of regression	1020.491	Akaike info criterion	16.95516
Sum squared resid	20828049	Schwarz criterion	17.42222
Log likelihood	-244.3274	Hannan-Quinn criter.	17.10458
F-statistic	40.20328	Durbin-Watson stat	1.921493
Prob(F-statistic)	0.000000		

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

Model selection summary



Model Diagnosis

Test result for serial correlation

Breusch-Godfrey Serial Correlation LM Test:

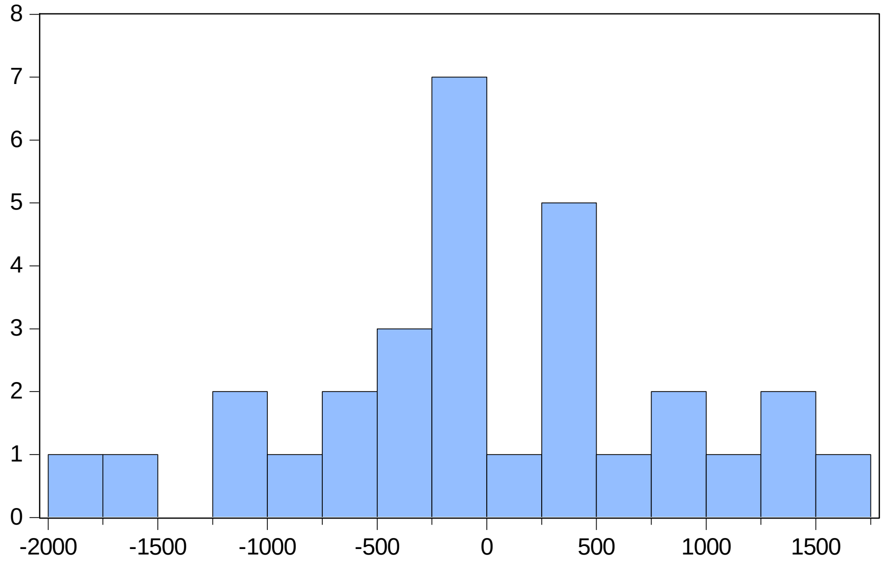
F-statistic	0.167030	Prob. F(2,18)	0.8475
Obs*R-squared	0.546623	Prob. Chi-Square(2)	0.7609

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 06/03/21 Time: 05:23
Sample: 1988 2017
Included observations: 30
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
E(-1)	0.025888	0.188390	0.137417	0.8922
G	5.264012	54.66280	0.096300	0.9243
I	5.214760	46.65630	0.111770	0.9122
I(-1)	-0.400155	23.70732	-0.016879	0.9867
LNGDP	-243.7542	1155.093	-0.211026	0.8352
LNP	-109.3989	566.4082	-0.193145	0.8490
PR	717.0010	2784.951	0.257456	0.7997
PR(-1)	-565.8906	2699.554	-0.209624	0.8363
RIR	4.457808	30.71555	0.145132	0.8862
C	3231.525	15137.14	0.213483	0.8333
RESID(-1)	-0.056653	0.319638	-0.177242	0.8613
RESID(-2)	0.147392	0.301086	0.489535	0.6304

R-squared	0.018221	Mean dependent var	-5.76E-13
Adjusted R-squared	-0.581755	S.D. dependent var	847.4719
S.E. of regression	1065.847	Akaike info criterion	17.07010
Sum squared resid	20448546	Schwarz criterion	17.63058
Log likelihood	-244.0515	Hannan-Quinn criter.	17.24940
F-statistic	0.030369	Durbin-Watson stat	1.722716
Prob(F-statistic)	1.000000		

Normality test



Series: Residuals	
Sample 1988 2017	
Observations 30	
Mean	-5.76e-13
Median	-70.59640
Maximum	1586.642
Minimum	-1905.348
Std. Dev.	847.4719
Skewness	-0.224546
Kurtosis	2.803097
Jarque-Bera	0.300567
Probability	0.860464

Heteroskedasticity Test: ARCH

Heteroskedasticity Test: ARCH

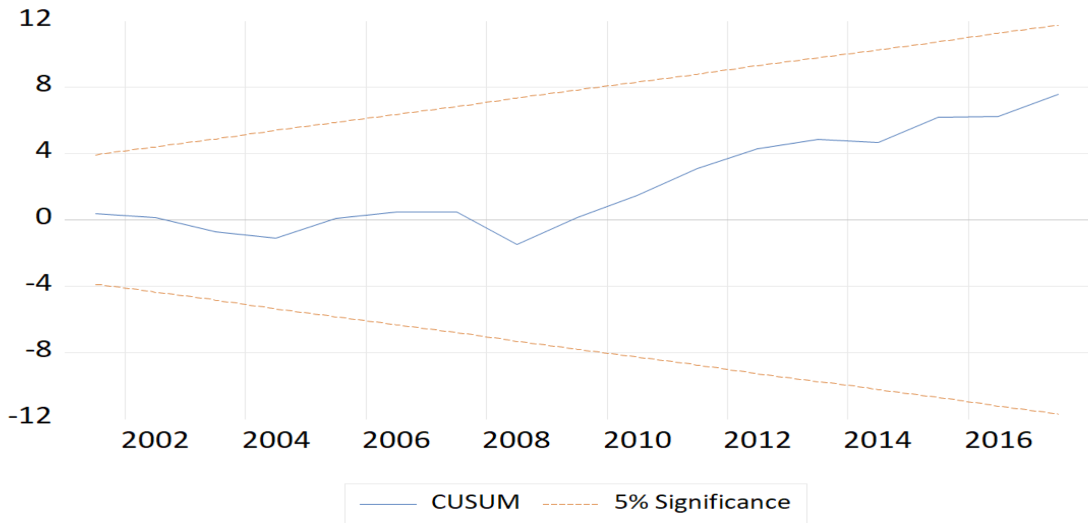
F-statistic	1.672850	Prob. F(1,27)	0.2068
Obs*R-squared	1.691937	Prob. Chi-Square(1)	0.1933

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 06/03/21 Time: 10:14
Sample (adjusted): 1989 2017
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	764834.0	195396.4	3.914268	0.0006
RESID^2(-1)	-0.216148	0.167118	-1.293387	0.2068

R-squared	0.058343	Mean dependent var	616620.9
Adjusted R-squared	0.023466	S.D. dependent var	862469.8
S.E. of regression	852290.2	Akaike info criterion	30.21571
Sum squared resid	1.96E+13	Schwarz criterion	30.31001
Log likelihood	-436.1278	Hannan-Quinn criter.	30.24525
F-statistic	1.672850	Durbin-Watson stat	2.201347
Prob(F-statistic)	0.206834		

Model stability test result



Cointegration or long run relationship test result

ARDL Bounds Test
Date: 06/03/21 Time: 05:25
Sample: 1988 2017
Included observations: 30
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	4.741975	6

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Test Equation:
Dependent Variable: D(E)
Method: Least Squares
Date: 06/03/21 Time: 05:25
Sample: 1988 2017
Included observations: 30

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(I)	-0.469497	28.36181	-0.016554	0.9870
D(PR)	3180.605	2881.657	1.103741	0.2828
C	-7695.283	12905.43	-0.596283	0.5577

G(-1)	-34.14253	45.55970	-0.749402	0.4623
I(-1)	-8.439510	55.96495	-0.150800	0.8816
LNGDP(-1)	463.9592	982.2142	0.472360	0.6418
LNP(-1)	974.3266	577.5599	1.686971	0.1071
PR(-1)	8014.620	2085.315	3.843361	0.0010
RIR(-1)	-47.32774	39.41904	-1.200632	0.2439
E(-1)	-0.765930	0.165240	-4.635253	0.0002

R-squared	0.652577	Mean dependent var	366.6667
Adjusted R-squared	0.496237	S.D. dependent var	1689.839
S.E. of regression	1199.385	Akaike info criterion	17.27821
Sum squared resid	28770509	Schwarz criterion	17.74527
Log likelihood	-249.1731	Hannan-Quinn criter.	17.42763
F-statistic	4.174078	Durbin-Watson stat	1.982971
Prob(F-statistic)	0.003743		

ARDL Cointegrating and long run form

ARDL Cointegrating And Long Run Form
Dependent Variable: E
Selected Model: ARDL(1, 0, 1, 0, 0, 1, 0)
Date: 06/03/21 Time: 06:09
Sample: 1987 2017
Included observations: 30

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
G	71.864915	78.445773	0.916109	0.3705
I	14.256242	6.702267	2.012219	0.0579*
LNGDP	-637.447105	1502.763484	-0.424183	0.6760
LNP	129.137203	61.215220	2.108428	0.0478**
PR	1276.890882	276.379992	4.609296	0.0002***
RIR	50.492274	42.249646	1.195093	0.2460
C	2743.775535	18975.830176	0.144593	0.8865

Cointegrating Form *(short run analysis)*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(G)	51.826610	51.257942	1.011094	0.3240
D(I)	39.350369	41.914487	0.938825	0.3590
D(LNGDP)	-459.705862	1027.275677	-0.447500	0.6593
D(LNP)	93.452640	51.985460	1.830683	0.0821*
D(PR)	254.951146	233.170236	1.091276	0.02881**
D(RIR)	36.413365	27.629798	1.317902	0.2024
CointEq (-1)	-0.721167	0.145207	-4.966482	0.0001***